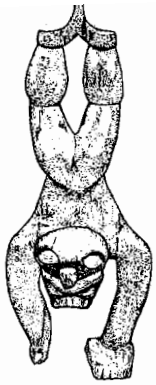
hawaii historic preservation



report 83-1

ARCHAEOLOGICAL INVESTIGATIONS OF THE MUDLANE-WAIMEA-KAWAIHAE ROAD CORRIDOR, ISLAND OF HAWAI'I:

An Interdisciplinary Study of an Environmental Transect

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Editors

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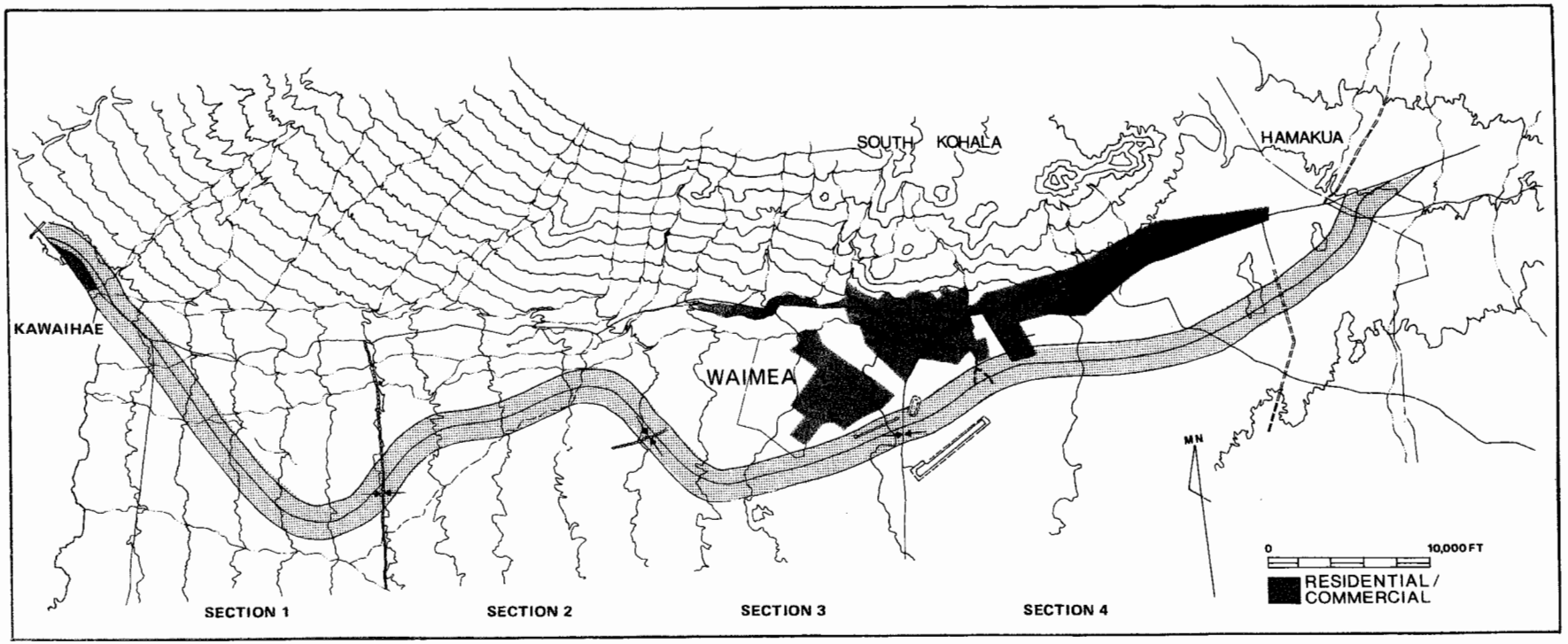

Fig. 1.1b. THE MUDLANE-WAIMEA-KAWAIHAE ROAD CORRIDOR, SHOWING SECTIONS 1 THROUGH 4.

Direct evidence for prehistoric agriculture is generally of two kinds: (1) crop plant microfossils (e.g., pollen and opal phytoliths) and macrofossils (e.g., carbonized tubers); and (2) physical remains of agronomic modification (e.g., field borders and terraces) and of physically altered soils. In Hawai'i, most attempts to investigate prehistoric agriculture have stressed the second of these two categories. In the Waimea-Kawaihae Project, we wished to continue this line of more orthodox archaeological inquiry, while also initiating attempts to obtain plant micro- and macrofossils. The lack of application of pollen and opal phytolith analyses in Hawaiian archaeology was largely due to the absence of reference collections, and to the somewhat laborious procedures required for the sampling, extraction, and analysis of these microsopic plant materials. While we recognized that our attempts to apply pollen and opal phytolith analyses would be hampered by these constraints, we nevertheless resolved to place some emphasis on these procedures. As expected (and as reports in this volume indicate), the results have been somewhat limited. However, we have made major strides in developing reference collections and in refining field and laboratory techniques, which will greatly facilitate future applications of pollen and opal phytolith studies in Hawaiian archaeology.

During the course of the Waimea-Kawaihae Project, emphasis was also placed on the recovery of plant macrofossils, and for the first time in Hawai'i, extensive use was made of flotation extraction of organic materials from open-site soils. The recovered materials, though meager by comparison with sites in other parts of the world, have shown that flotation can yield plant materials from open Hawaiian sites, and that the technique is worth applying on a regular basis.

Problem 5--Environmental Change

The past decade of research in Hawaiian archaeology has produced an increasing body of data to indicate that the lower elevations of all islands were extensively modified by human activities even prior to European contact (Kirch 1982). In historic times, documentary evidence testifies to extensive deforestation, erosion, siltation, changes in local weather patterns, and the like. The analysis of paleoenvironmental changes is clearly of utmost importance to the analysis of cultural adaptation, both in terms of man's impact on the ecosystem, and the reciprocal influence of the ecosystem on the human population.

As discussed by Kelly and Nakamura (1981), there is abundant historical evidence of major environmental changes along the course of the Mudlane-Waimea-Kawaihae road corridor. However, it is also likely that the prehistoric Hawaiian occupation of the area initiated certain changes even prior to European contact. The field systems in Section 4 may well have involved forest clearing and burning as part of their construction and implementation. Documenting the precise nature of such ecological changes, and the chronological framework within which they occurred, was a major and continuing problem throughout the Mudlane-Waimea-Kawaihae Project.

Data bearing on environmental change tend to be rather eclectic in scope. Historical research is one important source of data for changes that occurred within the period since European contact, and this avenue was explored thoroughly by Marion Kelly and Barry Nakamura of the project team (Kelly and Nakamura 1981). The analyses of pollen and opal phytoliths,

discussed above under Problem 4, were also of direct relevance to our attempts to reconstruct former environmental conditions. As a baseline control for the interpretation of the pollen and opal phytolith data, we also initiated a study of the contemporary vegetation zones of the Waimea-Kawaihae area, carried out by Holly McEldowney. In her study, McEldowney incorporated early historical descriptions of vegetation, to achieve a reconstruction of plant communities as they existed in the mid-19th century.

A major source of data on paleoenvironment in Hawai'i is that of fossil land snails, which can be sensitive indicators of microenvironmental conditions. During the survey of Section 4 of the highway corridor, subfossil land-snail deposits were located, and Carl Christensen was engaged to investigate these deposits during the intensive data recovery phase of the project.

A final source of paleoenvironmental data is that of charcoal recovered from archaeological excavations which, if identified, can provide data on local vegetation and use of plants by the Hawaiians. As with pollen analysis, lack of a reference collection had hindered earlier attempts to identify archaeological charcoal. In the Waimea-Kawaihae Project, we determined to move ahead with efforts at establishing a reference collection, and at refining techniques of charcoal thin-sectioning and identification. This work, carried out by Gail Murakami, has shown promising results.

Problem 6--Inter-*Ahupua'a* Variation

A perusal of the land records from the Great Mahele of the middle 1800s reveals that the geographic extent of *ahupua'a* units was quite uneven. Marshall Sahlins (pers. comm.) has suggested that there is a discrete patterning to *ahupua'a* size distribution, with each district (*moku*) having a "core" area with small but densely populated and economically productive *ahupua'a*. At the district borders, Sahlins suggests that the *ahupua'a* were larger and less productive, probably due to ecological marginality.

The large *ahupua'a* of Waikoloa, which is partly transected by the Mudlane-Waimea-Kawaihae road corridor, appears to be an example of such a marginal, border-area territorial unit. Survey data from the project were expected to assist in defining the settlement pattern contrasts between Waikoloa and other, "core area" *ahupua'a* and determine whether any differences could be correlated with environmental parameters.

Problem 7--Exchange Patterns

Although *ahupua'a* units have been regarded in the anthropological and ethnohistorical literature as having been economically self-sufficient, it is obvious that not *all* resources on any island were equally distributed. Such items as high-quality volcanic glass, fine-grained basalt for adz manufacture, large *koa* trees (*Acacia koa* Gray) suitable for canoe manufacture, and scoriaceous lava for abraders had rather restricted distributions. It is quite possible, then, that some form of inter-*ahupua'a* exchange may have operated to ensure the distribution of such items over a larger sphere. Unfortunately, we are quite ignorant as to the existence, extent, or operation of such putative exchange systems. Clearly, this problem will be resolved only through the application of a broad, regional research design,

Report 2

NOTES ON THE LANDS OF WAIMEA AND KAWAIHAE

by Dorothy Barrère

WAIMEA: *HE KALANA NO*

The geographic divisions of the island of Hawai'i originally comprised the six chiefdoms of the island. These chiefdoms were in existence by the 16th century when Liloa, the traditional dynastic founder of the ruling family of the island, was acknowledged as paramount by all the other chieftains of the then-autonomous chiefdoms of Hāmākua, Hilo, Puna, Ka'ū, Kona, and Kohala (Kamakau 1961:1). In the years following Liloa's death the dynasty branched into two powerful lines; one, the "Kona chiefs," generally dominated Kona, Kohala, and Ka'ū, and the other, the "I" chiefs, held Hilo, Hāmākua, and Puna. For nearly 300 years there was almost continuous warring within the family, as one chief or another sought to unify the island chiefdoms into one. When the unification was finally accomplished by Kamehameha I, late in the 18th century, the same geographic divisions of the earlier chiefdoms became the six districts of his kingdom. Their boundaries remained essentially the same as originally set out, not to be changed until after the Great Mahele of 1848.* Within the district boundaries, however, subdivisions of lands had taken place as conquering chiefs, especially Kamehameha, distributed lands among their supporters. His tributary lands remained as taxable land units until 1852, when all land taxes were abolished.

Among the subdivisions of land made by earlier chiefs there was one called the *kalana*, which may or may not have been synonymous with *'okana*. The dictionary definitions of *kalana* and *'okana* (Andrews 1865; Pukui and Elbert 1971) seem to be based on David Malo's earlier (ca. 1840) statements to the effect that *kalana* and *'okana* were alternative terms for a division (*'apana*), within a district (*moku o loko*), or an island (*mokupuni*) (Malo 1951:16). In 1865 Lorrin Andrews refined this definition to call *kalana* "a division of an island less than a *moku*, and synonymous with *'okana* in some places" (1865:251, 95). He defined *moku* as "A district; a division of an island, as Kona on Hawaii" (*Ibid.*:398). An *'okana*, said Andrews, was "a district or division of country containing several ahupuaas" naming Kona, Kohala and Hāmākua as *'okana*. The Pukui and Elbert dictionary follows Andrews (1971:113, 258). In Andrews' definitions *moku* and *'okana* were synonymous for "district" and *kalana* was a non-defined subdivision within a district. These definitions conflict with actual usage in several cases, an important one being that pointed out by Robert D. King, former principal cadastral engineer of the Territorial Survey Department, when he called attention to the use of *kalana* as meaning "district" in the Mahele Book of 1848, which recorded the land divisions between chiefs and king (King 1935:214). In 1893 an anonymous writer for a Hawaiian newspaper said "Maui was all cut up into moku, kalana and ahupuaa, which was not so on Hawaii, for its kalana and ahupuaa were within the moku" (Anon.:1893). With such differing applications of the terms *kalana* and *'okana* it appears probable that the terms meant different things in different localities and at different times.

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*Kona and Kohala were each divided into North and South districts in 1859; Hilo was divided into North and South Hilo in 1886 (King 1935:216, 218, 219).

In 1847 George Hu'eu Davis described his land of Kaikoloa as an *'ili*, i.e., an *'ili kupono*, within the *kalana* of Waimea, Waimea being similar to Lahaina, he said, and the *'ili* of Waikoloa similar to "those lands we hold in Lahaina" (Hu'eu 1847). Also in 1847 John 'I'i listed Waimea as a *kalana* within the 'Apana (section or district) of Kohala ('I'i 1847). In 1865 witnesses in testimonies regarding the boundaries between Waimea and Waikoloa used the terms *kalana* and *'okana* with some inconsistency. Unfortunately no Hawaiian texts exist of their testimonies, the following being the English transcriptions recorded in the Boundary Commission Book for Hawaii (No. 1, pp. 6-12):

> Waimea is an ahupuaa of Waimea, which is a kalana, with eight divisions (Ehu).
>
> Waikoloa is an ili of Waimea ahupuaa; Waimea is an Okana (Kanehailua).
>
> Punana, Puupili, Kaleiokumikiau and Puuhuluhulu join Waikoloa... they are all divisions of the okana Lihue (Kuahine).

Clearly by 1865 the terms *kalana* and *'okana* were being used loosely and had perhaps lost their original precise meanings, if indeed they had had any. Waimea soon afterwards lost its designation as a *kalana*, and became known only as an *ahupua'a*. The original certification of boundaries for Waimea, dated January 8, 1867, was written thus: "Boundaries of the Kalana (or Ahupuaa) of Waimea in South Kohala, Hawaii." The words "Kalana (or Ahupuaa)" were crossed out and "Ahupuaa (or Kalana)" written above them. The final certification reads: "Ahupuaa (or Kalana) of Waimea, Hawaii" (Boundary Commission Book for Hawaii, No. 1, p. 16). It follows that the *'okana* within the *kalana* of Waimea henceforth became known as *'ili 'āina* within the *ahupua'a*. The *'ili kupono* within the *kalana* lost their identity as lands paying taxes directly to the king, and were also called *'ili 'āina*.

WAIMEA TRADITIONS

The earliest chiefs of Waimea of whom we have record stemmed from the same Ulu-Hema line that led to Liloa, the founder of the island dynasty. Liloa's grandson Keawe-nui-a-'Umi took as one of his wives Ho'opili-a-Hae, daughter of Liloa's *kahuna* Pae-a-Molenole. From this union came 'Umiokalani, an ancestor of the Luahine, Palena, and Mahi families of Kona and Kohala. Ho'opili-a-Hae is credited in legend with having formed a *heiau* in the Lanikepu Hills of Waimea, dedicated to the training of virgins in the art of healing (Henriques n.d.).

Kanaloa-kua'ana, the oldest son of Keawe-nui-a-'Umi, was killed at Puakō after a battle with the invading Maui chief Kamalalawalu. His eyes pierced by an octopus spear, Kanaloa-kua'ana was killed and his eyes tattooed (Fornander 1916:IV,343). His brother Lonoikamakahiki then led the united forces of Hawai'i in battle with the invader. An account of this battle was written by Samuel Kamakau in 1871 (Kamakau 1961:55-61); two other versions were collected by Abraham Fornander (Fornander 1916:IV, 342-60 ; 1919:V, 440-51). The battle took place on the "grassy plains" (*kula pili*) of Waimea in the vicinity of Pu'u-'oa'oaka (Owaowaka) in the Kamakau version and at the adjoining hill of Hoku'ula in the Fornander versions. The major routes of travel for the war parties of the six chiefdoms are recounted as follows: from Kona up the western seacoast along the Kanikū trail to Puakō; from Ka'ū, from 'Ohaikea in Kapāpala

and up between Hualālai and Mauna Kea; from Puna, Hilo, and Hāmākua, up the eastern seacoast, then along the Mahiki trail, and from Kohala, from Kaholeiwai in upper Kawaihae through Momoualoa (Fornander 1919:V, 446-48). The Kona warriors were stationed between Pu'u Pā and Haleapala; those of Ka'ū and Puna from Pu'u Holoholoku to Waikoloa; those of Hilo and Hāmākua from Mahiki to Pu'u Kanikanihia, and those of Kohala from Momoualoa to Waiaka (Fornander 1916: IV, 344). In this battle the Hawai'i forces were victorious, the invading chief killed, and the Maui army annihilated (*Ibid.*:IV, 348).

There is no particular notice of Waimea in the accounts of battles and the regroupings of chiefdoms in the years that followed Lonoikamakahiki's victory until five or six generations later. Then, sometime in the 18th century, there seems to have been an important battle between the Kona chiefs and the I chiefs of Hilo at Mahiki in Hāmākua, not far beyond the Waimea boundary (Survey Map, 1911-1913). In this battle the Kona chief Ka-uaua-a-Mahi, a descendant of 'Umiokalani, was killed. Ka-uaua-a-Mahi's son Alapa-i-nui warred against his maternal brother Ke'eaumoku-nui of Kona and Kohala; he took these chiefdoms and eventually nearly all of Hawai'i (Kamakau 1961:63, 65-66, 76). He was a good chief, said Kamakau, and added: "He used to travel about the island and make his home for a time in one place and then in another" (*Ibid.*:75). He was said to have lived in Hilo, in Waipi'o, in Waimea, and finally in Kawaihae where he died at Kikiako'i (later Pelekane), leaving his son as heir to his chiefdoms. The heir was soon contested by Kalani'opu'u of Ka'ū and the supremacy of rule returned to the senior line of the Kona chiefs, of which Kalani'opu'u was the ranking member. He too is noted in Kamakau's accounts as a peripatetic chief (1961:105, 106, 109).

It may well have been that during the times of Alapa'i-nui and of Kalani'opu'u that the cultivating places at Waimea were first expanded to supply the chiefs' needs while they sojourned there and at Kawaihae. The abandoned cultivated patches, so often attributed to the decrease in the Hawaiian populations, were, in fact, as much the result of this practice of chiefs of traveling about their domains, feeding off the land until supplies were exhausted, then moving off to another.

The same necessity to expand the plantings at Waimea took place after Kamehameha wrested the rule from Kiwala'ō, heir of Kalani'opu'u. Kamakau repeatedly wrote of Kamehameha's movements from place to place on Hawai'i, including three sojourns at Puakō, Kawaihae, and Waimea (1961:182-83). During the course of Kamehameha's campaigns to win his kingdom there were two prolonged stays at Waimea and Kawaihae. One was in 1791 and 1792 when the building of the *heiau* at Pu'u Koholā necessitated the support of a large body of workers, and the other was in 1794 and 1795 at the time of preparation and staging of the Peleleu fleet that carried his wars across the sea to Maui and O'ahu. It was probably during this sojourn that the original *mele* "Hole Waimea" was composed by warriors of Kamehameha as they obtained wood from the Mahiki forest and fashioned their *pololū* spears (*Ka Na'i Aupuni*, 3/12/1906). On both these occasions there can be no doubt that food and tapas were brought from Kohala, Waimea, and beyond to feed and clothe the hundreds of people involved.

The local chiefs of Waimea do not figure prominently in the tales told of Waimea. One, however, became known during the reign of Kalani'opu'u for his prowess in cliff-leaping (*lele*

pali), a highly skilled performance that saved many a warrior's life in time of battle. This chief was Hina'i, who Kamakau referred to as a close relative of Kalani'opu'u (1961:111-12). Nuhi, the son of Hina'i, supported Kiwala'ō at Kamehameha's first battle at Moku'ōhai. When Kamehameha conquered Hawai'i and took Waimea as a *panala'au*, a conquered land, the Waimea chiefs were reconciled to him by the marriage of his sister Ka'ohelelani to Nuhi.

WAIMEA: *'ĀINA PANALA'AU*

The victorious Kamehameha followed the ancient custom of distributing conquered lands, *'āina panala'au*, among his principal supporters. According to one source of tradition he gave Waimea to his warrior brother Kalaimamahū, whose son Kahalai'a inherited it (Anon.:1893). When Kahalai'a died in 1826, Waimea reverted to the king, then Kauikeaouli, Kamehameha III. According to the same source, Puakō descended directly to Kauikeaouli upon Kamehameha's death; he apparently gave it to Lunalilo, a grandson of Kalaimamahū.

In a later distribution of lands after the Battle of Nu'uanu and/or his return to Hawai'i in 1812, Kamehameha rewarded his chiefs as well as his *haole* advisors John Young and Isaac Davis with further tracts of land, including parts of Waimea. John Young received as an *'ili kupono* the land of 'Ōuli and the *ahupua'a* of Kawaihae 2. A portion of Kawaihae was detached and given to the land of 'Ōuli so that the latter might have access to the sea (Boundary Commission Book 2:73, Kalualukela). Sometime before 1827 a portion of Kawaihae 1 was detached and given to Kawaihae 2 as recompense for the killing of one of John Young's men by an agent of the king (*Ibid.*:390, Kanehaku, *w.*).

Isaac Davis received a very large, but on the whole unproductive, tract in Waikoloa, the land previously held by the branch of Waimea chiefs represented by Papa, the father of Kaha'anapilo, wife of Isaac's son George Hu'eu Davis (Boundary Commission Book 1:8, Kuahine). 'Anaeho'omalu and Kalāhuipua'a, both containing valuable fishponds, were at this time detached from Waikoloa (*Ibid.*:6, Mi). They descended to Kamehameha III, who gave them as *'ili kupono* to his queen Kalama. The productive lands of Pu'ukapu, Pukalani, Noho'aina, Kuku'i'ula, and Paulama were withheld and Davis received only the "*pili* land" of Waikoloa (*Ibid.*). The Waimea chief Kupapaulu, brother of Nuhi, was the king's agent in the apportionment (*Ibid.*).

In 1865 George Hu'eu Davis, who had received Waikoloa by name only as a Land Commission Award, requested adjudication of its boundaries. The local Board of Commissioners for Boundaries accepted the testimony of the Crown witnesses and ignored that of Davis' witnesses. Davis appealed the decision and in 1867 won his case. The Third Judiciary Court of Hawai'i overturned the Commissioners' determination and ordered the boundaries settled according to the testimony of Davis' earlier witnesses. The 1865 boundaries had been surveyed and mapped by S. C. Wiltse in 1866; the corrected boundaries were mapped by J. S. Kaelemakule presumably in 1867 (Reg. Map 574). His map became the basis for a later survey and map by C. J. Lyons. The

Land Board records of Waimea called both the Crown land and Davis' land "Waikoloa," as did all the witnesses in the 1865 to 1867 testimonies. Later, the greater portion of the king's Waikoloa became known as the *ahupua'a* of Lālāmilo and the smaller portion as the *'ili 'āina* of Waikoloa-iki. The name Lālāmilo appears only as a land name in boundary testimonies and may be found on the Wiltse map of 1866 as adjacent to the land of Puakō. It is not known when the name Lālāmilo was extended to most of the king's Waikoloa.

