Environmental Variability and Traditional Hawaiian Land Use Patterns: Manukā's Cultural Islands in Seas of Lava

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THE HAWAIIAN ISLANDS provide an excellent opportunity to examine the