Pu'ukapu, a large land section of Waimea, was given by Kamehameha to Kalanimokū his *kalaimoku*, or prime minister (Boundary Commission Book 1:7, Ehu). In the 1865 Boundary Commission testimonies it appears that three of the *'ili 'āina* within Pu'ukapu may have been originally independent of Pu'ukapu, as witness stated that Kamehameha had given Pukalani to his man Keko'imoku, and that Nohoaina and Paulama belonged to the Waimea chief Kupapaulu, the same as mentioned above (*Ibid.*). Perhaps Kalanimokū absorbed these lands into his *'ili kupono* of Pu'ukapu. At any rate, Pu'ukapu descended to Kalanimokū's principal heir, his niece Kekau'onohi, who relinquished it in the Mahele of 1848. Pu'ukapu thus reverted to the Kamehamehas and was retained as a Crown land.

The lands of Waimea lying above Lālāmilo are not of concern to the present report. One, however, reflects the use of upland Waimea as a food producer for chiefs sojourning at Kawaihae. This was the land of Waiauia, given to Ke'eaumoku Papa'i-ahiahi, father of Ka'ahumanu, perhaps by his brother Kame'eiamoku the paramount of the chiefdom of Kohala. The two were older relatives of Kamehameha and his principal warrior chiefs. Ke'eaumoku is known to have had a residence at Kawaihae (Vancouver 1801:5, 106) and it is more than probable that Waiauia had been given to him as a source of food supplies on the occasions that he chose to sojourn there. Waiauia went to Ke'eaumoku-'opio, his son, and from the latter to his younger brother John Adams Kuakini, who was governor of Hawai'i from 1820 to 1844 (Land Board NR 41.8, *helu* 1968).

BEGINNINGS OF CHANGE

Captain George Vancouver's description of Kawaihae and its environs in 1794 included this on Waimea:

> ...the plains of Whymea...are reputed to be very rich and productive, occupying a space of several miles in extent, and winding at the foot of these three lofty mountains far into the country. In this valley is a great tract of luxuriant, natural pasture, whither all the cattle and sheep imported by me are to be driven, there to roam unrestrained, to increase and multiply... [Vancouver 1801:5, 107].

By 1794 Vancouver had left seven cows, three bulls, five ewes, and five rams on Hawai'i. According to Kona traditions, the cattle at least were kept at Kainaliu, in a great pen of 486 acres (Bowser 1880:550). Wherever they were kept to "increase and multiply" they did so, with such rapidity that by 1815 John Whitman reported

> The cattle have become so numerous on the Island that they are found in large droves and apprehensions were entertained that it would be necessary to destroy part of them on the expiration of

> the term which Van Couver set, when he left the first pair on the Island [Whitman 1979:61].

One source says that there were shipments of Hawaiian cattle as early as 1811 to supply settlers of Northwest America (Towne and Wentworth 1955:227-28).

The Wall of Kauliokamoa, a portion of the boundary between the Waikoloa lands of the king and those of Isaac Davis, was built at some time between 1813 and 1819 by the king's *konohiki* Kauliokamoa to keep the cattle off the cultivated lands of the king (Boundary Commission Book 1:6, 10; Mi, Kalua).

It has been estimated that by 1820 there were at least 1,600 cattle descended from those left by Vancouver (D. P. Fellows, pers. comm.). These, added to the descendants of those left by other voyagers, readily account for the "immense herds" of cattle in the Waimea area in the 1820s (Ellis 1917:303). By that time foreigners, including John Parker, were being employed "to shoot them, salt the meat in the mountains, and bring it down to the shore for the purpose of provisioning the native vessels" (*Ibid.*:301, 303).

There is little mention of the Hawaiians who dwelt on the lands of Kawaihae and Waimea in the early accounts except for those of Doyle (1945, 1953), who includes some of Father Lyons' comments on their changing life style. It is not until the Land Board records of the late 1840s that we get some details on the former settlement patterns and cultivated places on these lands. By then many changes had already taken place and more were to come as a result of the Mahele. Many of the agricultural sites had already been abandoned due to changed land uses, and in other areas the process of abandonment began as *kuleana* claimants failed to receive their scattered garden plots that had been their customary locations for farming.

From scattered references we piece together a sketchy view of Kawaihae and Waimea in the 1820s and 1830s. We find at the seashore a widely used anchorage at Kawaihae, where Kalanimokū kept a storage area for the sandalwood that was brought down from the mountains of Kohala and Waimea (Ellis 1917:298-99; Duperrey Map, Fig. 3.1). Nearby were salt ponds, where large quantities of salt were manufactured by evaporation of sea water. The salt of Kawaihae was its chief article of trade for the food and tapas brought for barter from Kona and Kohala. With the increasing use of Kawaihae as an anchorage by foreign vessels there was an ever greater demand for this item of trade. Salt was also manufactured at Puakō, a few miles to the south of the Kawaihae settlements, where the people depended on salt and the fish they caught for barter for food grown elsewhere (Doyle 1953:85).

On the rising ground above the seacoast settlements, several main trails led past occasionally cultivated grounds to the uplands of Waimea where there were, in the early 1820s, three major settlements about two miles apart. One was at Keaalii, one at Waikoloa, and one at Pu'ukapu. All three were concentrated where a major stream emptied itself upon the plateau.

The name Keaalii has long been lost to common knowledge (Judd 1932:14); however, its location has been deduced from a number of sources. The settlement was on the *kula* of Waimea, near the opening of Lanikepu gulch whose 100-ft waterfall, the only one of this height in the area, furnished the identifying landmark for relocating Keaalii (Perambulator 1836). A local chief, Kumu-o-ke-kipi, was living at "Kalaloa" in this vicinity when the Rev. Asa Thurston made

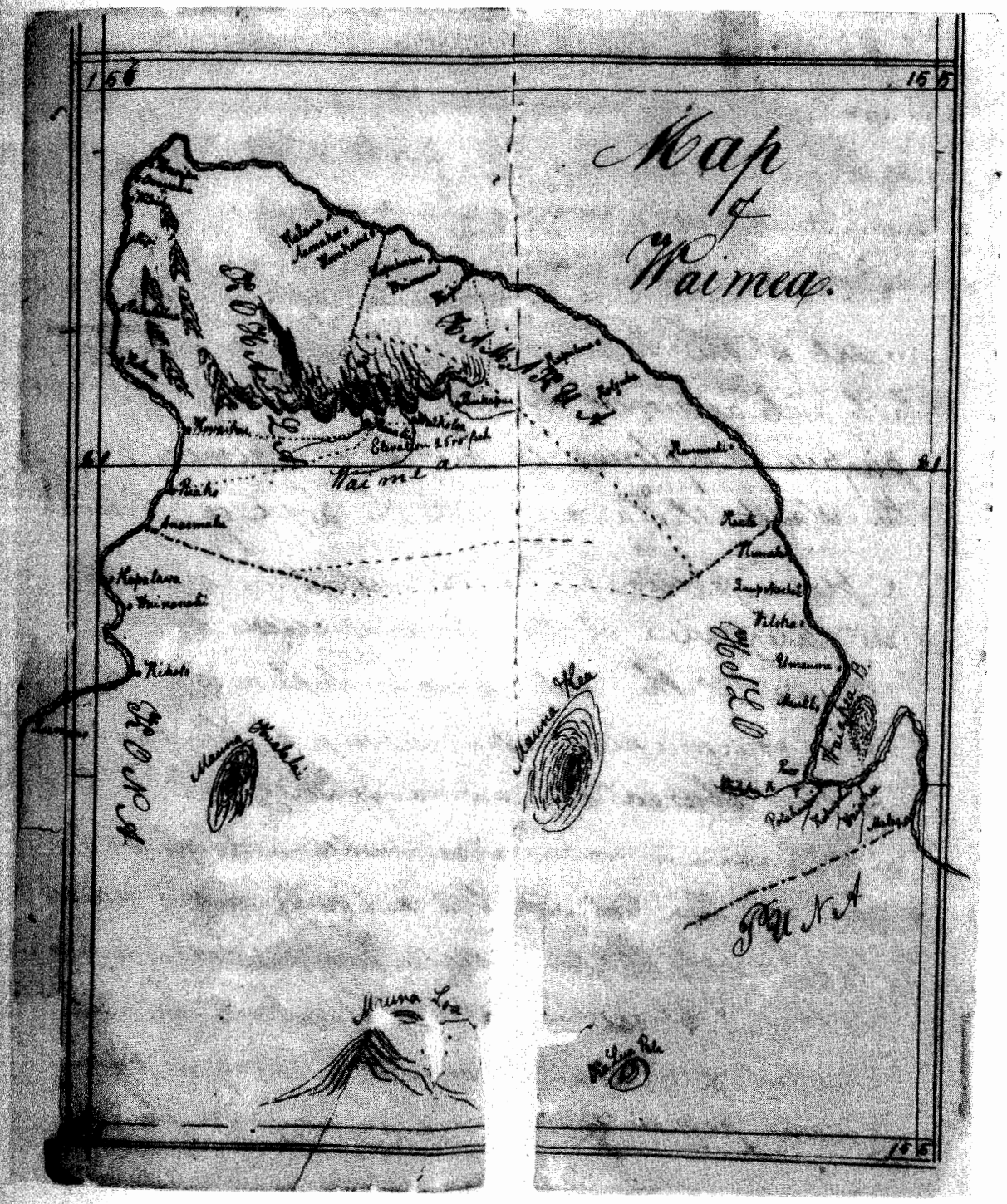

Fig. 2.1. MAP OF WAIMEA FROM THE COMMITTEE REPORT OF 1830. Hawaiian Mission Children's Society Library. The name Kealii appears above the word "Elevation" in the upper left portion of the map.

a brief visit to Waimea in August of 1823. Thurston apparently reported his name as Kumu-o-kapiki, and it so appears in the published account of the visit (Ellis 1917:301). The chief's wife was Papa'i, recorded as the *'ai-moku* (loosely, "governor") of Waimea in the days of Kamehameha (Anon.:1893). After Kumuokekipi's death, Papa'i married J. A. Palea, whose Land Commission Award 3828 included the land on which Kumuokekipi and Papa'i had lived (Land Board NR 8:381, NT 4:31, Aw. Bk. 5:46). Palea's land was called "Koaliula," a name corrupted to "Kawailiula" on modern USGS maps.

In December of 1829 a committee of missionaries went to Waimea to determine its suitability as a site for a possible health station. In their report of their three-week stay (Committee Report 1830), the Committee stressed meterological and climatic conditions at Waimea, and included a map showing the settlements of Keaalii, Waikoloa and Pu'ukapu, two of the main trails from Kawaihae and Puakō, and the main trail to Waipi'o, the original "Mud Lane" (see Fig. 2.1). One of the members of this committee, Dr. Gerrit P. Judd, returned to Waimea with his family in February of 1830, accompanied by the Rev. and Mrs. Ruggles and the Ka'awaloa chiefess Kapi'olani (*Fragments* 1903:26). The party of 70 was joined at Kawaihae by 43 others. On February 26 the entire group of 113 ascended the slopes and arrived at Keaalii, where the missionaries put up at "the best house in the district," an indication that it was or had been a chiefly domicile. We are assuming that it had been the residence of Kumuokekipi, who is presumed to have been deceased at this date.

The missionary group soon "removed to a school house half a mile distant" (*Ibid.*:30). The house was probably on the school lot at Waiaka 1, later recorded as being adjacent to the *pahale* of Kuahini (LCA 4127, Land Board Aw. Bk. 5:43). The school there may have been the first in Waimea, started by Maua'e, a young man from Puna who had been in charge of the canoe that Kuakini had furnished for the Ellis party of 1823 (Ellis 1917:204). Maua'e was among the native teachers trained at the Kailua mission station and in 1825 was assigned to Waimea (Bishop 1825, 1828), where he remained until his death by drowning in 1840 (*The Polynesian*, 6/6/1840).

Dr. Judd's account of his six-month stay in Waimea never mentions the schoolteacher Maua'e nor the ten schools already in operation in Waimea and Pu'ukapu (Bishop 1828). He does, however, note some interesting data of this period: the arrival of Gov. Adams (Kuakini) on March 19th "with all his train," (which we may be sure amounted to several hundred people) to "catch wild cattle"--another great demand on the food producers of Waimea; a carriage road linking Kawaihae and Waimea, being built by order of the governor, with a labor party of 40 persons convicted of breaking the *moe kolohe* laws; the increase in attendance at worship services from 200 to 1,000 when Kuakini arrived, and a further increase to 4,000 when the governor had a meeting house built at Keaalii; the building of the mission premises along the Waikoloa stream, and the first meeting house of what would become 'Imiola church (*Fragments* 1903:31-38).

School-learning and Christianity moved into Waimea soon after the cattle industry began in the region. Inevitably these Western influences undermined the lifestyle and economy of the Hawaiians living in the area. Another blow to their lifestyle occurred in mid-century when the Mahele of 1848, on the one hand, gave fee simple ownership of land to the Hawaiians and on the other hand, caused abandonment of a number of their heretofore cultivated places.

FROM THE LAND BOARD RECORDS

In the processing of awards to the chiefs and people subsequent to the Great Mahele of 1848 the ancient distinctions in designations of lands were blurred and lost in the voluminous records of the Board of Commissioners to Quiet Land Titles--commonly called the Land Board. The breakdown in land terminology caused much confusion in later years and led to many a court case. In one landmark case, Supreme Court Justice Albert F. Judd made this clarifying statement in regard to *'ili kūpono*:

> The ilis in question in this suit are not distinctly named "ili kuponos," this name not being preserved in the Mahele; but all the Ilis that were recognized and treated in the Mahele and awarded by the Commission [the Land Board] were undoubtedly "ili kuponos." This name was dropped, for, when separated from the Ahupuaa by Mahele and subsequent award, its necessity was gone. All other Ilis went with the Ahupuaa in which they were situated, and were not further distinguished [Harris vs. Carter 1877:203].

The Waimea/Kawaihae land records themselves do not support a kinship-related exchange pattern between upland and seacoast dwellers, nor do they indicate a seasonal occupation of sites *mauka* and *makai*. There were distinct settlement groups along the seacoast in Kawaihae 1 and 2 and in Puakō; on the *kula* or scrub lands of Kawaihae and Waimea; in the *kula* foothills; and in a band along the Waikoloa-Pu'ukapu juncture where the scrub land gave way to taller tree-growth and fuller underbrush.

The term *pahale*, as well as in its more general application as a houselot of about a quarter acre containing one or more houses, in these records often meant a cultivated area on which also stood one or more houses. Some *pahale* in Kawaihae included the salt pans adjacent to them. Interestingly, many upland claimants said in 1846 that their *pahale* were unenclosed, adding they were "thinking of doing so," and two years later when their witnesses gave testimony for them the *pahale* were described as enclosed. This change in pattern may indicate a growing concern over the encroachment of cattle in the area.

Of the 112 claims (including 11 non-awards) that were processed and tabulated for study and computerized statistical analysis, it was found that only one Land Commission awardee held a *pahale* at the seacoast and another one in the interior. This was Wahakane (LCA 3736), who received two *pahale*, one of 1.09 acres at Puakō (TMK 6-9) and another of 0.23 acres upland at Pu'ukī. There were two houses on the Puakō piece adjacent to the sea, where there was a landing place for small boats. One of these houses was occupied by Kaui, the "caretaker" for Wahakane (*ne noho hale malalo o Wahakane*) (Land Board, NT 4:19). On the southwest boundary was a school lot and in the southeast corner of the lot was a goat pen (*Ibid.*:Aw. Bk. 4:625). Upland in Pu'ukī (Map 2785) Wahakane had one house, partially enclosed and adjacent to the lot of his *punalua* Waiahole (LCA 3738; Land Board NT 4:19; TMK 6-5-04). In addition, Wahakane received 2.65 acres of *lo'i* land in Waipi'o; one parcel consisted of 13 *lo'i* and the other of one (*Ibid.*:Aw. Bk. 4:255). Little is known of Wahakane but clearly he was a man of enterprise. He received the houselot at Pu'ukī in 1824 (1825?) from Maua'e, the first schoolteacher in Waimea. Presumably recommended by the teacher, Wahakane entered Lahainaluna School in 1831 and remained there for four years (*Ka Hae Hawaii* 5/19/1858). He returned to Hawai'i and in 1834

received his lone *lo'i* in Waipi'o. Perhaps he was there as a teacher and the *lo'i* was his subsistence plot. In 1843 Wahakane took up an unoccupied piece of land (*wahi waiho wale*) at the seashore at Puakō and seems to have developed it as a shipping point for goat hides and for his *pa'i 'ai* (prepared taro) from Waipi'o. His development of the Puakō land was apparently unopposed by the small enclave of long-time holders of land in the vicinity and his tenure was sanctioned by the *konohiki* Beckley at the time of his claim in 1848.

William Beckley, *hapa-haole* son of Captain George Beckley who had been in the service of Kamehameha I, was for a number of years in charge of the king's cattle on Hawai'i. After the death of Governor Adams Kuakini on December 9, 1844, Beckley was appointed *konohiki* of Waimea, as well as manager of all the cattle there belonging to the king and the government. Beckley assumed, wrongly, that he had received all of Waimea to manage as he saw fit, believing, as he said, that there were no *'ili kupono* within it (Leleiohoku 1845). William Pitt Leleiohoku, Kuakini's heir and successor to the governorship of Hawai'i, protested to Keoni Ana, minister of the interior (*Ibid.*). There is no record of Keoni Ana's reply, but matters seem to have been adjusted satisfactorily, for the Land Board records show Beckley as the *konohiki* with power to sanction all land transactions, native and foreign, on Crown and Government lands, while the lands of the Young family and those of Hu'eu Davis continued to be managed by themselves or their own *konohiki*. Leleiohoku's 10-acre *'ili kupono* "Kamakahonu," (LCA 9971:58) and Lunalilo's Puakō (LCA 8559-B:6) were also unaffected by Beckley's authority.

As *konohiki* Beckley proved to be a lenient one. There is no case in which he disputed a claim, and in fact he was the principal witness for the majority of cases on the lands of which he had jurisdiction. As witness, he clarified the extent, location, and tenure of the simply worded claims, and ensured more than one award where none would have been made due to vagueness of claimant.

A unique situation developed on the Crown land at Pu'ukapu, where among the claimants were 18 who testified to their plantings of taro, sweet potatoes, bananas, sugarcane, melons, or *mamaki* as being "scattered" in the *ulula'au* or forest of Pu'ukapu. These holdings had been sanctioned by former *konohiki* and were unchallenged by Beckley. However--and it had to be with Beckley's sanction--the surveyor S. P. Kalama removed all 18 claimants from their original holdings and assigned each of them three acres of cultivable land at another location in Pu'ukapu. Fourteen of them also received an adjoining quarter-acre *pahale*, the other four retaining about two acres apiece in their former locations (TMK 6-4-01, 02). The resultant distribution of the assigned awards appears like a modern-day subdivision on tax maps (TMK 6-4, 6-4-05).

The action of the surveyor Kalama in relocating these particular Pu'ukapu claimants seems now to have been high-handed. Yet, as pointed out by C. J. Lyons, often-quoted authority on land matters in Hawai'i in the 1870s,

> ...It was impossible for the Commissioners to go upon the ground, so that responsibility in a large measure depended upon the surveyor. In dry or kula land, where the soil has to remain fallow for years between crops, it was difficult to decide what a kuleana should contain, and as we shall see there was much variety of practice (Lyons 1875:*1*(5):135).

We assume that the Hawaiian surveyor Kalama was familiar with his people's agricultural practices and that he endeavored to compensate for non-awardable fallow lands when he made the arbitrary awards of three-acre parcels.

William Beckley's own lands in Waimea were "Wa'awa'a" (LCA 976:2), a 25-acre piece of cultivable land, *'aina mahi 'ai*, in the *kula* of Waikoloa (Lālāmilo) and "Waikani" (LCA 976:1) a 4-acre *pahale* that he had purchased and on which he had several buildings and an adjoining cattle pen (Land Board Aw. Bk. 5:41). Nearby was "Waiemi," a 30-acre piece of land awarded to his wife Kuamo'o Ho'olulu, a granddaughter of the Kohala paramount Kame'eiamoku of Kamehameha's time. Between Beckley's *'aina mahi 'ai* and his *pahale* was a 250-acre tract called Lihu'e, which had been leased to Chinese early in the 1830s. Here they had started a sugar plantation and erected a mill. More on Lihu'e and its changing land use appears in a later section of this report.

Beckley's removal as *konohiki* and cattle manager in 1850 (Keoni Ana 1850) marked a new era in Waimea. Henceforth there was almost total emphasis on ranching and the growing Parker Ranch dictated land use in the region. Hawaiian agriculture declined accordingly and today its vestiges remain as a subject of study of archaeological and ethnographic interest.

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In 1810, just after negotiating the diplomatic acquisition of Kaua'i Island to Kamehameha's "kingdom," Isaac Davis died (Apple 1969:20). His children were then adopted by John Young. Young maintained a residence at Kawaihae, where he served as governor of Hawai'i Island from 1802 through 1812, and then as resident chief until his death at age 90, in 1835 (Apple 1969:20). With Young's presence, Kawaihae served as a key port for Euro-American ships calling in the islands. Young's houses, situated between Makahuna and Makeāhua Gulches, hosted many of the early sea captains, missionaries, and travelers. It was at Kawaihae, for instance, that the first Christian missionaries from the United States initially landed.

The impact of John Young on Hawaiian history has been great indeed. It was indirectly felt even through his offspring. John Young, Jr. (or Keoni Ana) served as an advisor to Kamehameha II and as premier for Kamehameha III. His granddaughter, Emma, became queen when she married Kamehameha IV. Some of the lands over which the highway ROW runs (in Section 1) are part of Queen Emma's Estate (now administered by The Queen's Medical Center). As summarized by Apple:

> Young seems to have been involved in every event of lasting importance in Hawaii from 1790 through 1820 [1969:20].
>
> * * *
>
> John Young (his Hawaiian name was *Olohana*) set the course which led Hawaii into the sphere of American influence and ultimately to statehood [1969:22].

The first mission station in Kawaihae was briefly manned by Elisha Loomis, who arrived in 1821. Kawaihae and Puakō were later brought into the territory serviced by Dwight Baldwin (from 1832 to 1835) and Lorenzo Lyons (1832 to 1876), who established a station in Waimea. Waimea thus became the center for the new religion in South Kohala and Hāmākua.

WAIMEA

Few of the early foreign visitors to Kawaihae ventured inland of the settlement. Archibald Menzies of Vancouver's expedition did travel a short distance inland of Kawaihae in 1793 and wrote of his excursion:

> I traveled a few miles back...through the most barren, scorching country I have ever walked over, composed of scorious dregs and black porous rocks, interspersed with dreary caverns and deep ravines....The herbs and grasses which the soil produced in the rainy seasons were now mostly in the shriveled state, thinly scattered and by no means sufficient to cover the surface from the sun's powerful heat, so that I met with very few plants in flower in this excursion. A little higher up, however, than I had time to penetrate, I saw in the verge of the woods several fine plantations, and my guides took great pains to inform me that the inland country was very fertile and numerously inhabited. Indeed, I could readily believe the truth of these assertions, from the number of people I met loaded with the produce of their plantations and bringing it down to the water side to market, for the consumption was now great, not only by the ship, but by the concourse of people which curiosity brought into the vicinity of the bay [Menzies 1920:55-56].

There appears to have been very little activity in the zone stretching from Kawaihae to the area of extensive agricultural and residential occupation in the uplands. One of the earliest visitors to pass through the uplands was the Rev. Mr. Thurston whose trip in 1823 was reported by Ellis (1969:399). After leaving Kawaihae and traveling for approximately two hours, Thurston reached 'Ōuli where he spent the night with the people living there. Another source mentioning some type of occupation in this intervening zone is Judd (1903:27-28) who, in 1830, wrote that on his trip to Waimea, his party stopped at a running stream approximately five miles from Kawaihae and there, "the people had provided baked hog, kalo, potatoes, etc." It should be kept in mind that isolated areas of activity may not have been reported, and that only shelters or gardening plots along the main trail over which these travelers passed would have been observed. So, while little has been reported of this less-desirable zone between the coast and the uplands, the true nature of land utilization of the area remains unclear.

The term Waimea is often used rather loosely and can refer to either of four places: the existing town of Waimea (sometimes called Kamuela); a large land division stretching from the coast to the uplands and encompassing several smaller subdivisions; the upland area only of that division, including the entire plain between Kohala and Mauna Kea mountains; and the upland region of intensive residential and agricultural occupation. Unless otherwise stated, the latter usage is the one adopted here.

As noted earlier, the area of Waimea differed markedly from the coastal zone. Whereas Kawaihae was rich in marine resources, Waimea was a productive agricultural zone due to fertile soil and generally adequate rainfall. In addition, three main streams flow off the Kohala slope and onto the plain, all of which were described by early visitors to the region (Andrews et al. 1830; Perambulator 1836). Though unnamed in the early discussions, the easternmost, and smallest, of these was probably the Lanikepu, which descends at Pu'ukapu, then sends one branch east, that was "soon lost in the swampy woods" (Perambulator 1836), and a second branch to the west. Only the latter branch can be seen today, and it appears likely to have undergone some artificial enlargement.

The second stream mentioned was the Waikoloa which enters the plain at the locality of the same name, and bends to the west. The third is Kohākōhau (sometimes referred to as the Keanu'i'omanō) which also flows to the west just a short distance to the north of the Waikoloa. These streams converge roughly halfway between the coast and Waimea town, and then continue down the Waiulaula Gulch to the coast. Both are perennial only at their headwaters, with most of the water flow diverted into pipelines for human and cattle consumption, or lost into the permeable gulch bottoms. While the flows of these streams were undoubtedly greater during the prehistoric and early historic times, even then their waters reached the ocean only during periods of heavy rainfall (Andrews et al. 1830; Perambulator 1836; Nakamura Ms.). The Waikoloa formerly abounded with water fowl, especially ducks (Perambulator 1836), and both streams were extensively tapped for irrigation purposes.

With the streams as the focus, the human settlement was scattered along the lower slope of Kohala mountain and stretched out onto the plain (e.g., Ellis 1969; Bingham 1969; Andrews et al. 1830; Baldwin 1832; Perambulator 1836; Kenway 1848; Doyle 1945). The settlement was not

in the form of a nucleated village, but, rather, consisted of a fairly continuous distribution of houses and agricultural fields. The area was divided into a number of named locales (e.g., Keaalii, Lihue, Kalaloa, Waiaka, Waikoloa, Alaohia, Pukalani, Pu'ukapu, and others), some of which undoubtedly had a greater population density than others.

Our first descriptions of Waimea come from Ellis, who reported the observations of other members of his party in 1823. Messrs. Bishop and Goodrich, coming to Waimea from the Hāmākua side, first passed through a fertile, well-cultivated countryside with few inhabitants. Then they reached Waimea.

> Here a number of villages appeared on each side of the path, surrounded with plantations, in which plantains, sugar cane, and taro were seen growing unusually large [Ellis 1969:354].

A few days later, Thurston traveled to Waimea from Kawaihae. After an overnight stop at ʻŌuli, he

> ...walked on to Kalaloa, the residence of the chief of Waimea, Kumuokapiki, Stump of Cabbage. Leaving Kalaloa, we walked on to Waiakea [Waiaka], from thence to Waikaloa [Waikoloa], Pukalani, and Puukapu, which is sixteen or eighteen miles from the sea-shore, and is the last village in the district of Waimea...
>
> The soil over which he had traveled was fertile, well watered, and capable of sustaining many thousand inhabitants. In his walks he had numbered 220 houses, and the present population is probably between eleven and twelve hundred [Ellis 1969:399].

A few years after the sojourn of the Ellis party, Waimea was visited by the Rev. Hiram Bingham who wrote of the "grandeur and beauty" of Waimea and the "scattered huts of the natives in the settlement." He went on to write:

> When we had escaped from the oppressive heat on the shore, and reached the height of about 2,000 feet, we were met by a chilly wind, which made our muscles shiver, though covered with a cloak....The clear rippling streams that wind their way along the verdant plain, through alternate plats of shrubbery, grass, *kalo*, sugar-cane, bananas, flowering bushes, and wild vines, occasionally crossed my path. Beyond the scattered cottages, the wild cattle were grazing unrestrained on their own territories bordering on the mountain. The green hills and mountains of Kohala, covered with trees and shrubbery, and their sides partly cultivated and partly covered with grass of spontaneous growth, rose on the north side of the plain [Bingham 1969:374].

It is quite clear that Waimea was agriculturally productive in the early years following Euro-American contact. Table 3.2† presents a list of agricultural products observed in the area prior to 1860. From these sources, as well as testimony of Kamaaina from the latter half of the 19th century (State Supreme Court, Carter Case: Vol. 24), it is clear that in the traditional system, taro was the dominant crop with sweet potatoes, sugarcane, and bananas also well represented. Information given in Table 3.2 suggests that pigs may also have been present in large numbers. Dogs are not mentioned but they are unlikely to have been fed or traded to Westerners so their relative abundance in Waimea remains unknown.

In the years following the first visits of foreigners to the Waimea region, subsistence agriculture declined sharply, although there were a couple of periods of increased activity.

Report 16

A DESCRIPTION OF MAJOR VEGETATION PATTERNS IN THE WAIMEA-KAWAIHAE REGION DURING THE EARLY HISTORIC PERIOD

by Holly McEldowney

INTRODUCTION

The following study presents a proposed description of the general character and distribution of 12 major vegetation communities in the Waimea-Kawaihae region during the early historic period (i.e., before 1850). As subsequent historic land-use practices have drastically altered or completely replaced these early historic communities, this proposed reconstruction is derived from the combined results of three approaches:

(1) classification and mapping of nine present plant communities (Zones I through IX) to define general environmental patterns throughout the region;

(2) the independent plotting of native and Polynesian-introduced plants (i.e., respectively, those thought to have occurred in Hawai'i before man and those brought by the Polynesian settlers) and the delineation of six relict native tree associations (Zones 1 through 6) to suggest the possible composition and distribution of former native communities; and

(3) the interpretation of landscape descriptions found in early historic published and unpublished documents.

In order to provide a coherent framework for the scattered details and broad generalities usually available through these approaches, this study encompasses the present district of South Kohala and a portion of Hāmākua rather than just the proposed highway corridor.

A separate discussion deals with the notorious role played by historically introduced cattle in modifying the vegetation of Waimea and argues that cattle-induced alterations of the vegetation, and other environmental factors, increased substantially after the shift from a predominantly Hawaiian subsistence-based economy to a commercial economy.

METHODS FOR CLASSIFYING PRESENT AND RELICT NATIVE VEGETATION

The classification of existing plant communities--including the primarily exotic pasture communities that dominate the region and those native species that persist as relicts--is based on a field survey and the interpretation of aerial photographs. The field survey, conducted over a total of 14 field days between September 1980 and March 1981, provided detailed vegetation descriptions for the proposed highway corridor and six transects running parallel to major stream-eroded ravines that dissect the south and southwestern flanks of the Kohala Mountains (Fig. 16.2). By including the Kohala slopes, from the forest reserve to the major highways, this sampling design allowed the simultaneous description of the pasture communities and native

plant communities persisting in the ravines. The ravines sampled were chosen because they contain the best examples of native relicts along a broad elevational gradient, and they dissect the slopes at roughly equal intervals. The patterns thus defined for the pasture communities along the Kohala slopes and along the highway corridor could then be directly compared with those derived from the distribution of native relicts. Plants associated with residential, commercial, and small-scale farming developments around Waimea proper were not described.

In describing the vegetation, data on the structure and floristic composition of the pasture communities were recorded at 38 irregularly spaced sampling points along the 20-mile road corridor. On the Kohala transects, similar information was recorded wherever changes in plant associations were apparent. Observations on the composition and distribution of relict native species were written as incidental notes.

The recording format used at each sample point followed that developed by J. D. Jacobi and F. R. Warshauer for the U. S. Fish and Wildlife Service's Hawai'i Forest Bird Survey (Scott, Jacobi, and Ramsey 1981:196-197). Designed to permit the rapid and consistent definition of structural and specific compositional features of plant communities, ground cover estimates in six percentage classes (i.e., 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 90%, 90%) were made at each sampling point by life-form (i.e., trees, shrubs, grasses, herbs, and ferns). Within each life-form group the additional distinction was made between native and exotic components (see Table 16.2). Each observed plant species was then listed separately in its appropriate life-form and was given a percentage class cover-rating as an estimate of that species' relative abundance.

Variations evident in these field descriptions were then compared with patterns recognizable on U.S. Geological Survey black and white aerial photographs taken in 1977 (approximately 1:45,000 scale). A mirror stereoscope (3X magnification) and the Kern PG-2 plotter were used for most of this interpretive work. The resulting classified and mapped patterns were first transferred to orthophoto quad maps (1:24,000 scale) prepared by the U.S. Geological Survey and the Department of Land and Natural Resources, State of Hawaii, and finally to a map scale of 1:100,000. This larger scale corresponds to the confidence levels within which the patterns were defined and drawn. These aerial photographs also allowed vegetation patterns to be defined for much of the region beyond the area surveyed. As seen in Figure 16.1, the degree to which these patterns could be extrapolated with confidence varied with each vegetation community.

PRESENT VEGETATION PATTERNS (ZONES I THROUGH VIII)

The eight major plant communities (Figure 16.1) currently dominating the unforested sections of the region are primarily open grass or grass and shrub communities used for cattle pasturage. Table 16.1 summarizes the distinguishing characteristics of each vegetation zone, as indicated by differences in species composition and by the foliage cover or relative abundance of different components. Also listed are plant species representative of those most

commonly found within each life-form group, and a description of features used to locate the boundaries between each vegetation type on the aerial photographs. Table 16.2 presents selected data extracted from the detailed vegetation descriptions to further illustrate elevational transitions between defined communities.

All vegetation units in this report are also grouped by moisture regimes (dry, moist, and wet). These categories are designed only to indicate relative differences in moisture within the study area and are not based on any environmental classification scheme developed for Hawai'i or elsewhere. In terms of mean annual rainfall, dry roughly corresponds to mapped rainfall isohyets of 10 to 20 in., moist to 20 to 40 in., and wet to 40 to 150 in. (Division of Water and Land Development, State of Hawaii, n.d.). These designations also aid in comparing the present, relict, and early historic vegetation patterns.

The present composition and structure of these communities primarily reflect the long-term cumulative effects of cattle grazing and ranching practices. Although these practices have varied since the cattle industry became more formalized in the second half of the 19th century (see page 432), the intentional and accidental introduction of grass and herb species, combined with continued grazing and browsing pressures from cattle, have contributed most significantly to this alteration.

As an example of the relatively recent and dynamic nature of the communities, nearly 75% of the vegetation presently found in the corridor is composed of grass species introduced since 1920, e.g., *Cenchrus ciliaris, Digitaria decumbens, Pennisetum clandestinum, Pennisetum setaceum* (St. John 1973: 22, 25, 36, 37). Most of these species were not common or even present in the region when Ripperton and Hosaka inventoried pasture lands from 1937 to 1938 (Ripperton and Hosaka 1942:47-51). Fountain grass (*Pennisetum setaceum*), an escaped ornamental introduced in 1926, has spread rapidly in the last 20 years over large portions of North Kona and South Kohala. This trend is apparent in Zone VI, where fountain grass dominates the corridor but is found with decreasing frequency to the north. Usually avoided by cattle, this stiff-bladed bunch grass increases in dominance following periodic fires. *Kiawe (Prosopis pallida)*, the only widely naturalized tree species in the pastures, was introduced to Oʻahu in 1828 (Neal 1965: 413). By the turn of the century, *kiawe* was already noted to be a prominent feature of the Kawaihae landscape (Alexander 1892:7; Hall 1904:9, 10), and by 1938 it had assumed a pattern similar to that described today for Zones I through IV (Ripperton and Hosaka 1942:22-23).

The following is an overview of how these major plant communities and the accompanying ranching practices vary over the broad range of environmental conditions found in the region. The wetter zones, Zones VI and VII, are the best suited to intensive grazing, and have been at least partially subject to management practices such as selective seeding, fertilizing, disking, weed control, and regulated grazing through paddock rotation. Although these practices have varied over time and among landowners, their use is uniform enough to present a consistent and detectable pattern throughout the region. As a result, these communities are primarily composed of propagated and volunteer grass and herb species (ca. 10 to 75 cm tall), which form a nearly continuous ground cover. Planted stands or alignments of exotic trees serving as windbreaks occasionally interrupt this expanse, while topographic features such as knoll and swale formations and gullies provide limited variations in an otherwise uniform terrain.

The intermediate vegetation types, Zones IV through VI, are basically unimproved pastures receiving little or no management, other than possible broadcast seeding and occasional rotation of smaller herds over minimally fenced open ranges. Primarily composed of mixed grass and shrub communities (10 to 90 cm) containing naturalized introduced species and some native shrubs adapted to grazing, these pasture communities are richer in plant species and more structurally complex than those of the wetter zones. The higher percentage of bare ground is ephemerally covered by numerous annual herbs following both seasonal and intermittent concentrations of rainfall. Grazing pressure probably keeps the few scattered trees found in these zones from spreading. The differences between knoll and swale formations are pronounced, with certain grasses favoring the swales with the deeper soil deposits and increased moisture retention, while other grasses are better adapted to the exposed conditions found on the intervening knolls. Plant communities fringing the intermittent streams generally resemble those of the wetter zones.

The driest zones, I through III, are also minimally managed open ranges. Use of these ranges and herd size fluctuate with periods of increased forage growth following seasonal or sporadic episodes of rainfall. Corresponding well with what Ripperton and Hosaka defined as a predominantly annual community (Zone A; Ripperton and Hosaka 1942:22, 31), contrasts between these zones and the more perennial communities of Zones IV through VI include a greater percentage of bare ground, a decline in the number and total cover of shrub species, and a greater tendency for grass and herb species to appear dry, withered, or dead. Zones I through III are the only pasture communities to contain a prominent tree component. *Kiawe* forms stretches of dense, tall-stature (6 to 10 m) thickets in Zone I, a fairly uniform, lower-stature (4 to 6 m) open-to-scattered-canopy across the slopes in Zone II, and restricted stands in gullies and substantial swales in Zone III.

Zone IX (Fig. 16.1) was not sampled or summarized in Tables 16.1 and 16.2 because adequate descriptions of these communities already exist (Jacobi Ms.; Rock 1974:65; Selling 1948: 55-70; Fosberg 1972). Designated as forest reserve and watershed lands, this zone encompasses wet, predominantly native *'ōhi'a* rainforest with the exception of several stands of introduced trees (e.g., *Eucalyptus robusta*, various Gymnosperms) planted near the forest reserve boundary. As is typical of many Hawaiian rainforests, *'ōhi'a* dominates an open-to-closed, relatively low-stature (5 to 15 m tall) canopy and is accompanied by native subcanopy trees (3 to 6 m tall) native shrubs (1 to 3 m tall), a herbaceous layer composed of saplings, native and introduced herbs, grasses, sedges, rushes, and ferns (< 1 m tall) and numerous epiphytic ferns and bryophytes. Representative components of these structural layers are similar to those listed in Table 16.3 for Zones 1 and 2. Variations within this general forest type include: differences between sheltered stream cuts and more exposed ridges; relatively flat patches where waterlogged or swampy ground supports sedges, rushes, and/or matted ferns; and bog-like formations in the summit area. These bog-like communities, roughly similar to those described for Kaua'i, Moloka'i, and West Maui (Selling 1948:69), primarily contain dwarfed (i.e., < 1 m tall) forms of tree and shrub species found in the neighboring forests and moss hummocks mixed with grasses, sedges, and rushes. Large portions of the forest floor and open areas have been drastically altered by feral pig rooting, allowing the replacement of many native ground-cover species by introduced grasses and herbs.

APPLICATIONS OF PRESENT VEGETATION ZONES

This study of the present vegetation was initially designed for two primary purposes: (1) to serve as an independent variable that could be correlated with defined environmental and cultural patterns; and (2) to be part of the comparative study between these existing patterns and those evident in the relict native vegetation and from the early historic literature.

To serve as truly independent variables, the definition and delineation of each zone rely entirely on floristic and structural variations in the vegetation. Problems arose, however, in comparing these zones with previously defined environment patterns because other classifications were either not defined independently or were too general to be truly comparable. For example, soil types defined for the region are based on a limited number of described profiles, classified in part by rainfall and temperature data, and delineated along vegetation patterns (Soil Conservation Service 1972:2-4, 73). The vegetation zones described for the Island of Hawai'i (Ripperton and Hosaka 1942:16-19; Robyn and Lamb 1939: 244-252) include climatic variables and elevation trends. On the three rainfall maps consulted, generalized interpolations differed substantially, partly because each represented data from different time spans (Division of Water and Land Development 1970:18; Division of Water and Land Development, n.d.; Taliaferro, 1959:5).

Instead of serving as a correlate, these present vegetation patterns may be more important as integrative indicators of environmental conditions. Defining the composition and structure of established vegetation communities can more precisely reflect long-term cumulative effects of interrelated climatic and edaphic variables than any other single method. Such potentially significant (particularly to agricultural concerns) factors as soil moisture relations, evaporation potential, topographic exposure, wind velocity, and dew, could only be evaluated after an intensive and time-consuming study, and the results would still reflect conditions for only a limited time span. That the patterns defined in the 1977 aerial photographs are generally similar to those apparent in 1965 (Soil Conservation Service 1972:Map Sheets #10-12, 14-16, 18-20, 23-25) strengthens the potential long-term usefulness of this approach.

The Waimea region is well suited to this approach because land use, topography, and substrate types are relatively uniform and vegetation types do form contouring zones. In areas where vegetation types form mosaics reflecting variable landscape types and uses, defining indicator vegetation units would be far more complex. On a broader scale, correlations between known cultural patterns and environmental parameters defined by vegetation units could be used to predict the probability of unknown or previously destroyed cultural resources, and to discuss variations in these cultural patterns.

For the comparative study developed in this paper, these present vegetation zones aid in predicting the extent of early historic vegetation types. Because several articles suggested that the early historic introduction of cattle severely altered both the vegetation and climatic patterns of Waimea, it was initially suspected that comparisons between the present vegetation, the relict plants, and the early historic patterns might substantiate these claims.

Comparisons of Figures 16.1, 16.2, and 16.3, however, suggest that, within the confidence levels of the three approaches, the general environmental patterns of Waimea have remained fairly constant, although the specific characteristics of these patterns have been drastically altered. This constancy further strengthens the validity of using existing vegetation to discuss questions dealing with early historic and, with qualification, prehistoric periods.

RELICT VEGETATION (ZONES 1 THROUGH 6)

Throughout the text, the term "relict vegetation" refers to native plant species persisting within the matrix of a more recently formed, dominant community type. In general, this implies that relicts represent what remains of former communities, either as scattered individuals that are not reproducing regularly and will eventually disappear, or as members of isolated communities that are reproducing and maintaining themselves on a limited scale. In using these relicts to predict the possible nature of former communities, the major problem is that they represent an incomplete or biased picture of former communities because they have been subjected to the same long-term selective pressures that created and maintained the current pasture communities. As these selective pressures, particularly cattle grazing, do not affect all structural components or plant species equally, the remaining formations represent, in terms of composition, relative abundance, and structure, only those features tolerant of these pressures. In this case, introduced grass and herb species have almost entirely replaced the native herbaceous component, while numerous long-lived native trees and unpalatable shrubs persist. Leguminous native tree species such as *koai'a*, *māmane*, and *wiliwili* have the additional advantage of reproducing vegetatively. This may explain, in part, their current prominence and ability to withstand disturbance. This study therefore views the presented classifications as only a minimal suggestion of what could have occurred in the region in the past. As part of the comparative study, these patterns are also used to predict the extent of early historic vegetation types.

Table 16.3 summarizes the major distinguishing and representative features of the six zones (Fig. 16.2). Major variations in relict populations were first defined from the field notes, then the elevation or location of these changes was plotted, and these points were roughly joined. These patterns primarily represent variations in species association and the relative abundance of tree species, the only component of the vegetation to appear consistently in large enough numbers and over an elevational gradient broad enough to provide an adequate data base. Relict formations found vary from a series of scattered trees to closed-canopy pockets or stretches with structurally complex understories. Although inconsistently distributed, the more structurally intact formations generally occur in Zones 1 through 3, while scattered patches with less diverse and complex understories are found as low as Zone 5.

The following examples may give a clearer idea of how these associations were defined. Zone 1 is essentially identical to the wet, *'ōhi'a* rainforest defined as Zone IX of the present vegetation. Zone 2 is also dominated by *'ōhi'a* and contains similar understorey species, but consistently lacks the understorey tree, *ōlapa*, and the abundance of epiphytes indicative of the

wetter conditions found in Zone 1. By far the richest in tree species, Zones 3 and 4 are composed of nearly the same trees. They differ in that *'ōhi'a* is more prominent in Zone 3 and has an understorey resembling the wetter units, while in Zone 4 *koai'a* is more prominent and the understorey resembles drier units. Although *koai'a* is the most common tree in both Zones 5 and 6, a marked decrease in the number and kinds of tree and shrub species distinguishes Zone 6 from 5.

Only a few scattered trees, *wiliwili*, *koai'a*, and *'iliahi* occur below the region defined (ca. < 600 m elevation). The native shrub, grass, and herb species found in this lower region are not considered relicts, as they are established components of the pasture communities; any discussion of their composition and distribution relies on the definitions presented in the previous section.

Although plants classified as Polynesian introductions (St. John 1973:82, 91, 140, 210, 230), and used extensively by the Hawaiian people, grow in each relict vegetation unit, their distribution and abundance varies considerably between ravines. In major segments of Lanikepu and Keanu'i'omanō gulches, *kī* (*Cordyline terminalis*) occurs in a nearly continuous series of scattered patches, occasionally associated with banana (*Musa* sp.), and once with *wauke* (*Broussonetia papyrifera*) and *hau* (*Hibiscus tiliaceus*). In the four other ravines sampled, *kī* occurs in the moist and wet units (3,800 to 3,000 ft elevation) but is found with decreasing frequency with each ravine to the west. This pattern may reflect the more intensive use of land in the Lanikepu region during the early historic period. An exception to this pattern, *kukui* (*Aleurites moluccana*), along with some *kī*, forms a band of open-to-closed-canopy patches between 2,700 and 2,100 ft elevation in the deep segment of Honokoa Gulch. The original planting of *kukui* and its continued persistence probably reflect the localized moisture regime created by the ravine's depth.

Another problem in basing past vegetation patterns on these relict examples is that plants found in the localized moisture regimes of sheltered ravines may not be analogous to the more exposed slopes. If this is consistently the case, then the patterns based on ravine vegetation would apply to lower elevations than patterns based entirely on slope communities. If such discrepancies are present in this study, they are probably less pronounced, as numerous stretches of the ravines sampled are relatively shallow, broad, and nearly as exposed as the slopes. The consistency with which the vegetation patterns changed downslope, in spite of variable ravine topography, suggests that these patterns may more closely resemble those that could occur on the slopes. The only clear example of this discrepancy was found in Zone 6 along the bottom of Honokoa Gulch, the deepest ravine sampled. These tree species were clearly more representative of the moister zones above, although the species found on the ravine wall were consistent with the general definition of Zone 6.

EARLY HISTORIC VEGETATION PATTERNS

INTRODUCTION

The following approximation of 12 major vegetation communities occurring between 1792 and 1850 (Fig. 16.3) is derived primarily from early historic documents, and secondarily from

the previously described present and relict vegetation patterns. Two major assumptions underlie this approximation. First, land-use practices are considered an integral part of a plant community's character because the impact of such practices can potentially range from the minor alteration of isolated areas to the creation and subsequent maintenance of entire community types. Second, it is argued that the overall character of both the vegetation and the predominantly Hawaiian approach to land use remained recognizable throughout the early historic period, even though specific features of these patterns were undergoing substantial change. The nature of these changes and the choice of 1850 to mark the end of the early historic period is discussed in the last section of this report, dealing mainly with the shift from a predominantly Hawaiian subsistence-based economy to that of a commercial economy revolving around the cattle industry.

The historic descriptions substantiating the 12 vegetation types come mainly from the written accounts of visiting and resident foreigners and from native Hawaiian testimony taken to formalize land titles before and after the Great Mahele in 1848. Whenever possible, these major vegetation patterns have been derived from the earliest references, while material from the later part of the early historic period, or subsequent periods, elaborates or refines the already established patterns. A Hawaiian term has been applied to vegetation types whenever evidence in the native testimonies suggests that the Hawaiian people of this region were identifying these areas as such. Otherwise, designations reflect dominant structural or compositional features of the vegetation.

Approximating the boundaries between these vegetation types was difficult. Although numerous specific and general references describe locations that can be plotted and illustrate distinct variations between locales, few references document where these transitions occurred. In mapping the boundaries, all documented points of transition were plotted (i.e., dotted points or lines in Fig. 16.3) and then extended, using boundaries from either relict or present vegetation patterns. Where neither of these means of extrapolation or interpolation was possible, a straight line arbitrarily separates known variations. In all cases, these boundaries consistently encompass individually described locations and generalizations established in the literature.

The distribution of known cultural remains was intentionally excluded as a factor in defining these patterns. This allows the proposed patterns to be used as an independent variable, should correlations be made with known cultural patterns. When compared with the archaeological data, these results also serve as an example of the kinds of information that can and cannot be resolved through this type of approach.

THE *PILI* LANDS

What are designated as "*Pili* Lands," or the dry vegetation types, appear to have been predominantly open grasslands during the early historic period. As with present communities, lower grasslands (*pili* land 1) had the characteristics of an annual plant community, while the upper grasslands (*pili* land 2) were more perennial in nature.

The term "*pili*" was applied to these grasslands because resident Hawaiians giving boundary testimony in Kohala between 1865 and 1873 consistently and clearly distinguished between a lowland area called *pili* and the upland cultivated region (Boundary Commission Book for Hawaii: Vol. A, 6-10, 73, 80-81; Vol. B, 129-130, 147, 276). Mentioned in 11 of 17 land divisions described between Pu'ukapu and Māhukona, the boundaries, in most cases, begin at the shore, cross the *pili* and then pass into the cultivated area. The presence of *iwi 'āina* (i.e., "a ridge of small stones which the natives formed in clearing their potato and kalo patches" [Ibid.:Vol. A, 164]), and terms such as "*kula*," "the cultivating grounds," and "the fertile lands" most frequently indicate this cultivated region.

In Hawaiian dictionaries and botanical references, *pili* is predominantly equated with the specific grass *Heteropogon contortus*, a noted thatching material for Hawaiian structures (Andrews and Parker 1922:546; Pukui and Elbert 1971:303; Hillebrand 1981:508; St. John 1973:31). The use of *pili* in these testimonies suggests, however, that *pili* may also be a generalized term for grassland, or a prominent grass component, and does not necessarily imply the composition or dominance of a vegetation type by *Heteropogon contortus*. This additional definition is primarily supported by the use of the term *pili* for areas beyond the known distributional range of *Heteropogon contortus* (Ripperton and Hosaka 1942:49; < 2,000 ft elevation in this study). such as the central plain of Waimea and the high-elevation slopes of windward Mauna Kea (Boundary Commission Book for Hawaii:Vol. A, 6-10; Vol. B, 28-57). Although the former distribution and abundance of other grasses bearing the name *pili* in some form (e.g., St. John 1973:23, 35, 43) are not known, none are likely to have dominated all the regions to which the generalized term "*pili*" is applied.

Pili Lands 1

Throughout the early historic period, descriptions of a barren, stoney, and dried landscape overshadow what might have been said about the composition of this withered and scanty plant community (e.g., Ellis 1917:300-302; Bishop 1825; Committee Report 1830; Judd 1903:Vol. 2; Lyons 1833:2152; *Sandwich Islands Gazette* 1836; *The Polynesian* 1840; Lyman 1846:June 13). Observations by Archibald Menzies, naturalist on Vancouver's 1792-1794 voyage, typify these descriptions, as well as substantiate the annual or ephemeral nature of the vegetation, and verify that this community existed before feral ungulates, primarily introduced by Vancouver, had any serious impact:

> I travelled a few miles back from Kawaiahae...through the most barren, scorching country I have ever walked over....The herbs and grasses which the soil produced in the rainy seasons were now mostly in a shrivelled state, thinly scattered and by no means sufficient to cover the surface from the sun's powerful heat [Menzies 1920:156].

Other descriptions of these grasslands record the presence of "very low shrubs, thistles, and dry looking grass" (Committee Report 1830), and a cover of "long grass to the coast" (*Sandwich Islands Gazette* 1836). Many stress the barrenness and lack of greenery to the extreme of suggesting that there was no vegetation.

Included in this lower region but not mapped, for lack of distributional evidence, are plant communities that accompanied scattered settlements along the coast. Resembling the

surrounding slope in most respects, this vegetation type is marked by prominent stands of trees. These stands were probably created intentionally and maintained through some form of propagation, as they are entirely composed of tree species recognized as either Polynesian introductions, economically valuable to the Hawaiian people, or cultivated to some degree. Examples include: the "cocoanut [*Cocos nucifera*] groves" at Kawaihae (Kotzebue 1821:295-296; Lyman 1846:June 13; Bates 1854:380); "cocoanut groves, the *lauhala* [*Pandanus* sp.], the *loulu* [*Pritchardia* sp.] or low palm tree, and the *kou* [*Cordia subcordata*]" (Lyons 1863) at Puakō; *kou* and cocoanut at 'Anaeho'omalu (Land Board:Non-Award 4100); and "a grove of *milo* [*Thespesia populnea*]" at Kalāhuipua'a (Boundary Commission Book for Hawaii:Vol. A, 384). The origins and and uses of these species are frequently discussed (e.g., Neal 1965:51-53, 119-121, 564, 714-715) with the exception of the *loulu* palm. The use of *loulu* included, according to Hillebrand and Rock, the frequent eating of immature seeds, the cultivating of *Pritchardia hillebrandi* on Moloka'i, and the occurrence of *P. affinis* near Hawaiian dwellings (Hillebrand 1981:450; Beccari and Rock 1921:19). Even though *loulu* could have occurred in Puakō before Hawaiian settlement, these statements, and the association of *loulu* with other preferred species, strengthen the probability that it was tended. Land Board claims for 'Anaeho'omalu and Puakō further illustrate that *niu* (cocoanut) and *kou* were considered cultivated and their use controlled by specific individuals (Land Board:LCA 4099; Non-Award 3825, 4100).

Pili Lands 2

The division between an annual and a more perennial grassland relies on accounts of a marked increase in the verdant aspect of the landscape and abundance of vegetation during ascents from Kawaihae to Waimea (Committee Report 1830; Judd 1903:Vol. 2; Lyons 1833:2152; *The Polynesian* 1840, 1847; Lyman 1846:June 13). Coinciding with this change is a pronounced and sharp transition from the hot and dry conditions of the lower region to a colder, trade-wind-influenced climate, often accompanied by rain (Doyle 1945:41; Olmsted 1969:228; *The Polynesian* 1840, 1847). This transition, described as occurring roughly halfway between Kawaihae and the level plains (Judd 1903:Vol. 2; Lyons 1833; Olmsted 1969:228; *The Polynesian* 1840, 1847; Lyman 1846:June 13), so closely corresponds to a similar shift in the present vegetation that the mapped boundary between Zones III and IV (Fig. 16.1) was used to delineate this early historic distinction.

The upper extent of the *pili* lands is documented in the Waikoloa lands testimony (see Report 2, p. 30) and on an 1867 map encompassing the central plains. Consistent with contrasts made between the *pili* and cultivated lands throughout leeward Kohala, the boundary testimonies designate the "Wall of Kauikamoa" as dividing the *pili* that extends south to the district of Kona from the cultivated or fertile lands of the north (Boundary Commission Book for Hawaii: Vol. A, 6, 10). The approximated early historic vegetation boundary thus follows this wall (i.e., marked with dots in Figure 16.3, running east-west near Pu'u Huluhulu) and is extended northwest and east along corresponding relict and present vegetation boundaries. To more accurately represent the distinctions made in the testimonies, this line should follow the lower extent of agricultural surface features or *iwi 'āina*, if such information is ever available.

The upper boundary of the *pili* lands across the plains to the south apparently divides grasslands from an open-canopy forest rather than cultivated lands. The dotted line representing this was adapted from an 1867 map (Survey Office Reg. Map 574) surveyed by Kaelemakule (Fig. 16.4) in which the margin of this forest, characterized by interspersed tree and grass symbols, is clearly portrayed. Even though the non-forested section of the map is not specifically labeled or symbolized by Kaelemakule, references such as "the plains being for the most part covered with long rank grass" (*Sandwich Islands Gazette* 1836), a large area near Pu'u Holoholokū being "covered with dry grass"(Lyman 1846:June 15), and the importance placed on Davis' Waikoloa being *pili* (Boundary Commission Book for Hawaii:Vol. A, 6-10), confirm that these were predominantly grasslands before 1850. This may be part of the "great tract of luxuriant grasslands" in the Waimea plains reported by Vancouver in 1792 (Vancouver 1801:5,107).

Two other features of this community were also deducible. References to the dry aspects of these grasses and the presence of bare ground (*The Polynesian* 1840; Lyman 1846:June 15) imply that, while this community was more perennial than the lower *pili* lands, it is less perennial than the vegetation type described as *Kula* 2. This closely parallels contrasts found between Zones IV/V and Zone VII of the present vegetation. Also, these grasslands probably supported some scattered trees or scrub, as suggested by the 1834 statement that the plains were covered by grass "with but little wood" (*Sandwich Islands Gazette* 1836). The presence of very scattered relict tree species in comparable areas today and in the early 1900s (Rock 1974:54) supports this.

Documented use of the *pili* lands primarily centers around the scattered coastal settlements. Descriptions generally stress contrasts between the small dispersed coastal populations, engaged primarily in fishing, and larger inland populations with their productive plantations (Menzies 1920:156; Ellis 1917:300-302; Doyle 1945:85-86; *Sandwich Islands Gazette* 1836; Olmsted 1969:228; Lyman 1846:June 13). Although Lyons claimed that food was not grown in places such as Puakō (Doyle 1945:85-86), some lowland agriculture is mentioned in boundary testimonies. Cultivation occurred "in the makai portion" of 'Ōuli and in an "old cultivating ground" at roughly 600 ft elevation along Waiulaula Gulch (Boundary Commission Book for Hawaii:Vol. B, 64, 74). Other activities would include the tending of salt works recorded at Puakō and Kawaihae and fishponds at Kawaihae, Puakō, Kalāhuipua'a, and 'Anaeho'omalu (*Sandwich Islands Gazette* 1836; Lyons 1859, 1862; Boundary Commission Book for Hawaii:Vol. A, 6-10; Vol. B, 296-97).

The use of trails and associated activities dominate discussions of what was called the "untended and uncultivated" (*Sandwich Islands Gazette* 1836) expanse of grasslands behind the coastal settlements. According to the 1867 court case dealing with Waikoloa, "wild birds and *pili* grass" were the main source of "revenue" from these *pili* lands before there were "cattle or sheep" (*Hawaiian Gazette* 1867).

Land-use practices capable of substantially altering, if not maintaining, these open grasslands can only be surmised, as no specific reference to such practices was found in this literature search. Although the overall intensity of this land use appears low, the potential long-term impact of any practice is great because plant regrowth can be slow in arid environments and is often dependent on seasonal or periodic rainfall. Widespread fires, similar to

that described by Menzies (1920:32-33) as being intentionally set on Kaua'i to favor fresh grass growth over woody species, would increase the abundance, and ease the collection of thatching and mulching material. Such grassland might also be the preferred habitat of the unidentified "wild birds" that served as revenue, along with *pili* grass. As another example, collection of firewood could reduce the abundance of woody species, although this demand might be lessened by alternative sources such as driftwood and stream-carried debris. The intermittent use of this coast by ranking chiefs (see Report 2, p. 27) would have given a periodic and unpredictable aspect to population sizes, land-use practices, and the resulting effects.

THE *KULA* LANDS

The two vegetation types designated as the *kula* (i.e., *kula* 1 and 2) represent the major inland expanse of agricultural lands. Both communities appear to have been predominantly open grasslands with a distinct but unevenly distributed tree and shrub component that formed the matrix for actively tended plant communities around residential features and in agricultural plots. The entire character and composition of these two vegetation types probably reflects the long-term and active effects of agriculturally related land-use practices.

The term "*kula*" was chosen for three reasons. First, in the Kohala Boundary Commission testimonies *kula* is used in four native testimonies to distinguish, in conjunction with *iwi ʻāina* and specified agricultural fields, the cultivated lands from the *pili* lands (Boundary Commission Book for Hawaii:Vol. A, 129-31; Vol. B, 8-82). Second, three dispersed 1846-1848 Land Board claims that fall within these vegetation types are specified as occurring within the *kula* (Land Board:LCA 976:2, 4195; Non-Award 4191). Third, the Reverend Lorenzo Lyons described an 1832 excursion through "*ke kula*," four or five miles from the mission station through cultivated lands (Doyle 1945:63-64).

According to this usage, *kula* could be defined as a predominantly open vegetation type used for cultivation. In general, this corresponds with numerous recorded definitions that include elements of an open landscape (e.g., "a field" or "pasture"), an inland location (e.g., "open country back from the sea") and a place of human activity (e.g., "where people live" and a "field for cultivation") (Andrews and Parker 1922:332; Pukui and Elbert 1971:164). The occurrence of an extensive *ʻauwai* system in the Waimea *kula* may partly contradict the 1884 legal definition of lands not in wet taro cultivation (Pukui and Elbert 1971:164). That *kula* can be applied to both grass and scrub lands is implied by Kamakau's use of *kula pili* to describe a Waimea battle field and an 1848 Waimea lease application for land in "*kekahi kula nahelehele*" (i.e., a certain kind of scrub) (Kamakau 1961:55-61; Interior Dept. 1848).

Forming the boundaries for this agricultural expanse were the *pili* lands along the seaward extent as previously described and, inland, a pronounced band of vegetation communities characterized as "wooded" or "forested." The line dividing the *kula* and forested lands (i.e., *kula* 2 and the *ʻōhiʻa* rainforest) lies north of all located descriptions of cultivated lands and reflects Menzies' 1793 observation, from a distance, of "fine plantations in the verge of the woods" and references to agricultural activities commencing below the "woods" along the southern

flank of Kohala Mountain (Menzies 1920:156; Baldwin 1832; *Sandwich Islands Gazette* 1836; Bates 1854:358). This boundary begins at the northern edge of Waiaua, said to border the "*kuahiwi*" (i.e., forest) (Land Board:LCA 589), and follows relict and present vegetation patterns. The eastern boundary (i.e., between *kula* 2 and the *ululā'au*) marks a transition to lands also containing scattered settlements and agricultural plots but apparently supporting substantial tree growth. An arbitrary line representing an indistinct division between the mixed open forest and the *kula* lies beyond the southernmost plotted agricultural Land Board claims.

The division within these agricultural lands (i.e., between *kula* 1 and 2) reflects the second pronounced increase in the verdant aspect of the landscape described between Kawaihae and the most inland Waimea settlements. Characterizing the general vegetation of the upper *kula* lands, the descriptions imply an increase in percentage of ground covered by grasses, as well as the presence of scattered shrubs and low stature trees. Indicative descriptions such as "grasses in considerable quantities," "large bushes and even small trees," "trees of various kinds...scattered here and there," and "bushes" were generally placed where the plains or level lands begin (Committee Report 1830; Lyman 1846:June 13; *Sandwich Islands Gazette* 1836). As the most specific reference locates this transition at "Kealii" (Committee Report 1830), the boundary begins at this point and is extended along corresponding relict and present vegetation patterns.

The general appearance of the lower *kula* must be surmised, as no reference specifically characterizes these lands. If analogous to the intermediate or transitional characteristics of the roughly comparable present vegetation zone (Zone VI), then the lower *kula* would contain characteristics of both the upper *pili* and upper *kula* lands. A resemblance to the upper *pili* plant communities is supported by the absence of accounts describing a variation in the vegetation that coincides with native distinctions between the "fertile" and *pili* lands, while numerous references stressing the gradual increase, with increasing elevation, in the verdant and complex nature of the vegetation would imply a growing, although not marked, resemblance to the upper *kula*.

The two accounts that are attributable to these agricultural lands (i.e., 3 to 5 miles below or from "Waimea"), mention the historically introduced cactus (i.e., "prickly pear") and the annual herb "*pualele*," giving the impression of drier moisture conditions and an open vegetation type underlain by "extremely rocky" ground, particularly when contrasted with the deep "light soil higher on the plains" (Doyle 1945:63-64; *The Polynesian* 1847). Most crop species noted were historic introductions (e.g., watermelon, pole beans, corn, pumpkins, onions, potatoes) with the exception of *wauke* (*Broussonetia papyrifera*), a Polynesian introduced shrub ("6 or 7 feet tall, 1 in. diam.") from which barkcloth is made.

The transitional aspect of this zone probably reflects its location at the fluctuating interface between the leeward sea breezes and the tradewinds. In terms of moisture, this zone receives the benefits of rain or mist when the trades are strong and, under the prevailing conditions, it is shaded by the sea-breeze-derived convection cloud banks that form along this interface (Leopold 1949). These clouds not only reduce evaporation but occasionally bring brief showers. In present vegetation Zone V, the pronounced aeolian streaking evident on aerial

photographs, which is only slightly apparent in the section of Zone VI that coincides with the lower *kula* lands, may indicate that the wind velocity increases towards the center of the plains. If so, distributional variations in the wind's intensity may have been a significant variable in delineating the "fertile" productive agricultural lands and the *pili*.

Most descriptions of these settlement and agricultural areas were too general to ascribe specific contrasting characteristics to the upper or lower *kula* lands or, to some degree, the *ululā'au*. Overall the most common element of these accounts is patchiness. The "villages," "cottages," and "inhabitants" appeared "scattered" "here and there" (*The Polynesian* 1840, 1848: Jan. 29; Judd 1903:Vol. 2; *Sandwich Islands Gazette* 1836; Committee Report 1830; Olmsted 1969: 230; Kenway 1848; Bingham 1969:374). The vegetation and agricultural features included: "alternate plots of shrubbery, grass, *kalo*, sugar cane, bananas, flowering bushes, and wild vines"; hillsides "partly cultivated and partly covered with grass of spontaneous growth"; interspersed "plantations"; "numerous acres of cleared upland ground"; "some fields of upland taro"; "the green taro patches on the plains and hillsides"; "hedges"; and "broken squares of trees" (Ibid.).

Ideally, to address the nature of this general vegetation type, plant associations found in actively tended plots and around residential features (e.g., crop species, weed species, ritual plants, border plants, ornamentals, etc.) should be described along with those agricultural or subsistence practices (e.g., length of fallow, secondary crops, mulching, weeding, pig husbandry, etc.) that directly or indirectly influence the composition and structure of surrounding vegetation communities. Although the detail available in the early historic documents does not even approach this ideal, the following section summarizes some agricultural features and practices that can be documented for the *kula* lands and which probably apply to the *ululā'au* as well.

As depicted, the *kula* lands roughly bracket all specifically or generally located agricultural features documented in the Land Records (i.e., the Land Board Records and the Boundary Commission Testimonies). Features such as "cultivating grounds," *kō'ele* (i.e., "small land unit farmed by a tenant for the chief"), *'auwai*, *kuaīwi*, *iwi 'āina*, ditches, *kīhāpai*, and *mala*, in addition to several residential features, are documented as occurring within this band between and including the lands of Kawaihae 1 and Waiaua, with the exception of Panoluukia and Kapia (Boundary Commission Book for Hawaii : Vol. B, 64-74, 147-149, 390; Vol. D, 599-613; Land Board LCA 8513, 4129, 969, 3828, 3903, 4152, 4195, 4123, Non-Awards 3844, 3915, 4195). This exception is obviously an omission in the historic record because structural remains indicative of agricultural and residential use were noted during the field survey. *'Auwai* (i.e., ditches) are recorded as the boundaries on land claims or between *ahupua'a* as high as 4,000 ft elevation in Kawaihae 1 and between 3,200 and 2,800 ft in Pauahi, suggesting that the extensive *'auwai* system found on portions of the plains occurred to some degree across the slopes (Boundary Commission Book for Hawaii:Vol. B, 390, 599-613; Land Board:LCA 4513, 590B). The more general historic accounts note the dominance of taro, particularly on Kohala's southern flank, a full range of Hawaiian crop species (i.e., taro, sugar cane, sweet potatoes, plantains, arrowroot, etc.) and numerous historically introduced crops (Irish potatoes, onions, corn, etc.) plus "plantations,"

"fields," "patches," "ditches," "water runs now dried up," and "banks of water courses" (Ellis 1917:265-266; Bishop 1825; Committee Report 1830; Judd 1903:Vol. 2; Baldwin 1832; Menzies 1920: 156; *Sandwich Islands Gazette* 1836; *The Polynesian* 1848:Jan. 29; Kenway 1848; Lyons 1862; Bingham 1969:374). Together this information is not sufficient to discuss patterns within the *kula* lands and variations in the intensity of this land use, although one pattern may be noted. In two cases a claimant received large plots of agricultural lands upslope from his residential claim (see Fig. 16.4), suggesting the presence of distant plots where one might need additional shelter (Land Board:LCA 4513, 590B). On the other hand, claimants also describe planted lands within or near their residential compounds (e.g., Land Board:LCA 4199, 4152).

The need to let agricultural lands lie fallow probably accentuated the patchy nature of this plant community by creating a mosaic of fields in varying stages of secondary growth. Accounts such as "alternate plots of shrubbery, grass, ...wild vines," and "partly covered with grass of spontaneous growth" may describe these secondary growth communities (Bingham 1969:374). Curtis Lyons' generalization that "In dry or *kula* lands...soil has to remain fallow for years between crops" (Lyons 1875:1(5), 135) is reflected in the Land Board claim for *aina mahi ua pahulu* (i.e., cultivating land, exhausted or worn-out soil) in the *kula* lands of Mamoualoa (Land Board:LCA 3903). In a broader sense, the periodic expansion of, or increase in, demands placed on agricultural production by the movements of chiefs or the temporary pooling of a labor force (see Report 2) may be viewed as an overall part of this fallow system. Rather than solely indicating a decrease in population, these forms of fallow probably explain the numerous references to unused lands bearing the "marks" of former cultivation (Baldwin 1832; *Sandwich Islands Gazette* 1836).

While statements such as "numerous acres of cleared upland ground" (*Sandwich Islands Gazette* 1836) indicate the clearing of vegetation, only two references actually mention these practices. In one case, "exuberant vegetation" was burnt before planting (Ibid.), and in another, Lyons aptly compared the use of fire with a tool in describing the burning by a "native" of only the base of a single tree in order to remove it: "The tree is set afire in such a way so as to burn only at the bottom....after awhile the man goes to see whether it has fallen or not" (Doyle 1945:72-73). Although not giving an idea of the extent, frequency, or intensity of fires, which are generally recognized as one of man's most effective means of intentionally or accidentally altering vegetation communities, these references do illustrate the use of fire in clearing agricultural plots in this region and the knowledge and skill with which fire could be used by Hawaiians. While surveying in Hāmākua in 1852, Curtis Lyons described the spread of "a fire which had been kindled by an old man for burning off land....After working most desperately for four hours beating it with tea [ti] bushes, we put it out with the help of some reinforcements" (Lyons 1852:April 17). This may suggest that most fires in agricultural lands were controlled in some manner.

Although Handy recognized the presence and detrimental effects of insects on Hawaiian crops (Handy 1940:149), no study addresses their influence on planting practices. The following statements made between 1832 and 1848 in Waimea illustrate this problem: "The principal of these [problems] are the difficulty of raising food here for one half the year, owing to worms which destroy it"; famine arises "from the ravages of a worm that abounds in Waimea....as soon

as food begins to sprout the worm commences the work of destruction"; "The first [drawback] arises from swarms of grubs that infest the district; they begin to make their appearance early in March and continue until the end of July"; and "the whole district is infested at a certain season of the year with a kind of caterpillar which destroys everything of this sort, even potatoes frequently" (Baldwin 1832; Lyons 1837; *The Polynesian* 1847, 1848:Aug. 26). After an attempt to correlate these caterpillars, grubs, and/or worms with descriptions of native and historically introduced insects (Zimmerman 1958:197-336), those associated with *kōlea*, the American Golden Plover [*Pluvialis dominica fulva*] (Wilson 1899:162; Perkins 1903:450), and various Hawaiian terms for insects (Pukui and Elbert 1971:24, 39, 234-235, 297, 311), it remains unclear whether or not this phenomenon occurred prehistorically or originated during the historic period. The fact that at least ten native caterpillar species could have frequented the grassy plains of Waimea (Dr. Frank Howarth, pers. comm.) justifies considering their role in the development of agricultural practices and associated plant communities. The above statements and those in an 1865 Hawaiian newspaper article discussing the problem of "*peelua*" (caterpillars, army worms, etc.) (*Kuokoa* 1865:June 8) suggest that their influence had at least four major facets. First, their population flushes helped determine when during the year crops should be planted, as damage appeared heaviest on young sprouting plants. Second, fluctuations in their abundance and the subsequent impact varied not only seasonally but between years, causing a scarcity of food and an increased dependence on supplemental or famine foods. Third, their presence could cause an increase in labor needed during initial planting phases, as the *Kuokoa* article suggested that to minimize crop loss the planter should plant plenty, "some for you and some for the *peelua*" ("*nou kekahi, a no na peelua kekahi*") (Ibid.). Finally, as pointed out in the Hawaiian article and in the feeding habits of numerous related insects (Zimmerman 1958:197-336), such pests can make barren (*neoneo*) both planted areas and scrub (*nāhelehele*) or grasslands. As such, these insects could be a significant factor in determining the overall composition of various plant communities and possibly favor, or maintain, the presence of open grass or scrub lands in certain areas.

THE *ULULĀ'AU*

The vegetation community delineated as the *ululā'au* encompassed a patchwork of scattered agricultural and residential features interspersed with numerous trees, probably forming an open, *'ōhi'a*-dominated canopy, and a luxuriant, structurally diverse understorey. Classified as an intermediate moisture regime, this plant community was distinctly wetter than the moist agricultural lands, yet more open and compositionally distinct from the neighboring rainforest. Variations in the type, duration, and/or intensity of land-use practices probably obscured any clear affinities between all or part of this vegetation type and neighboring plant communities.

This general characterization, drawn mainly from an 1830 account, combines descriptions of the third and fourth transition in the progressively wetter and more complex aspect of the vegetation along the major route from Kawaihae inland. Both transitions are described as corresponding to, and indicating a shift to, wetter, trade-wind-dominated climatic conditions that included greater rainfall, a prevalence of fog and mist, and longer periods of cloud cover. After passing through the relatively open *kula*, the plant community at the "settlement"

of Waikoloa (i.e., the location given for the third transition, 2 miles east of Kea'ali'i) was described as containing "vegetation of all kinds indigenous to the island...in abundance and always green," "grass high and tall," "shrubbery," and "trees" (20 to 50 ft tall) that "nearly" surround the mission establishment (Committee Report 1830; Judd 1903:Vol. 2; *Sandwich Islands Gazette* 1836). At the next major "settlement," Pu'ukapu (i.e., the location given for the fourth transition, 4 miles east of Kea'ali'i), the trees were "much larger" (i.e., "10 to 20 or 25 ft. in diam.," "20 to 50 or 60" ft tall) and "the smaller species of vegetation such as grass, weeds, bushes etc. are tall, thick, and tangled" (Committee Report 1830; *Sandwich Islands Gazette* 1836).

Coinciding with these descriptions and indicating the prominence of a tree component, was the use of "*ululaau*" and "Alaohia" in the Land Board records for Waikoloa Nui, Pu'ukapu, and adjacent lands. In describing the location of their garden plots, seven claimants placed them within the *ululā'au* (e.g., "2 *mala kalo maloko o ka ululaau oia aina*"). Of these, two could not be located and five were plotted or estimated to occur (Land Board:LCA 4231, 4513:2; Non-Awards 3984, 4505, 4193) within the vegetation type. *Ululā'au*, literally meaning "to grow" (*ulu*) and "tree" (*lā'au*), has been translated as "thicket of trees," "grove of trees," "a wood," and "forest," and was, therefore, chosen to designate the entire community (Andrews and Parker 1922:600; Pukui and Elbert 1971:342). In a similar manner, the general place name Alaohia was was given 19 times as the location for various claims, 14 of which we were able to plot (Fig. 16.4) (Land Board:LCA 3674, 3738, 3785, 4024, 4505, 988, 3682, 3733:2, 4026, 4231; Non-Awards 3844, 4193, 4233, 3828-B, 4126, 4184). Alaohia may mean the "way" or "path" (*ala*) of *'ōhi'a* and may refer to the western perimeter of the wooded lands, where *'ōhi'a* growth became dominant. Supporting this interpretation is the plausible correspondence of relict Zones 1 - 3 with this vegetation type. Not only is *'ōhi'a* a dominant or co-dominant in these zones, but it is also currently the dominant relict species in ravines dissecting the lands delineated as the *ululā'au*. In reminiscing, Albert Lyons (1841 to 1926), son of the Reverend Lorenzo Lyons, spoke of the mission premises at Alaohia, the forest "largely of ohia lehua," which covered the plateau, and translated Alaohia as "fragrance of ohia" (Doyle 1945:45). While this supports the prominence of *'ōhi'a* as covering an undefined portion of the "plateau," his translation is questionable, as *'ōhi'a* is not noted for fragrance (i.e., *'ala*).

The western boundary of the *ululā'au* thus follows the western extent of claims specified as occurring in either the *ululā'au* or Alaohia. The remaining borders arbitrarily enclose all located claims and descriptions of residential or agricultural use, with the exception of a point along the northern perimeter that marks beginning "at the woods" (Boundary Commission Book for Hawaii: Vol. A, 10; Survey Office Reg. Map 574). Most distinctions--such as the "dense forest is contiguous" with Pu'ukapu, the "last village in the district"--were too general to plot (Bishop 1828; Ellis 1917:300-302; *Sandwich Islands Gazette* 1836).

As previously stated with regard to the *kula*, most early historic descriptions of settlement and agricultural practices were too general to assign specific characteristics to either the *ululā'au* or the *kula*. This lack of distinction may imply that land-use practices did, in general, appear similar or uniform, particularly when differences in the vegetation and weather were noted. General characteristics that were probably shared with the upper *kula*

include the scattered distribution of residential complexes, the patchwork of agricultural plots in varying stages of planting and regrowth, the full range of crop species, and the "well watered" fields that may imply irrigation of at least part of this vegetation type. As indicated in the Land Board records, *kalo* was the dominant crop, although *'uala* and *kō* were common. An exception is the greater prominence of plots planted in *mai'a* (Land Board:LCA 4212:1, 4214:1, 4227:1, 4513:2, 4218:2, 3733:2, 3672:1, 4183:1, 4210-B, 3675:1, 3685:1, 3733:1, 3842:1, 3923:1, 4130:1, 4132:1; NA 3684, 3762, 4233, 3984, 4150, 4193).

Although these Land Board records are an incomplete and relatively late representation of early historic agricultural patterns, two possibly distinctive features are apparent in these testimonies, claims, and awards. One feature is the extremely scattered distribution of numerous garden plots or fields, mostly in Pu'ukapu. At least 15 individuals each claim to cultivate a variety of crop species in two to ten (an average of five per claimant) very scattered (e.g., *kāwalawala-loa*) garden plots (i.e., *kīhāpai* and *māla*) (Land Board:LCA 3672, 3675:1, 3685:1, 3733:1, 3823:1, 4130:1, 4132:1, 4183:1, 4210-B, 4210:1, 4212:1, 4214:1, 4218:1, 4227:1; Non-Award 3984). Although some scattered plots adjoin those of other landholders, many are isolated, being surrounded by "*konohiki*" land (i.e., general lands, controlled by the *konohiki* or overseer, that form the matrix for individually or family-held lands) (e.g., Land Board:LCA 4183, 4227, 4230).

This scattered pattern could represent a form of shifting cultivation adapted to the wetter conditions of the *ululā'au* and explain the prominence of "grass" and "weeds" in the described understorey. A prominence of grass and weeds can indicate secondary growth associations or disturbance, especially when contrasted with the more structurally complex, fern-dominated undergrowth often found in relatively undisturbed moist and wet forests. In one example of this pattern, a claimant stated that he cultivated "here and there" in Pu'ukapu after abandoning the six *kīhāpai* (garden plots) inherited from his parents, because the inherited plots were overgrown with "*honohono*" (Land Board: Non-Award 4150). If this "*honohono*" refers either to the historically introduced *Commelina diffusa* or to *Oplismenus hirtellus*, which currently bear this name, then the described phenomenon may be a recent response to a historically introduced problem. On the other hand, the presence of *honohono*, whether applied to native or historically introduced weed species, may have been indicative of the abandonment phase rather than a cause for abandonment.

The second distinctive feature concerns five claims to garden plots of *māmaki* (*Pipturus* sp.), a fibrous plant from which *kapa* (barkcloth) was made (Land Board:LCA 3842:1, 4210-B, 4231; Non-Awards 4193, 4233; Kamakau 1976:115). Generally considered indigenous, no major botanical studies treat this plant as a cultigen, particularly when compared with *wauke* (*Broussonetia papyrifera*), which is listed as a Polynesian introduction, a crop species, and more prominent source of barkcloth (St. John 1973:140, 144; Neal 1965:318, 301-302). The general abundance and importance of *māmaki* in Waimea is further established by the 1834 statement that the "sides of hills [abound] in that plant so valuable to the natives, the *mamaki*" (*Sandwich Islands Gazette* 1836) and by references to *kapa* as a common tax and export item (Doyle 1945:64; Lyons 1862). As discussed in the rainforest section (see below), where *māmaki* is also a prominent resource, no references were found describing the manner or degree to which this plant was actively cultivated, tended, or encouraged. In present vegetation communities,

māmaki often colonizes open or disturbed areas in moist or wet regions (e.g., beneath canopy openings caused by tree falls, along stream banks or road cuts), suggesting that the *māmaki* claimed in the Land Board records could have been secondary growth or crop stands in plots previously planted in other crops.

Despite the abundance of trees in the *ululā'au*, neither historic accounts nor land records mention tree species considered to be Polynesian introductions or of economic value similar to those recorded in the arboricultural associations in the coastal settlements or in the Hāmākua settlement and agricultural lands. If this absence or lack of prominence is not just an omission in the historic record, it may indicate that Waimea's climatic and edaphic conditions, particularly the wet, cool temperatures and strong winds, were not conducive to the development of a substantial arboricultural component. Of those economically important tree species commonly found elsewhere, only small isolated populations of *hau* and *kukui* were recorded as relict species during this survey (see Table 16.3). The location of both in sheltered gulches may support the above suggestion.

THE MOIST FOREST TYPES

The southern vegetation communities classified as moist moisture regimes have been divided into four forest types: mixed open canopy, open *māmane/koa*, tall stature *koa*, and open *māmane*. While the general unifying character of these forest types and their distinction from bordering plant communities is primarily based on early historic descriptions, the distinction among the four forest types is drawn from the current distribution and dominance of relict tree species and that which was documented in the late 19th and early 20th centuries.

All four forest types shared the general characteristics of having an open canopy and the appearance of a wooded parkland, particularly when contrasted with the grassy plains to the west and the dense "impenetrable" rainforest to the east. Statements typifying these characteristics, generally made while enroute from the Waimea settlements, through Parker's ranch house at Mana, and along Mauna Kea's eastern slope, include: "a scanty forest" (*The Polynesian* 1840); "those parts of the plain adjoining Hamakua are better wooded having a parklike appearance" (*Sandwich Islands Gazette* 1836); "well shaded by clumps of trees" (*The Polynesian* 1847); and is "thickly wooded with large trees, entirely free from underbrush, and is covered with a greensward, giving it the appearance of a parkland" (*The Polynesian* 1848:Jan. 29).

As a whole, the western boundary of these forests follows the forest margin shown in Kaelemakule's 1867 map (Survey Office, State of Hawaii, Reg. Map 574). His depiction of these forests with interspersed tree and grass symbols further substantiates their open nature. The northeastern boundary bordering the wet dense forest is derived: first, from the present boundary between wet and moist pasture communities (Fig. 16.1); second, from four plottable points of nine references to an "upper edge of the woods," "outside the woods," or "above the woods" (Boundary Commission Book for Hawaii:Vol. A, 3-4, 110-112, 119-121; Vol. B, 96-97, 105-106, 441-448); and third, from patterns presently evident in the distribution of relict wet *'ōhi'a/koa* and moist *koa/māmane* associations (Jacobi et al., Ms.: 'Umikoa and Keanakolu Quads.).

The combined notes of several prominent naturalists who visited the region between 1888 and 1910, the first to document the general distribution of specifically named tree species,

imply that *māmane* was the most prominent component of this forest stretch. These generalized comments speak of the *māmane* woods "that abound in that district" (Wilson 1890:184), are found "near Mana" (Ibid.:191) or "in the Waimea district" (Perkins 1903:427), and that form a "belt of forest" (Rock 1919:29; 1974:23, 25) above the wet forest and before the grassy plains. The westernmost community type was designated a mixed open forest because both Rock and Henshaw noted the presence of *olopua* or *pua* (*Osmanthus sandwicensis*) and *naio* (*Myoporum sandwicense*) with the *māmane* on the plains below 3,500 ft elevation (Rock 1974:23; Henshaw 1904:57; Pilsbry and Cooke 1912-1914:96-97). This sufficiently resembles the relict communities defined as Zones 3 and 4 (Fig. 16.2; see Table 16.3) in which *olopua* and *māmane* are prominent, although no one species dominates and the association thus has a "mixed" character. This distinction made by Rock between a lower *māmane/koa* association and an upper *māmane*-dominated forest belt (Rock 1974:25), a pattern still traceable (Jacobi et al., Ms.: 'Umikoa and Makahalau Quads.), provides the foundation for defining the open *māmane/koa* and open *māmane* forests. The straight northwestern boundary of the *māmane/koa* association roughly coincides with the western extent of low-stature *koa*, as noted during a brief field reconnaissance.

Early historic accounts and the present distribution of relict communities both substantiate the occurrence of a taller-stature, and possibly more closed, *koa*-dominated forest to the east of these lower-stature *māmane* associations. "Sawyers" established "sawpits" within the margin of this forest, which provided the closest source of sizeable and suitable *koa* timber for both the Waimea settlements and export (French 1844; *The Polynesian* 1848:Feb. 5, Aug. 26; 1847:Nov. 13; Bates 1854:368, 369). These early accounts place these establishments about 12 to 15 miles east of Parker's homestead, or at Hanaipoe. The proposed boundary of this community roughly follows the mapped distinction made by Jacobi between tall-stature (i.e., >10 meters tall), *koa*-dominated associations and low-stature (i.e., < 10 meters tall), *māmane/koa* associations in the present vegetation (Jacobi et al., Ms.: 'Umikoa Quad.).

Land-use practices known to have originated during the historic period--primarily sandalwood collecting and the exploitation of cattle herds--tend to overshadow discussions of established, and possibly prehistoric, Hawaiian practices. The earliest references emphasizing that settlement and agricultural activities occurred in the northern well-watered portions of the plains (Committee Report 1830; *Sandwich Islands Gazette* 1836), suggest that these southern communities were not intensely used. Assuming that the *kula* lands and these open forest types do represent generally comparable moisture regimes and broadly similar potential plant communities, the contrast between them may illustrate the long-term results of differing land-use types and intensity.

Although little is presently understood about Hawaiian pig-husbandry practices and the extent or use of feral populations, references to "many wild boars" in the parklands bordering Hāmākua (*Sandwich Islands Gazette* 1836) and to the "great many wild hogs" on Mauna Kea (Doyle 1945:168) at least establish the presence of feral populations during this period. Native testimony in 1848 claims that the wild pigs in the forest from Waimea to Hilo (presumably the Hilo District) belonged to Pu'ukapu since the time of the claimant's father (Land Board:NR, Vol. 8:44), indicating that feral populations could have been an older utilized resource. Although not specifically documented, use of other resources described for the rainforest

(e.g., bird-catching, collection of famine foods, etc.) may have occurred to some extent within these communities as well.

Various references establish the importance of sandalwood, the most famous of early historic export commodities, in the Waimea region (Ellis 1917:298-299; *The Polynesian* 1847; Wilkes 1845:217), while remarks such as, these "woods frequented by sandalwood cutters" (Judd 1903:Vol. 2; Boundary Commission Book for Hawaii:Vol. B, 28-59) roughly place the collection of this resource within these forest types. Presently, sandalwood is a prominent component of relict associations in comparable moist environments sampled (i.e., Zones 4 and 5; Fig. 16.2 and Table 16.3). If this were true of early historic communities, and a majority of this moist band to the northwest was opened for agricultural use, then these less intensely used moist forests, particularly the mixed open and open *māmane/koa* associations, would probably contain the greatest abundance of exploitable sandalwood.

The spread of cattle and their subsequent use throughout the southern plains and forests has been the subject of numerous historic studies about the ranches of Hawai'i. To what extent cattle-grazing or, to a lesser degree, sandalwood-collecting may have caused or accentuated the open or parkland appearance of these plant communities is difficult to tell. Not only was the number of cattle the highest in these areas (Ellis 1917:300-302; Committee Report 1830; Judd 1903:Vol. 2; *Sandwich Islands Gazette* 1836), but their presence as a potentially altering factor, particularly of the understorey, was well established before the earliest overland accounts. Accidental or intentional fires during both the historic and prehistoric periods could also reinforce, if not induce, this open aspect, particularly in areas adjacent to settlement and agricultural lands, or in the more susceptible, drier moisture regimes. A clause in the 1840 Hawaiian Constitution prohibiting the lighting of fires in the mountain regions (Constitution of Hawaii 1840), may suggest that fires could easily have occurred in these areas. The frequency and cumulative disturbance of these fires would be decreased if they were in disfavor.

THE RAINFORESTS

A distinct and uniform tract of rainforest divided the windward Hāmākua settlements and agricultural lands from those of Kohala. Most frequently, this forest is portrayed as "dense" or "impassable," interspersed with swampy lands, composed of "luxuriant" and "abundant" vegetation of all kinds, and crossed only by "treacherous" and "muddy" trails (Bishop 1825, 1828; Committee Report 1830; *Sandwich Islands Gazette* 1836; *The Polynesian* 1840; Lyman 1846:June 16; Judd 1903:Vol. 2; Boundary Commission Book for Hawaii: Vol. B, 73-74, 390-395). These descriptions were primarily made along trails crossing from Pu'ukapu to Kapulena or through Pā'auhau; after three to four hours of travel, these trails emerge onto "open" country 3 to 5 miles inland from the windward coast (Bishop 1825; Lyman 1846:June 16; *The Polynesian* 1848:Feb. 5).

The full range of common rainforest species and structural components described (e.g., "*hapu'u*," "vines," "large trees of various kinds," "mostly *ohi'a*") sufficiently resembles the extant *'ōhi'a* rainforest found along the crest of the Kohala Mountains (i.e., Zone 1, Figure 16.2 and Table 16.3, or Zone IX, Figure 16.1 and Table 16.1), or the *'ōhi'a/koa* rainforest in the Hilo District, to argue that these forest types once merged and formed a continuous band.

Reflecting this presence of *Acacia koa* on Mauna Kea and its absence on Kohala, these rainforests were divided into two types, the *'ōhi'a* rainforest and the *'ohi'a/koa* rainforest. The northern boundary of Kalōpā *ahupua'a* roughly divides these two types because (1) Kalōpā gulch is currently the northernmost extent of *Acacia koa* in the lower forests (Quentin Tomich, pers. comm.); (2) this boundary coincides well with the distinction made between tall-stature *koa* and low-stature *māmane/koa* moist-forest types; and (3) Kalōpā *ahupua'a* is the northernmost land division of the Hilo and Hāmākua Districts, for which native boundary testimonies mention canoe-making (Boundary Commission Book for Hawaii:Vol. A, 110-112). Consistently and frequently, Hawaiians giving testimony, mostly in 1873, between Pi'ihonua (in the vicinity of Hilo Bay) and Kalōpā claim that they either were descended from or were themselves "canoe makers." They also name localities in the lower forests where these and associated activities occurred (Ibid.:Vols. A and B, Districts of Hilo and Hāmākua).

The distribution and use of forest resources north of Kalōpā are most clearly portrayed in the Hāmākua and Kohala boundary testimonies. Of all the resources that could be, or were, obtained in these forests, the most frequently mentioned are birds, fiber plants, and famine or supplemental food. Although few of the resources themselves appear to have had a limited distribution, their use tended to be clustered or localized in specific areas and linked by major or subsidiary trails. As indicated by roughly plottable localities or ranges given in the boundary testimonies, these activities occurred in scattered locales throughout the broad band defined as rainforest.

Birds documented as being sought in these forests were *'ō'ō* (Boundary Commission Book for Hawaii:Vol. A, 171-174), *mamo* (Ibid.:Vol. A, 171-174; Vol. B:64-67; Land Board:LCA 3686; NR, Vol. 8, 44), *'ua'u* (Boundary Commission Book for Hawaii:Vol. B, 147-149, 279-280) and unidentified seabirds (Ibid.:Vol. B, 119-121). The *ō'ō* (*Moho nobilis*) and *mamo* (*Drepanis pacifica*), both forest birds, provided feathers for the prominent yellow patterns in Hawaiian featherwork crafts, while the seabirds, including *'ua'u* were collected as a form of taxation by ranking chiefs (Lyons 1875:111). According to these testimonies, at least some bird "catchers" resided in the forest for one to two months at named established locations (Ibid.:Vol. A, 94-98; Vol. B: 13-74, 147-149, 279-280, 390-395).

The two important fiber plants "collected" or "gone after" were *māmaki* and *olonā* (Boundary Commission Book for Hawaii: Vol. A, 59-60, 71-75, 91-93, 94-98, 99-103, 110-112, 171-174; Vol. B, 77-79, 96-97, 144-145, 441-448), the latter primarily supplying fiber for strong cordage (e.g., "gather bark to make fishnets") (Ibid.:Vol. A, 19-21; Kamakau 1976:44-45). Terms such as "*olona* grounds" and "*mamaki* patch" further substantiate the repeated use of established areas, as well as possibly suggesting some form of cultivation. As both plant species are considered endemic or indigenous to the Hawaiian flora (St. John 1973:144) and occur as natural components of predominantly native plant communities, the degree to which these plant populations were culturally manipulated and/or simply exploited is difficult to determine from these sources. Such manipulation, if it did occur, could range from activities generally associated with cultivated crops (e.g., selection of parent stock, preparation of planting soil, active tending such as weeding or trimming, etc.) to the simple encouragement of these favored plant

species over other species within the plant community. The use of "collected" or "gone after" may imply, however, that overall a more casual approach was taken toward these plant resources.

Early accounts of the Waimea people preferring "to trust almost entirely to the natural production of the hills" (*Sandwich Islands Gazette* 1836) or resorting "to the use of roots such as grow wild in the woods and mountains" (Lyons 1837), point to the importance of the forested region as a food source during times of famine or when food was scarce. Plants named as being sought include those considered Polynesian introductions and crops such as *mai'a*, *kī*, and taro, as well as endemic ferns such as *'ama'u* and *hāpu'u* (*Sandwich Islands Gazette* 1836; Lyons 1837, 1848). The presence of large *mai'a* groves or patches and, to a lesser extent, taro planted in swampy areas along land boundaries within the forested region (Boundary Commission Book for Hawaii:Vol. A, 3-4, 43-45, 99-103; Vol. B, 60-63), reinforces the emphasis on localized areas and resembles the potential semi-cultivated state of the fiber plants. Such edible plants could also have been used by people temporarily residing in or passing through the forests. The wooded or forested ravines that dissect the *kula* and *ululā'au* were probably used in a similar manner, as many contain both relict crop species and edible ferns (Table 16.3).

The overall disturbance created by these practices probably was minimal, affecting mainly scattered and/or clustered, localized areas. Collection of edible ferns could have caused widespread disturbances, as many are widely and uniformly distributed members of predominantly native plant communitites. If, however, this need for supplemental food were infrequent or sporadic, the chances of long-term cumulative alteration of the forest would have been lessened.

WET, UNFORESTED AGRICULTURAL LANDS

A broad band of unforested agricultural land stretched along the entire windward coast from Waipi'o Valley to Hilo Bay and abruptly formed the northern extent of these rainforests. Between 1793 and 1850, numerous offshore and overland observations consistently describe this band as an open, unwooded expanse extending inland from the predominantly cliff-faced shoreline to a distinct forest edge. These gently sloping lands, covered primarily with thick grass of various kinds, ferns (e.g., *'ama'u*), and some woody species (e.g., *Rhus sandwicensis*), were broken by numerous thickly wooded stream-cut ravines, groves of trees, dispersed garden plots, and scattered habitations (Menzies 1920:51; Ellis 1917:251-253, 258, 261-264; Lyman 1846: June 16; *The Polynesian* 1848:Feb. 5; Goodrich 1826:4; Pickering 1840-41:6, 8, 147-148, 169, 176, 177, 202; Douglas 1834:333; Macrae 1922:46, 48-50, 57; Bloxam 1925:51; Brackenridge 1840-41:23, 29-31, 231; Wilkes 1845:114-116; Douglas 1914:298, 304; Stewart 1970:361.

As with the Waimea *kula* lands, these vegetation communities probably resulted from the long-term cumulative effects of agricultural and subsistence practices (McEldowney 1976:18-25). Goodrich, in 1826, and others lamented that only 1/20th of the potential ground within this "zone of cultivation" was being actively cultivated (Goodrich 1826:4). This statement, combined with other factors such as the low fertility of the underlying weathered ash soils (McCall 1975:10), suggests that much of this uncultivated land was lying in some form of fallow. Several prominent features of these plant communities further imply that plant species beneficial to the subsistence economy of the Hawaiian people were somehow being actively

encouraged, emphasizing the overall aspect of a created and maintained vegetation community. As with the arboricultural associations reported in the coastal settlements near Kawaihae, the thickly wooded ravines and scattered groves were dominated by tree species of known economic value (e.g., *hala*, *kukui*, *'ōhi'a 'ai* or *Eugenia malaccensis*, *'ulu* or *Artocarpus altilis*). Also, several major components of the probable secondary growth community (e.g., *'ama'u*, *pia* [*Tacca leontopetaloides*], and Convolvulaceae spp.) are noted famine or supplemental foods and were also eaten by, or fed to, pigs.

Throughout the districts of Hilo and Hāmākua, the "edge of the woods" or "the edge of the forest" serves as a major landmark in native testimonies describing *ahupua'a* boundaries extending inland from the coast (Boundary Commission Book for Hawaii:Vols. A and B, Districts of Hilo and Hāmākua). In Hāmākua, seven of the 13 references to the lower "edge of the forest" were plottable (Ibid.:Vol. A, 3-4, 94-98, 99-103, 110-112, 119-121; Vol. B, 60-62, 77-79, 81-82, 96-97, 105-106, 441-448), and arbitrary lines join these points to depict the forest's edge in Fig. 16.3. This coincides well with overland descriptions of the area between Waimea and Waipi'o, placing the forest 3 to 5 miles from the sea (Bishop 1825; Lyman 1846:June 16; *The Polynesian* 1848:Feb. 5).

"THE INFLUENCE OF THE CATTLE ON THE CLIMATE OF WAIMEA AND KAWAIHAE, HAWAI'I"

In 1856, while editor of the *Sandwich Islands' Monthly Magazine*, Abraham Fornander wrote an article arguing that large cattle herds had altered or ameliorated the climate of Waimea by destroying a "thick wood" that covered "the whole of the plain" as early as 1825 or 1830 (*Sandwich Islands' Monthly Magazine* 1856). This claim--that the removal of a vegetation community had caused broad-scale changes in the region's climate--has serious implications for any discussion, based on current weather data, of Hawaiian adaptation to varying environmental conditions. If the climate had indeed changed, it would have been impossible to formulate the preceding comparative study. After reviewing both the early historic accounts and the present environmental data, however, it became apparent that neither support Fornander's claims. While cattle probably did alter the composition and structure of the vegetation communities, the general characteristics and distribution of major plant communities remained consistent and recognizable throughout the early historic period, suggesting that these herds, rather than drastically modifying vegetation patterns by 1825, adapted to already existing patterns. The pronounced cattle-induced transformation of the landscape occurred during and after the period in which Fornander wrote, not before. Coinciding with, and probably causing, this accelerated change in the landscape, was the transition from a predominantly Hawaiian community with a subsistence economy to that of a commercial economy revolving primarily around cattle ranching. This series of events thus serves as an example of how the greatest impact of an introduced organism or phenomenon can occur, not just with its introduction or presence, but in conjunction with cultural or economic changes.

According to Fornander, two major climatic features changed after the thick woods extending to the "very edge" of the plains were removed. First, the strong downslope winds, the *mumuku*, which occasionally strike the leeward coast, were reduced in force and frequency,

and the interface between the tradewinds and the leeward land and sea breeze regimes shifted 3 to 4 miles inland. Although Fornander's assessment of the *mumuku* is difficult to judge, his assertion that thick woods covered the entire plain is not substantiated by the early historic accounts, which suggest an open grassland over a large portion of the plains. Fornander's rough location of the interface between the windward and leeward wind regimes correlates well with that described in 1830 (Committee Report 1830) and with the situation today, indicating that this pattern has probably remained relatively constant despite the even more drastic vegetation changes that have taken place since 1830. Fornander's statements were quickly adopted and exaggerated by Dr. William Hillebrand, a physician-naturalist, in an 1856 address given to the Hawaiian Agricultural Society (Hillebrand 1856). In his address, Hillebrand advocated the preservation of forests for watershed and the control of feral cattle by using Fornander's purported examples to illustrate the impact of cattle. During the 1920s both articles were reprinted in the *Hawaiian Planters' Record* to support, by historic precedent, the growing political efforts to designate and manage forest reserves throughout the islands. These, plus other observations, helped to promote and inspire numerous generalizations that the native forests of Hawai'i were primarily reduced in area by the ravages of cattle, without considering the role that Hawaiian land-use practices could have played in altering vegetation patterns before Captain Cook's arrival.

In trying to assess the possible extent of cattle's early impact on the Waimea plains, maximum reproduction estimates were calculated beginning with the 17 head left by Vancouver in Kona. Precluding predation, no more than approximately 1,600 cattle could have colonized the region by 1820 (David P. Fellows, pers. comm.; Barrère, Report 2). The earliest distributional information indicates that these herds were most prevalent in the "fine pasturage" along the southern edge of the plains and had readily spread throughout the moist forest types (see Fig. 16.3) in Waimea and along Mauna Kea's eastern slope (Macrae 1922:52-53; Douglas 1914:299; Ellis 1917:300-302; Committee Report 1830; *Sandwich Islands Gazette* 1836; Olmsted 1969:233). Despite these large numbers and their herding behavior, it seems unlikely that 1,600 widely dispersed animals could have altered, beyond recognition, an entire forest type by 1825 to 1830.

Between the early 1800s and 1844, at least two features of the predominantly Hawaiian subsistence economy helped to preserve the overall diversity of vegetation types and associated Hawaiian land-use practices found in the region. Both served primarily to keep the cattle to the south of the major settlement and subsistence lands. The first factor consisted of one or more walls that were built and maintained by community effort to "carefully preserve" the cultivating lands from "the enchroachment of the cattle" and "to form an extensive garden" (Committee Report 1830; *Sandwich Islands Gazette* 1836; Lyons 1837; Boundary Commission Book for Hawaii: Vol. A, 6, 10). The second, and more significant factor, was the active exploitation of these wild herds as early as the 1820s for hides, tallow, and jerked beef (Frost and Frost 1977:177-180; Ellis 1917:300-302; Committee Report 1830; *Sandwich Islands Gazette* 1836). This exploitation greatly reduced the number of cattle throughout the region, while the use of the Waimea settlements as the focal point for hunting and related activities helped to drive the cattle to the south and keep them there. Although a commercial enterprise, often run under the direction of foreigners, the overall management of cattle retained elements of a Hawaiian approach. The

Hawaiian community was mobilized through various means (e.g., *kō'ele* days, "convict" labor, etc.), to assist directly or indirectly in this enterprise, as the herds were owned primarily by the king or government and were often administered by Governor John Adams Kuakini (Frost and Frost 1977:178; Baldwin 1832; Doyle 1945:64, 66). Prominent foreigners who directed many of these activities were "given" productive lands, just as Hawaiian chiefs or individuals were "given" lands for services rendered to higher ranking chiefs (Frost and Frost 1977:178; Land Board:LCA 589). By 1840 a *kapu* was placed on hide and tallow production from wild cattle in fear that the herds would soon be depleted (Frost and Frost 1877:180; Brundage 1871:9). The period of transition, mainly between 1844 and 1850, began with Kuakini's death and the appointment of William Beckley as *konohiki* of Waimea in addition to his role as manager of the king's and government's cattle (Lyons 1846). This change led to the increased use of the settlement and agricultural lands for pasturage and holding pens, turning Waimea into what Lyons called a "cattle pen": "By another unfavorable arrangement 2/3 of Waimea have been converted to a pasture for government herds of cattle, sheep, horses, etc." (Ibid.). The events following the Great Mahele in 1848, and an 1850 act allowing foreigners to purchase lands, reinforced this trend. In this change from Hawai'i landholding practices to Western land-ownership policies, many native residents were legally awarded parcels too small to totally support their households (see Report 2), while the surrounding lands, which had been an additional source of garden lands or supplemental foods, were converted to pasturage. If unable to buy or lease additional lands, these residents were forced into commercial enterprises or to leave Waimea.

With these new opportunities to control specific parcels of land, former cattlemen and others (e.g., John Parker, James Fay, G. S. Kenway) began to establish and manage more formalized ranching operations in which lands were eventually fenced, new breeds of cattle were introduced, and predation on calves by wild dogs was reduced (Brundage 1971:10-14). By concentrating these commercial efforts on privately controlled parcels and emphasizing domestic herds rather than wild herds,intensified grazing practices were brought closer to the Waimea settlements and the wild herds multiplied as a result of a decrease in hunting pressure (Ibid.). Thus the total number of domestic and wild cattle increased, causing a rise in their overall impact.

The consequences of this transition, on the Hawaiian community as well as on the environment, were great. Although many of these problems or signs of change were evident during the early historic period, they only became common or prominent characteristics after 1850. With the presence of cattle within the residential and subsistence lands, houselots and gardens were individually enclosed rather than the entire community (Lyons 1855, 1862). Waimea grew increasingly dependent upon Waipi'o for food production, whereas such imports had previously been only an occasional supplement (*The Polynesian* 1840, 1847, 1848:Aug. 26; Lyons 1846, 1854; Bates 1854). The population appears to have remained relatively constant (roughly between 1,000 and 1,500) until 1841, despite fluctuations related to Kuakini's residence (Ellis 1917:300-302; Committee Report 1830; Baldwin 1832, 1835; Lyons 1833, 1835, 1841). By 1848, after describing a numerous and diverse foreign population in Waimea, Kenway stated that "it can scarcely be said that there is any native population at all" (Kenway 1848).

In terms of environmental degradation caused by intensified grazing and the expanding wild herds, the most dramatic alterations occurred in the vegetation. By the early 1900s, the tree

canopy had disappeared, or was rapidly doing so, in the rainforests and moist forest types covering the plains and slopes towards Hāmākua (Rock 1974:25-27, 54-55). Most of the tree component in the *kula* and *ululā'au* had also been reduced, and exotic grasses replaced most of the understorey in all these former vegetation types (Ibid.). Although dusty light soil during the dry season and the presence of dust clouds were occasionally mentioned before 1850 (*Sandwich Islands Gazette* 1836; *The Polynesian* 1840, 1848:Aug. 26), between 1873 and 1910 the plains had become "a worthless dusty desert, perpetually incroaching [sic] on the grass," "a steady drift of sand dunes," and so thick with dust that "everything appears to be hazy as in a dense mist or fog" (Bird 1964:148-149; Dutton 1884:167; Rock 1974:54). In 1877, a Royal Commission cited cattle as being the primary cause of the diminishing quality and quantity of Waimea's water supply (Royal Commission 1877). Even though droughts had apparently been common during the early historic period, the severity of their effects increased after 1850 (Committee Report 1830; Royal Commission 1877).

Overall, the fate of Waimea's vegetation roughly parallels that of the New Caledonian savannas, as described by ethnobotanist Jacques Barrau (Barrau 1980). As in Waimea, where Vancouver and subsequent early historic accounts spoke of "a great tract of luxuriant, natural pasture" (Vancouver 1801:5, 107) the white settlers of New Caledonia established and ran their introduced cattle industry on the myth of "natural pasture" (Barrau 1980:259). "The gardened savanna landscape of the Melanesians gave the white settlers the false impression of a lush and nutritious resource of primary grass production," whereas much of this savanna community had been directly or indirectly created and maintained by the native peoples as part of their subsistence economy (Ibid.:255-256, 259-260). Eventually the cumulative effects of cattle grazing led to overall environmental degradation and impoverished pastures dominated by tough grasses and exotic weeds (Ibid.:258-260). In attempts "to restore and then maintain the productivity of the new, specialized ecosystems," intensive pasture management practices, similar to those presently used in Waimea, have been introduced and adopted (e.g., fertilizing, use of agricultural machinery, sowing of grass and legume seeds, grazing rotation, and water management) (Ibid.:261). Thus "the diverse and productive" landscape of the Melanesians became a specialized, highly managed vegetation community catering to the cattle industry. In Waimea, the gardened landscape of the Hawaiian people, including "evergreen hills and extended plain diversified with thick wood, open pasture, low shrubbery and fruitful plantation" (Judd 1903:Vol. 2) has become a uniform expanse of open grasslands varying primarily in hue.

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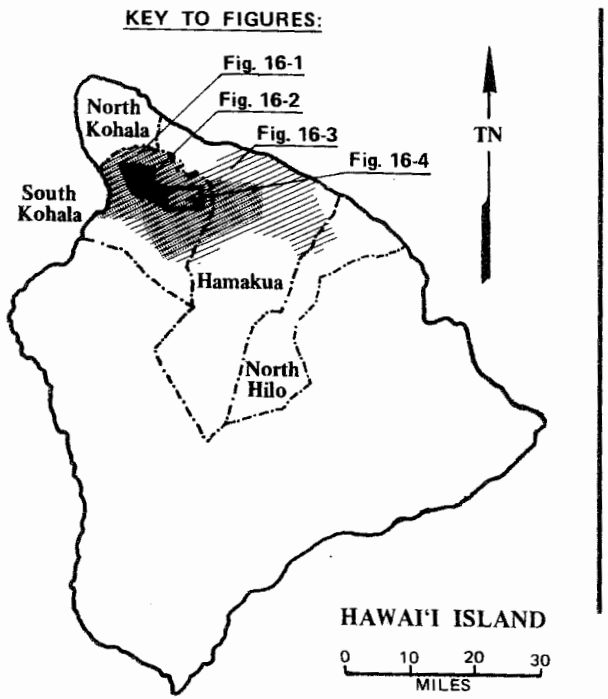

KEY TO SYMBOLS

Fig. 16-1		Fig. 16-2
	DRY	
kiawe thickets — I.		
open canopy *kiawe*, buffel grass - *pili* grassland — II.		
buffel grass - *pili* grassland, *kiawe* restricted — III.		
mixed grasses and shrubs, very scattered *kiawe* — IV.		
natal redtop-Bermuda grass dominated grass and shrub community — V.		6. — *koai'a, naio-'iliahi-wiliwili*
	MOIST	
combines features of Zones V and VII — VI.		5. — *koai'a, naio-māmane*
kikuyu-rattail grassland — VII.		4. — *koai'a* and mixed trees
	WET-MOIST	
		3. — *'ōhi'a* and mixed trees
	WET	
mixed, wet grasses and herbs — VIII.		2. — *'ōhi'a-pilo*
'ohi'a rainforest — IX.		1. — *'ōhi'a-ōlapa*

Boundary Between Associations ——— Boundary Between Associations

Uncertain Boundary – – – or ?

▪▪▪▪▪▪▪▪▪▪▪▪▪▪ Ravines Surveyed

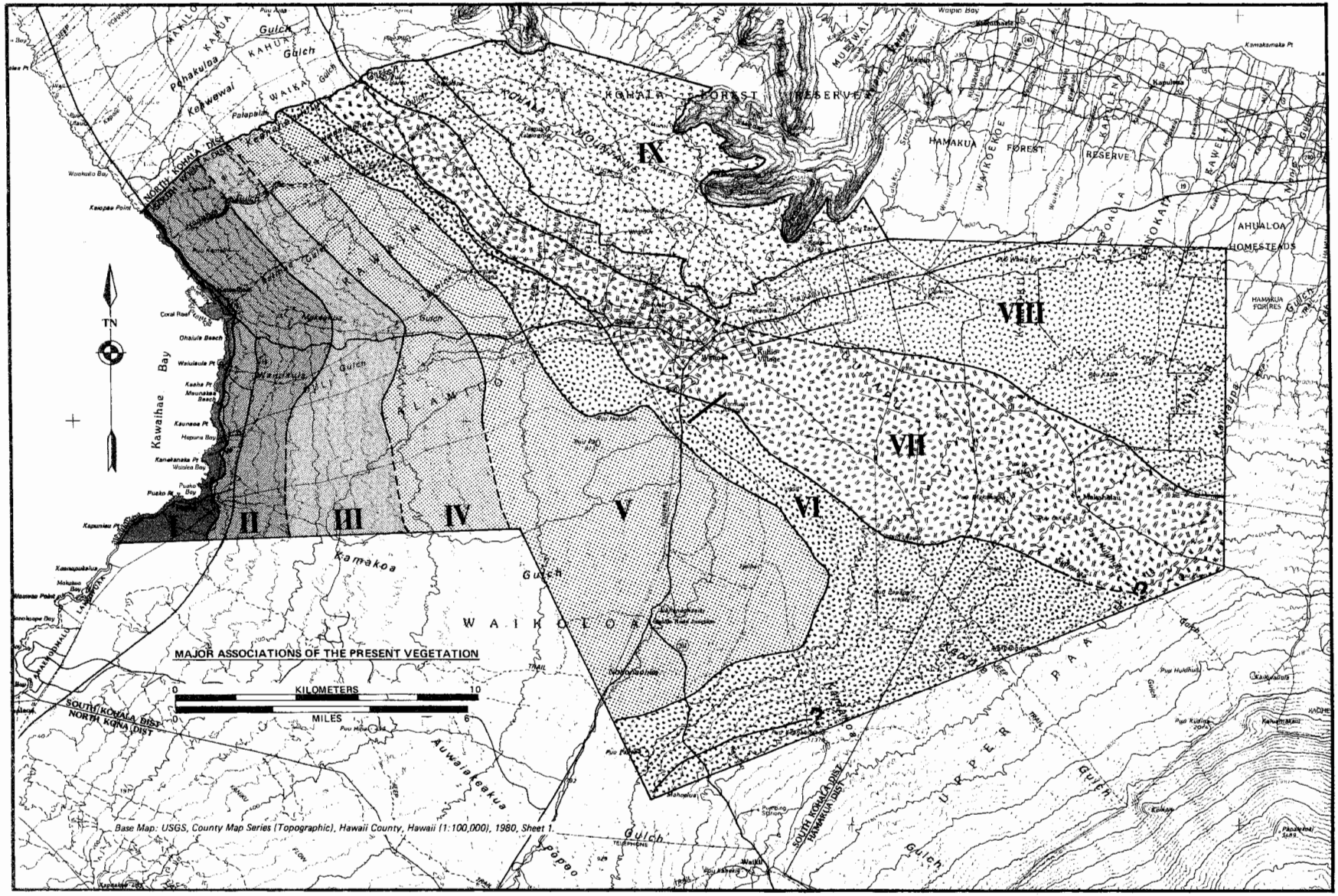

Fig. 16.1. ZONES I THROUGH IX, REPRESENTING MAJOR COMMUNITIES OF PRESENT VEGETATION.

Table 16.1

SUMMARY OF MAJOR CHARACTERISTICS DISTINGUISHING PRESENT VEGETATION ZONES I THROUGH VIII.

Zones	Distinguishing Characteristics	Representative Plant Species	Features Used to Delineate Zone Boundaries
I	Tall, closed canopy (60%) *kiawe* (*Prosopis pallida*) thickets interspersed with open stretches resembling Zone II. The understory also resembles Zone II. This zone is outside the corridor and was not intensively surveyed.	xg = buffelgrass (*Cenchrus ciliaris*) ns = *'ilima* (*Sida* sp.), *hi'aloa* (*Waltheria americana*)	Coastline serves as lower boundary and the distinct inland margin of the *kiawe* thickets forms the inland boundary. Where thickets are interspersed with open spaces, the line was extended between the thickets.
II	Slopes covered with an open-to-scattered canopy, medium-stature (15 to 40% cover) *kiawe* interspersed with closed-canopy *kiawe* thickets along intermittent stream channels. Grassland dominated by buffelgrass mixed with *pili* (*Heteropogon contortus*). Few native shrubs and herbs present in low abundance.	ns = *'ilima*, *hi'aloa* xg = *Festuca* sp. xh = *Cassia leschenaultiana* nh = *pā'ū-o-Hi'i-aka* (*Jacquemontia sandwicensis*), *'ihi* (*Portulaca cyanosperma*)	The upper boundary coincides with the upper extent of a uniform distribution of scatter *kiawe* across the slopes. Zone includes areas where fires recently opened *kiawe* canopy.
III	Open-to-closed canopy *kiawe* occurs almost continuously along stream channels and in scattered stands in flats and swales. Grassland on open slopes is dominated by buffelgrass, mixed with a larger proportion of *pili* than in Zone II. Abundance and diversity of shrubs is slightly greater than in Zone II.	ns = *'ilima*, *hi'aloa*, *'ākia* (*Wikstroemia* sp.), *nehe* (*Lipochaeta lavarum*), *'āweoweo* (*Chenopodium oahuense*) xs = *haole koa* (*Leucaena leucocephala*) ng = *Eragrostis variabilis* xg = *Festuca* sp. nh = *pua-kala*	The upper boundary coincides with the inland extent of *kiawe* trees, which are restricted to gullies and there form a nearly continuous open-to-closed canopy. Boundary line determination was aided by field descriptions for segments where gullies are not distinct.
IV	Predominantly a shrub and grassland interspersed with very scattered patches of *kiawe*. The abundance and diversity of native and exotic shrubs, exotic grasses, and exotic herbs is greater than Zone III. Fountain grass (*Pennisetum setaceum*) dominates the corridor and associated exotic grasses dominate most of the zone to the north.	ns = *'ākia*, *'āweoweo*, *nehe*, *'a'ali'i* (*Dodonaea* sp.), *'ilima* xs = *haole koa*, lantana (*Lantana camara*), indigo (*Indigofera suffruticosa*) ng = *pili* xg = bufflegrass, Bermuda grass (*Cynodon dactylon*), natal redtop (*Rhynchelytrum repens*) xh = *Verbena littoralis*, *Cassia leschenaultiana*, *Emilia javanica*, Compositae spp.	Upper boundary drawn roughly along the upper extent of the very scattered *kiawe* trees and where a reduction in shrub ground cover was detected. Location also depends on field descriptions, as this boundary was the most difficult to detect.

Table 16.1 (cont'd)

Table 16.1 (cont'd)

Zones	Distinguishing Characteristics	Representative Plant Species	Features Used to Delineate Zone Boundaries
V	A mixed shrub and grassland dominated by natal redtop and Bermuda grass, interspersed with other exotic grasses, native and exotic shrubs, and exotic herbs. Abundance and diversity of exotic herbs is greater than in Zone IV.	xt = black wattle (*Acacia decurrens*), silk oak (*Grevillea robusta*), *Eucalyptus* sp. ns = same as Zone IV xs = *haole koa*, lantana, indigo, prickly pear (*Opuntia megacantha*) xg = fountain grass, buffelgrass, *Cenchrus echinatus*, guinea grass (*Panicum maximum*), rattail grass (*Sporobolus africanus*) xh = *Cassia leschenaultiana*, *Emilia javanica*, Compositae spp., *Plantago lanceolata*, *Bidens pilosa*, *Lepidium virginicum*	Upper boundary follows the lower extent of scattered kikuyu grass-dominated swales characteristic of Zone VI.
VI	Contains the major characteristics of Zones V and VII. Knolls and exposed areas resemble Zone V and the swales and protected flats resemble Zone VII. Planted and adventive exotic tree species occur in scattered segments.	See Zones V and VII for representative species.	Upper boundary follows the lower limit of a nearly continuous ground cover of kikuyu grass.
VII	Grassland dominated by kikuyu grass (*Pennisetum clandestinum*) mixed with rattail grass (*Sporobolus africanus*). The abundance and diversity of shrubs, herbs, and other grasses are much less than Zones V and VI. Several areas are planted with exotic trees as windbreaks.	xg = Hilo grass (*Paspalum conjugatum*), Bermuda grass xh = *Trifolium repens*, gosmore (*Hypochoeris radicata*, *Vicia sativa* nf = *Pteridium aquilinum*	Upper boundary is drawn where kikuyu grass begins to share its dominance with other grasses of moist areas. On the aerial photographs, these other grasses appear as darker patches or segments within a lighter matrix similar to Zone VII.
VIII	Grassland composed of mixed exotic grasses and exotic herbs. Species are more typical of wet pasture communities. Exotic trees are planted in rows or stands as windbreaks.	xg = *Axonopus affinis*, pangola grass (*Digitaria decumbens*), kikuyu grass, *Sacciolepis indica*, *Setaria glauca* xh = *honohono* (*Commelina diffusa*), *Cuphea carthagenensis*, *Drymaria cordata*, *Ludwigia octivalvis*	As this community extends beyond the limits of the study area, the eastern boundary is arbitrarily drawn.

Table 16.2

DATA EXTRACTED FROM DETAILED DESCRIPTIONS OF VEGETATION TO SHOW ELEVATIONAL TRANSITIONS BETWEEN COMMUNITIES

% of Ground Covered by Vegetation (P=< 5%)	Zones I	II	III	IV	V	VI	VII	VIII
Trees	75-90	25-50	P	P	P	P	P	P
Native Shrubs	5-25	5-25	5-25	25-50	5-25	P		
Exotic Shrubs	P	P	P	5-25	5-25	5-25	P	
Native Grasses	5-25	5-25	5-25	P				
Exotic Grasses	25-50	50-75	50-70	75-90	75-90	75-90	75-90	75-90
Native Herbs		P	5-25	P	P			
Exotic Herbs		P	P	5-25	25-50	5-25	5-25	25-50
Native Ferns			P				P	P
Exotic Ferns								
Bare Ground	50-75	25-50	5-25	5-25	5-25	5-25	P	P

Average Number of Species Recorded per Description	Zones I	II	III	IV	V	VI	VII	VIII
Trees	1	1	1	1	1	1	1	1
Native Shrubs	2	2	3	5	4	1		
Exotic Shrubs	1	1	1	4	1			
Native Grasses		1	1	1	1			
Exotic Grasses	1	1	2	3	5	5	3	4
Native Herbs		2	2	2	2			
Exotic Herbs		1	1	4	6	6	3	6
Native Ferns		1				1	1	

Range of Species Recorded per Description	Zones I	II	III	IV	V	VI	VII	VIII
Trees	1	1	1	1	1-2	3+	1-2	1-3
Native Shrubs	2	1-2	2-4	5	3-5	1-2		
Exotic Shrubs	1	1	1	3-4	4-6	1-3	1	
Native Grasses		1-2	1-2	1	1			
Exotic Grasses	1	1-2	2-3	3	4-6	4	3-4	3-6
Native Herbs		1-2	2	2	1-2			
Exotic Herbs		1	1	4	2-8	5-8	1-4	2-12
Native Ferns			1			1	1	

Total Number of Species Recorded within the Corridor (includes incidental observations)	Zones I	II	III	IV	V	VI	VII	VIII
Trees	1	1	1	3	5	3+	3	5
Native Shrubs	2	3	5	8	7	4		
Exotic Shrubs	1	2	1	6	6	3	1	5
Native Grasses		2	2	1	1			
Exotic Grasses	1	4	2	5	7	6	6	11
Native Herbs		3	3	3	2			
Exotic Herbs		3	8	8	17	13	7	16
Native Ferns			1		2		4	3
Exotic Ferns							2	1

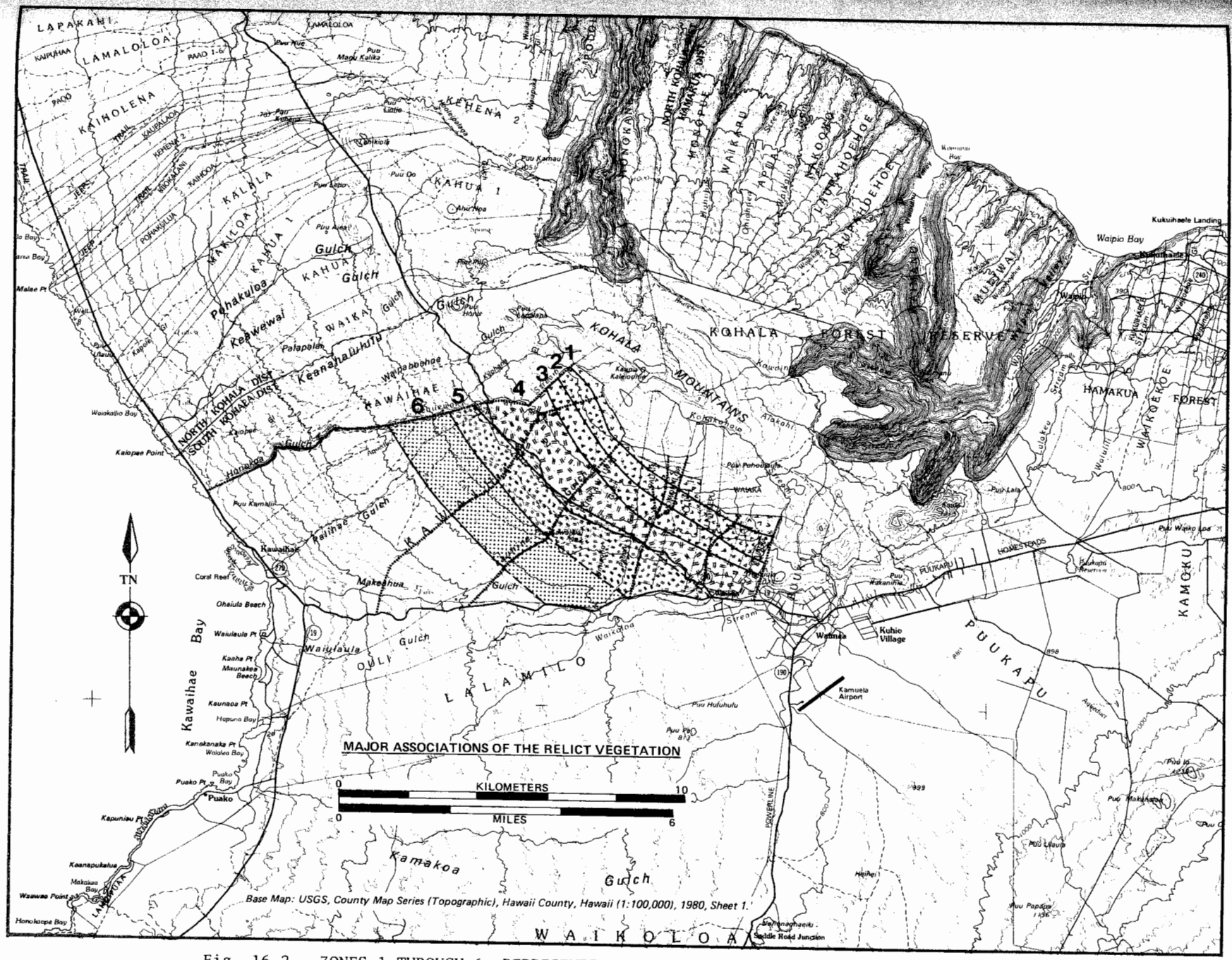

Fig. 16.2. ZONES 1 THROUGH 6, REPRESENTING RELICTS OF FORMER VEGETATION COMMUNITIES.

Table 16.3

SUMMARY OF MAJOR CHARACTERISTICS DISTINGUISHING RELICT VEGETATION ZONES 1 THROUGH 6

Zones	Characteristics	Representative Trees	Native Shrubs	Native Ferns	Grasses	Polynesian Introductions
Wet Zone 1	*ʻōhiʻa* (*Metrosideros*) dominated canopy with *ʻōlapa* (*Cheirodendron*) and mixed tree sub-canopy	*manono* (*Gouldia*) *pilo* *alani* (*Pelea*) *kāwaʻu* (*Ilex*) *kōlea-lau-nui* (*Myrsine lessertiana*) *kōpiko* (*Psychotria*) (10)*	*ʻōhelo* (*Vaccinium*) *kanawao* (*Broussaisia*) *ʻieʻie* (*Freycinetia*)	*hāpuʻu* (*Cibotium*) *ʻamaʻu* (*Sadleria*) *uluhe* (*Dicranopteris*) *hōʻiʻo* (*Athyrium sandwichianum*) *Asplenium* spp. numerous epiphytes		*kī* (*Cordyline*)
Wet Zone 2	*ʻōhiʻa* dominated canopy with mixed sub-canopy trees dominated by *pilo* (*Coprosma*)	*manono* *kāwaʻu* *kōlea-lau-nui* *kōpiko* *olomea* (*Perrottetia*) *neneleau* (*Rhus*) (9)*	*ʻieʻie* *ʻōhelo* *māmaki* (*Pipturus*) *naʻenaʻe* (*Dubautia*) *ʻōhā* (*Clermontia*) *ōpuhe* (*Urera*) *ʻākala* (*Rubus*) *maile* (*Alyxia*)	*hāpuʻu* *ʻamaʻu* *hōʻiʻo* *pala* (*Marattia*) *uluhe*	*Carex alligata* *Uncinia*	*kī*
Wet-Moist Zone 3	*ʻōhiʻa* co-dominant with mixed canopy trees	*neneleau* *kōlea-lau-nui* *pāpala* (*Charpentiera*) *olopua* (*Osmanthus*) *hame* (*Antidesma*) *kōpiko* *poʻolā* (*Claoxylon*) *pāpala-kepau* (20)*	*ʻieʻie* *ʻōhelo* *kilioe* (*Embelia*) *māmaki* *ʻaʻaliʻi* (*Dodonaea*)	*ʻamaʻu* *palai* (*Microlepia*) *ʻōwali* (*Pteris cretica*) *Cyclosorus* spp.	*Uncinia*	*kī* *maiʻa* (*Musa*)

Table 16.3 (cont'd)

Table 16.3 (cont'd)

Zones	Characteristics	Representative Trees	Native Shrubs	Native Ferns	Grasses	Polynesian Introductions
Moist Zone 4	*koai'a* (*Acacia*), *naio* (*Myoporum*), and *olopua* (*Osmanthus*) co-dominate. Mixed canopy trees as common components	*māmane* (*Sophora*) *pāpala-kepau* *'iliahi* (*Santalum*) *'āla'a* (*Planchonella*) *alahe'e* (*Canthium*) *halapepe* (*Pleomele*) *hō'awa* (*Pittosporum*) *maua* (*Xylosma*) (20)*	*maile* *'a'ali'i* *nehe* (*Lipochaeta*) *'ūlei* (*Osteomeles*) *'āweoweo* (*Chenopodium*)	*'ama'u* *palai* *ke'ape'ape* (*Cyrtomium*) *Dryopteris* spp.	*Carex wahuensis* *Eragrostis variabilis*	*kī* *mai'a* *wauke* (*Broussonetia*) *hau* (*Hibiscus tiliaceus*)
Moist Zone 5	*koai'a* dominates with *naio* and *māmane* (*Sophora*) as common components	*kōlea* (*Myrsine lanaiensis*) *'iliahi* *wiliwili* (*Erythrina*) *maua* *'ohe* (*Reynoldsia*) *lama* (*Diospyros*) (10)*	*'ūlei* *'a'ali'i* *ko'oko'olau* (*Bidens mensiesii*) *'ākia* (*Wikstroemia*) *hi'aloa* (*Waltheria*) *kulu'ī* (*Nototrichium*)			*kī*
Dry Zone 6	*koai'a* dominates with *naio*, *'iliahi* (*Santalum*) and *wiliwili* (*Erythrina*) as common components	*māmane* (8)*	*'āweoweo* *'ūlei* *kulu'ī* *hi'aloa* *'iliahi* *'ilima* (*Sida*)			*kī* *kukui* (*Aleurites*)

*Total numbers of tree species recorded in each zone.

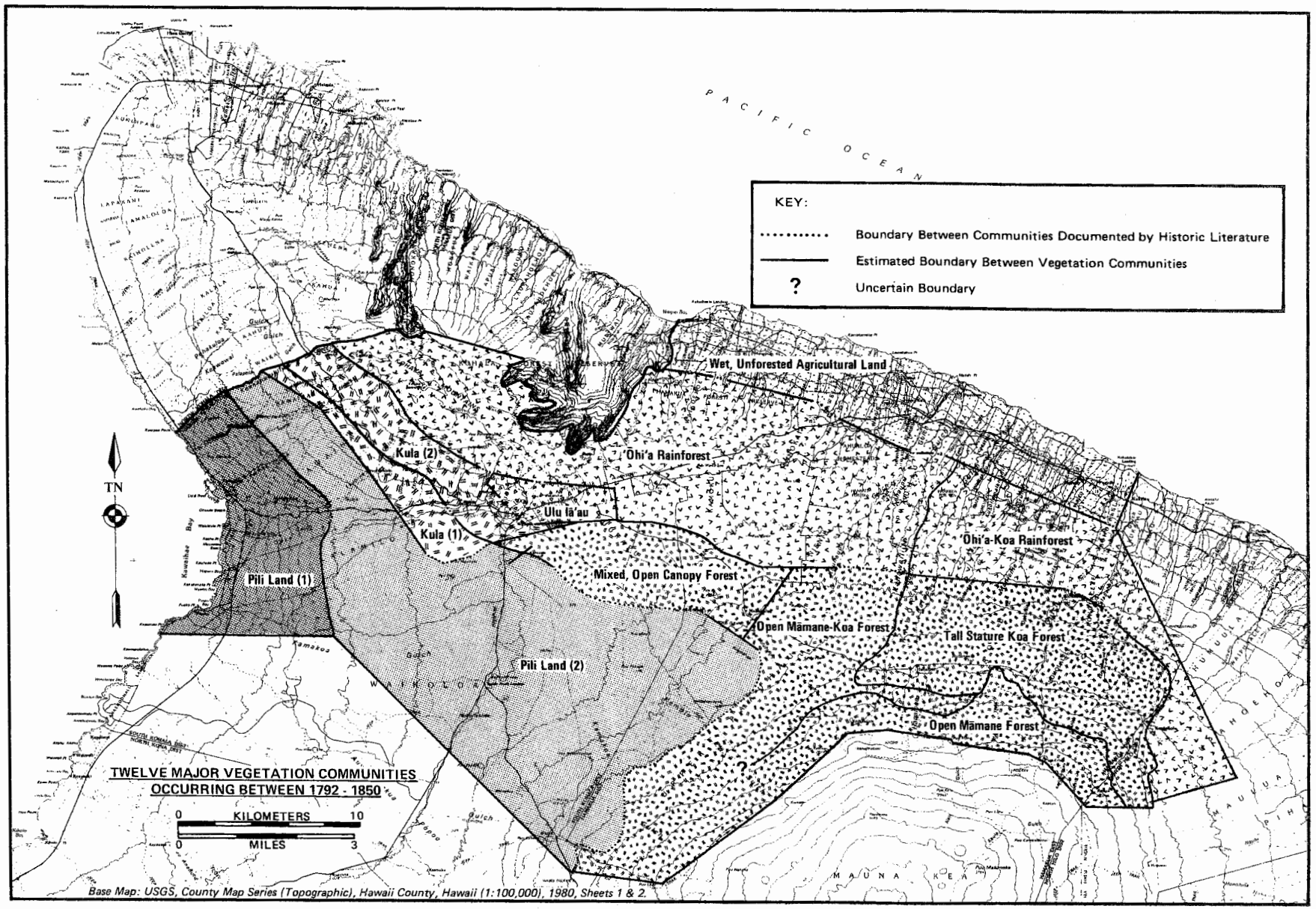

Fig. 16.3. PATTERNS OF EARLY HISTORIC VEGETATION, 1792 - 1850.

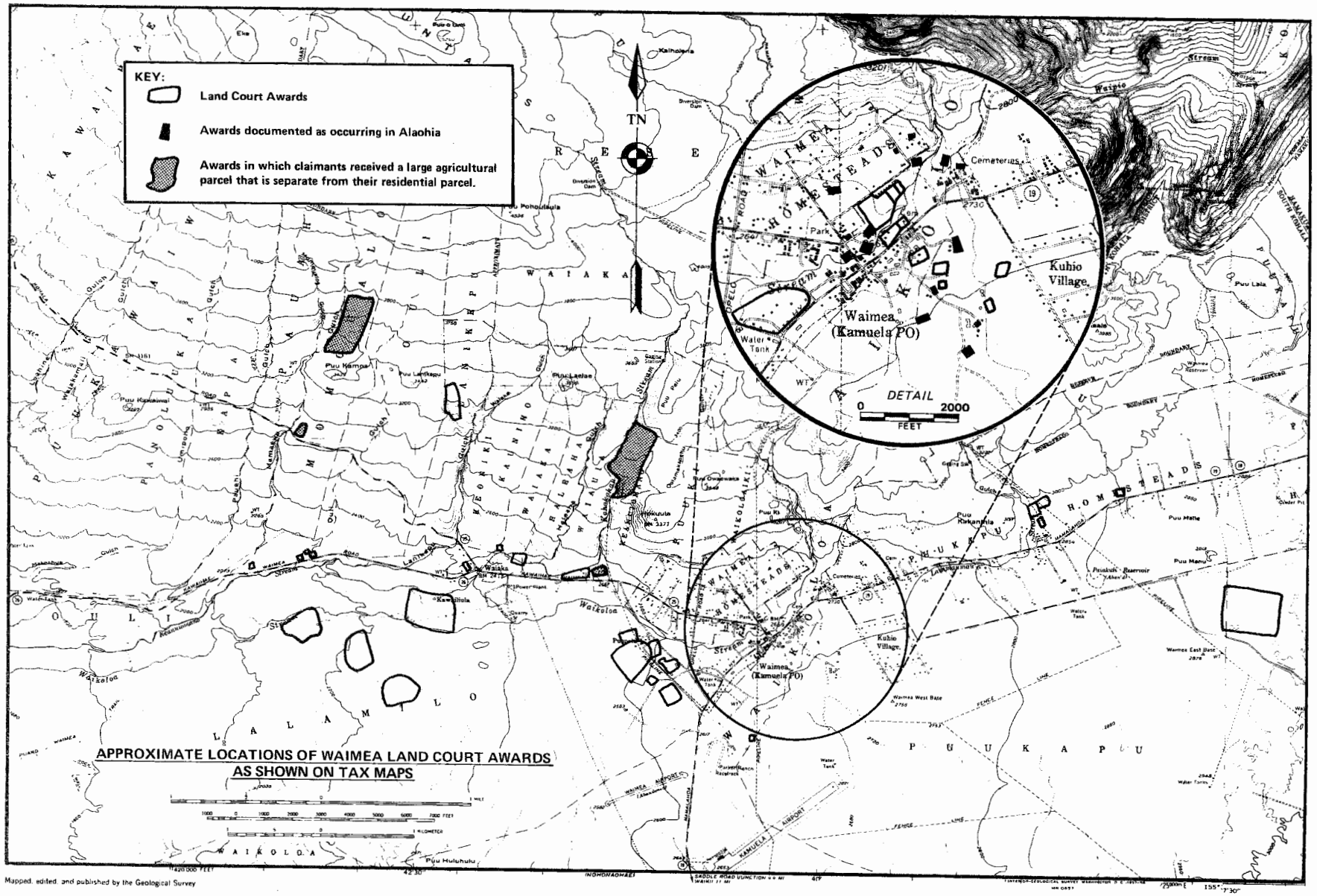

Fig. 16.4. LAND COURT AWARDS IN WAIMEA.

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Report 17

ANALYSIS OF LAND SNAILS

by Carl C. Christensen

INTRODUCTION

Snail analysis is a method in which nonmarine mollusk shells from archaeological or paleontological excavations are studied to determine the nature of the former environment in which these animals lived. The technique has been used most extensively in archaeological investigations in Britain and in studies of Pleistocene sediments in Europe and North America (Evans 1969, 1972 [the latter is a comprehensive text on the subject]; Wallace [1979] has carefully discussed the use of snail analysis in New Zealand). Its methods are analogous to those of pollen analysis, although snail analysis is generally more sensitive to local environmental conditions, while pollen assemblages may be more representative of conditions in a broader geographical area. The two techniques are complementary to some extent, as preservation of snail shells is best under alkaline conditions that are unfavorable for pollen, while acidic environments, where pollen is best preserved, are rarely suitable for shell preservation.

In Hawai'i little use has yet been made of snail analysis, despite the early recognition of its potential value in paleoenvironmental reconstruction by Henshaw (1904), Pilsbry and Cooke (1912-1914), and Perkins (1913). This is due in large part to the incomplete state of our knowledge of the Hawaiian land snail fauna. In Europe and North America the species encountered in snail analysis are widely distributed and taxonomically well known, and information regarding their ecology is usually available from published sources. In Hawai'i, by contrast, many members of the diverse native fauna are highly restricted in range, are poorly known taxonomically (many as yet undescribed), and published ecological data are few. Furthermore, many species represented in recent subfossil deposits are now extinct, a circumstance preventing direct observation of their habitat preferences. Other species still extant have been extirpated over much of their former range, so that modern ecological observations may not reveal their former occurrence with plant communities that have themselves been destroyed over much of their former extent; a highly pertinent example is the "dry forest" once widespread in these islands (including much of West Hawai'i) but now reduced to a few much-altered relict stands.

Because of these conditions it is not to be expected that snail analysis in Hawai'i will ever attain the precision now possible in some continental settings. Even so, the Hawaiian land snail fauna is an excellent subject for investigations of paleoenvironments and, in particular, of anthropogenic environmental modification. Although ecological data for these snails are sparse, some information is available from published sources or can be extracted from records associated with existing systematic collections. Furthermore, because most native species are highly vulnerable to extinction due to ecological disturbance, human activities in a particular area are likely to be reflected in a marked reduction in the

probably not established here prior to 1870 [Atkinson 1977; see also Tomich 1969]) were not found in this stratum, a result consistent with Henshaw's chronology. The absence of shells from the stratum above the burn layer does suggest rapid soil deposition following extinction of the native fauna, although differential preservation is a plausible alternative hypothesis. The uppermost soil levels in this region may be more acidic than underlying layers; this could result in destruction of shells once present in surface layers, in which case the presence of hsitorically adventive taxa in the burn layer but not above it could be attributed to burrowing by these animals and subsequent destruction of shells above the burn layer, rather than to true co-occurrence with the now-extinct native land snail fauna.

SUMMARY

Paleomalacological evidence demonstrates that Sections 2, 3, and 4 of the highway corridor once supported a diverse fauna of native terrestrial mollusks. Xerophilous elements were present throughout this region but were most abundant at lower and more arid sites (modern Vegetation Zones V, VI, and VII) where no land snail species thought to prefer wet forest were found; at higher elevations where rainfall is greater (modern Vegetation Zone VIII, in the central portion of Section 4 of the highway corridor) a presumed wet-forest snail did occur, and here xerophilous snails were considerably reduced in abundance. By analogy with the snail assemblages, it is suggested that Sections 2, 3, and the lower portion of 4 once supported xerophytic vegetation possibly similar to the dry forest of the Pu'uwa'awa'a region. Mesophytic elements were more strongly represented in the central portion of Section 4, and the region between these two parts of Section 4 (between Sites 8808 and 8817) may have marked the transition between these two vegetation communities. Destruction of the native vegetation and its associated land snail fauna may be the result of burning during or prior to the early to mid-19th century, although this hypothesis should be tested against the results of archaeological, historical, and other biological investigations undertaken as part of the Waimea-Kawaihae Archaeological Project.

ACKNOWLEDGMENTS

I thank Dr. C. M. Simon, Department of Zoology, University of Hawaii, for computer analysis of resemblance between land mollusk assemblages.

Report 18

PHYTOLITH ANALYSIS OF SOIL SAMPLES

by Deborah M. Pearsall and Michael K. Trimble

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INTRODUCTION

This paper is a report on the analysis for phytolith content of 58 archaeological and 14 control soil samples from the Waimea-Kawaihae road corridor, Hawai'i. The study area extends across a range of ecological zones, from the arid coast, through mesic elements, to the wet uplands of the interior of the island. This range of environments in a small geographic area provides an excellent opportunity to examine the changing distribution of human populations across the landscape, through time.

In the most general terms, the phytolith analysis focuses on how past human populations of the study area altered the island ecosystem. Of *particular* interest is documentation of the process of deforestation and determination of how far into the xeric area the pre-settlement inland forest extended. Specifically, analysis of phytoliths has been used to determine the nature of the grass component of the vegetation and the relative abundance of grasses versus herbaceous and woody dicotyledons through time in different locales. The majority of archaeological samples selected for study were drawn from sites suspected to be old agricultural fields. Stratigraphic archaeological column samples should show the nature of vegetation cover prior to agricultural activity, results of initial clearing and cropping, and the process of utilization of land until present day. For comparative purposes, several residential occupation areas were included. Two control columns, from areas lacking residential or agricultural activity, and surface pinch samples from six vegetation zones were also analyzed. The results of this study provide a source of information on vegetation patterning in the past that complements other ethnobiological data sources. A variety of phytolith assemblage patterns were identified from the archaeological samples analyzed. Interpretation of these patterns, based on the correlation of surface phytolith assemblages to known vegetation formations, allowed identification of a number of episodes of forest clearing. No uniform pattern of vegetation change emerged. Trajectories of change varied among ecological zones and time periods included in the study. This suggests variable use of land through time, not inconsistent with known behavior of humans in the past.

The following sections of this paper describe the sites that were sampled, discuss techniques of phytolith analysis and its application in archaeology, detail procedures used, and present data obtained. Interpretations of the data, presentation of tentative conclusions, and areas that require further research are also discussed.

role of smaller herbaceous cover seemed minimal in soil phytolith deposition. The comparison of grass species identified in the vegetation and the resulting short-cell phytolith occurrence revealed an over-representation of festucoid phytolith types (round/oblong, square/rectangular). This confirms the suspicions raised in the interim report. Study of modern comparative material revealed a number of sources of festucoid-type phytoliths in non-grass taxa. The apparently high festucoid nature of many of the archaeological soil strata must be interpreted with this in mind. It is clear, however, that there are endemic festucoid grasses present on the Island of Hawai'i (see Table 18.3) and the high panicoid nature of the current grass flora is due primarily to historic period introductions. Panicoid occurrences in lower column strata of the prehistoric period have sources in several endemic panicoid species. The surface pinch sample study was used to develop a model of non-grass dominated/grass dominated vegetation types based on large-cell phytolith percentages. This model was then used to interpret the phytolith assemblage shifts in the archaeological column groups. Supporting data from other ethnobiological and archaeological studies is needed to test this model and the interpretations generated from it.

The agricultural, cultural, and control columns from the Waimea-Kawaihae road corridor showed a wide variety of phytolith assemblage patterns. A number of episodes of forest clearing, both partial and fairly complete, were identified. Episodes of reestablishment of mixed woody and grass cover were also seen. A number of instances of strata with very low phytolith occurrence suggest forces were at work removing silica from soil under some conditions. Erosion or leaching are two possibilities which could be explored.

The application of phytolith analysis in the Waimea-Kawaihae project has generated a source of information on vegetation patterning in the past that can complement other data sources. Phytolith analysis is not without its own interpretative problems, but as more studies are done, techniques will be improved and the contributions and limitations of the approach better understood.

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Report 21

DISCUSSION AND SUMMARY

by Patrick V. Kirch

In 1979, I first proposed that West Hawai'i be used as a conceptual regional unit for the organization, analysis, and synthesis of archaeological and ethnohistoric data from the leeward portion of Hawai'i Island (Kirch 1979:198-201). The West Hawai'i region forms a discretely bounded analytical unit, environmentally and socio-politically, in terms of the indigenous chiefdom organization of the island. As noted in Report 1, the Waimea-Kawaihae Project was carried out--to the extent possible within the framework and constraints of contract archaeology--as a contribution to the prehistory of this large and fascinating region. In this discussion and summary, I present a brief review of some of the major contributions of the Waimea-Kawaihae Project to our understanding of West Hawai'i prehistory, and point out some problem areas to which future research (whether contract-generated or not) might profitably be directed. As in my earlier discussion of West Hawai'i (1979:198-201), I will cover, in turn, three major topics: (1) *substantive* contributions made by the Waimea-Kawaihae Project to our knowledge of West Hawai'i prehistory; (2) *methodological* innovations made by the Project in the analysis of materials from the region; and (3) *theoretical* contributions, not only to regional prehistory, but to the general disciplines of archaeology and anthropology.

Virtually any archaeological investigation can be said to make some substantive contributions to regional prehistory, by the addition of new data--distributional, chronological, artifactual, and so on--to the information base upon which synthesis must ultimately rest. At this basic level, the Waimea-Kawaihae Project has indeed contributed a great deal of new "grist" for the archaeological "mill." A large number and variety of structural features have been mapped and excavated, an extensive series of radiocarbon and hydration-rind age-determinations have been run, sizeable artifact assemblages have been collected and analyzed, and diverse sorts of non-artifactual materials have been recovered that aid in understanding the relationship of prehistoric man to the environment. Beyond this basic level of substantive contribution, however, there are several specific aspects of the Waimea-Kawaihae project results that deserve special comment; some of these contributions are major, and others can perhaps be regarded as simply interesting footnotes to prehistory, but all add measurably to our overall comprehension of the Hawaiian past.

In my view, perhaps the most important substantive contribution of the Project lies in the definition and detailed investigation of the upland agricultural system. We now have evidence that the prehistoric and early historic inhabitants of the Waimea region practiced an intensive form of cultivation, utilizing what Clark has termed "supplemental irrigation." This is, in a way, a combination of the two better-known forms of indigenous Hawaiian agriculture, irrigated pondfield cultivation on the one hand, and dryland field-system cultivation on the other. The evidence from the Waimea area can be considered a truly novel contribution to Hawaiian archaeology and ethnobotany; the kind of intensive cultivation evidently practiced in

the area is not, for example, described in the classic study of Hawaiian agriculture by Handy and Handy (1972).

Due to the routing of the highway corridor, most of our studies of the Waimea agricultural system were concentrated on its periphery, rather than in the core area, which centers around Lālāmilo (Clark 1981). Fortunately, as Clark notes in Report 8, a second archaeological contract with the State of Hawai'i (conducted while the Waimea-Kawaihae Project was in progress), did allow us to survey this Lālāmilo core area and, as a result, the relationship of our more peripheral study area became evident. In Section 4 of the highway corridor we were able to investigate a portion of the more intensively cultivated field system. The fact that much of our work was conducted on the periphery of the system should not necessarily be seen as a negative aspect of the project. Indeed, by examining the expansion of the Waimea agricultural system into marginal extremes, we can come to a better understanding of the constraints--environmental, agronomic, and social--under which the system operated and developed.

The archaeological investigations in Section 2 of the highway corridor might superficially be viewed as rather negative in their results, since little was found in the way of substantial prehistoric Hawaiian occupation. But here, too, we have gained a better understanding of the environmental limits to prehistoric Hawaiian efforts in land utilization. The fact that some attempts at agricultural production were even undertaken in this marginal "barren zone," tells us something critical concerning late prehistoric Hawaiian culture. Whether these attempts to wring a small bit of agricultural produce out of such an unyielding and marginal environment should be interpreted in terms of "population pressure," or should perhaps be ascribed to the oppressive domination of a demanding, stratified chieftainship, are matters that will be debated by prehistorians for some time to come.

As with any agricultural people, the prehistoric Hawaiians were obviously constrained in their efforts to develop and expand production by particular aspects of the natural environment, such as rainfall, the distribution of soils, vegetation cover, and so forth. At the same time, human activity modifies physical and biotic environments, and even non-industrial societies can have major impacts on local ecosystems, so that the interaction between human populations and the environment is reciprocal. In Hawai'i, evidence accumulated over the past several years has suggested that local environments indeed changed, sometimes radically, in response to Hawaiian land-use patterns (Kirch 1982). As noted in Report 1, one major thrust of the Waimea-Kawaihae Project was to determine to what extent the local ecosystem had been affected by the prehistoric human inhabitants. In this effort, we attempted to apply a wide range of evidence, using an interdisciplinary approach. Although for technical reasons, described in various reports in this volume, the results are less conclusive than might have been hoped for, I do believe that we have made clear gains in the substantive arena. Evidence for human-induced *disturbance*, if not degradation, of the environment has been obtained through the studies of subfossil land snails, opal phytoliths, and pollen. We have gained as well a more realistic grasp of the difficulties involved in such interdisciplinary studies; more will be said of this below.

Sites investigated during the Project were not especially "rich" in artifactual remains, and those who regard the primary aim of archaeology to be the typological study of artifacts so as to construct cultural sequences will doubtless be disappointed in our results. Several interesting artifact forms were discovered, however, such as the *kōlea* stones, a type of hunting device not previously recognized amongst Hawaiian material culture (Pyle 1982). More importantly, though, in this Project we have finally begun to pay serious attention to one of the most neglected but nevertheless ubiquitous artifact types in Hawai'i: the flaked assemblages of volcanic glass. The differential densities of these flakes and cores over an array of sites, and the different internal distributions within particular sites, as well as patterns of edge wear or utilization, obviously have the potential to tell us much regarding prehistoric Hawaiian activities and behavior patterns. In this Project we have not only refined methods for describing, coding, and analyzing these flaked-stone assemblages, but we have also made some progress toward understanding the processes of core reduction used to remove flakes. A great deal of work remains to be done before we can correctly interpret patterns of edge damage and utilization (much of it involving replicative experiments), but a clear start has been made in this direction.

Several other substantive discoveries, made during the course of our work, have added interesting insights into prehistoric Hawaiian culture. One of these was the excavation of the cremation burial in Section 3, described by Reeve in Report 6. Although cremation had been described in the ethnohistoric record (Malo 1951:57), to our knowledge this is the first archaeological documentation of the practice anywhere in the Islands. Yet another insight is provided by the volcanic-glass lithic scatters studied by Reeve in Section 3, which he plausibly interprets as representing the actions of a work party stripping the bark from paper mulberry plants. Again, this kind of site appears to be a "first" in Hawai'i, although in this instance it is probable that other such sites exist and simply have been not recognized as such. A third instance of what we might call a "footnote to prehistory" is provided by the pig cranium discovered in a cairn in Section 2 and discussed by Welch in Report 5. The interpretation of the cairn is still not clear, but the analogy with *ahupua'a* ("pig cairn") is obvious, and the possibility that this feature represents some kind of territorial or boundary marker is intriguing. In Hawaiian archaeology, cairns are frequently dismissed as features not worth more than simple recording; the Section 2 find may cause some of us to rethink this position.

I turn now to a consideration of the Project's efforts in the methodological arena. First of all, we have the fundamental issue of chronological control, which is so vital to all efforts in archaeology. As I noted in Report 1, the past decade in Hawaiian archaeology has seen a shift in dating techniques from the radiocarbon method to a reliance--at times almost exclusive--on the hydration-rind method of assessing the age of volcanic glass. Regarding this shift with a degree of healthy skepticism, we resolved to use the Waimea-Kawaihae Project as an opportunity to (1) reevaluate the hydration-rind technique, and (2) to obtain as large an array of radiocarbon age-determinations as feasible. As a result, we now have one of the best-controlled regional chronologies within the State, and we are able to do a comparative evaluation of the two techniques. For reasons discussed in detail by Olson in Report 10, it is clear that the emphasis given to hydration-rind dating in recent years was not fully warranted, and that

the degree of precision claimed for the volcanic-glass "dates" is probably greatly inflated. This is indeed a serious problem, since it has repercussions for all aspects of Hawaiian archaeology that depend upon close chronological control. For example, Cordy's (1981) recent studies of the development of "complex rank societies" in the North Kona area of West Hawai'i depend totally upon hydration-rind dating for temporal control. As Olson points out, given the current state of the hydration-rind dating "art" (as he prefers to call it) in Hawai'i, we should not expect the technique to function as more than a tool for rough relative dating. This means that we shall still have to rely heavily on radiocarbon dating for our chronological frameworks; as Clark points out in Report 9, ^{14}C dating itself has many problems, especially for samples only a few centuries old. Indeed, it is probable that we shall have to seriously rethink much of the chronological work done in Hawai'i over the past decade. Nonetheless, in injecting a more "realistic" view of the problems of dating in West Hawai'i (and in the Islands generally), we believe that the Waimea-Kawaihae Project has made a real and lasting contribution to the discipline.

As I noted earlier, another area in which we have contributed methodologically is in the analysis of the volcanic-glass flaked-stone assemblages. We hope that the coding systems defined here will be adopted, refined, and utilized by other archaeologists working in West Hawai'i and elsewhere in the archipelago, so that we may gradually build up the kind of data base that will eventually allow a truly definitive investigation of this ubiquitous, but important artifact class.

Aside from the matter of chronology, perhaps the most significant contribution of the Project to the development of methods in Hawaiian archaeology was the concerted application, for the first time, of a full range of techniques for paleoenvironmental analysis. As research concerns in Hawaiian archaeology have moved, over the past few years, away from matters of origins and sequence definition, to encompass problems of settlement pattern, adaptation, land use, and the like, it has become apparent that we needed to develop and apply more powerful methods of obtaining ecological data (other than the standard techniques of "midden analysis"). The Waimea-Kawaihae Project marks the first serious application of pollen analysis, opal phytolith studies, and charcoal identification to materials from archaeological sites in Hawai'i, as well as the first concerted application of the flotation method to recover plant macrofossils. Paleo-malacology, which had previously been applied in only a limited number of instances (e.g., Kirch and Christensen 1980) was also included in the present Project. Another unique feature of the project was the application of modern vegetation studies to provide a control baseline, and extrapolation, from an analysis of the relict vegetation and historic documents, of vegetation patterns in the past. I must stress that application of this interdisciplinary approach has not been easy, nor without serious difficulties, and in this regard the Project has been something of learning process. For pollen, opal phytoliths, and charcoal, we faced (and still face) the serious obstacles of developing adequate reference collections for the identification of materials recovered from archaeological sediments. Under the aegis of the Waimea-Kawaihae Project, a good start has been made in developing such collections, and these will prove to be of inestimable benefit to researchers who may wish to apply these methods in the future. While the yield of plant macrofossils from the Waimea-Kawaihae sites was not great,

we have learned that flotation is a viable technique for Hawaiian archaeological sediments, and that certain sites have the potential to provide much data of ethnobotanical significance. In my view, the technique of charcoal identification, even though hindered at present because of a small number of reference specimens, shows the greatest promise of providing direct data on plant utilization by the prehistoric Hawaiians.

Finally, I close this discussion of the Waimea-Kawaihae Project results with some brief comments regarding the *theoretical* aspects of prehistory in West Hawai'i. Elsewhere, I referred to the potential of the West Hawai'i region to make significant contributions to such major anthropological problems as "population growth and its socio-political implications, patterns of ecological adaptation to both terrestrial and marine environments, and the causes and constraints of increasing social stratification" (Kirch 1979:201). The materials generated by the Waimea-Kawaihae Project have, I believe, added a significant data base for consideration of these major research concerns. Reeve, in Report 6, has discussed some of his findings in relation to the socio-political context of early post-contact Hawai'i, suggesting that the expansion of the Waimea field system to its marginal extremes may owe much to the pressures of a demanding and oppressive polity. This is indeed an interesting suggestion, one which differs from many current interpretations of agricultural intensification in Hawai'i, which have tended to stress ecological factors, rather than social or political ones. The questions of population growth, and of inland expansion, discussed in Report 1 as significant research concerns for West Hawai'i, are, in light of our chronological work, in need of serious re-thinking. The matter of whether prehistoric Hawaiian population had reached a plateau, was on the decline, or was in fact still increasing when Europeans arrived in these islands, is of some interest, not only for an understanding of Hawaiian prehistory, but in terms of the wider question of man's role in island ecosystems everywhere. The estimation of prehistoric population depends heavily on accurate chronological control, and as we have shown in this Project, this is an area that needs a great deal of further work.

The present volume, which has as its aim the presentation of our field data and analytical results, is not the proper vehicle for a lengthy discussion of the theoretical aspects of prehistory in West Hawai'i. However, we hope that in the various papers presented here we have pointed to some of the directions which such work must pursue, as well as adding considerable new data that will be of use in such an endeavor. Fundamentally, archaeology should tell us something--not only about another culture, which thrived in a time now remote--but about ourselves, the nature of human society, and its interaction with the surrounding environment. We trust that the Waimea-Kawaihae Project, representing the efforts of our modern society to preserve something of what came before us, has added in some modest measure to this effort.

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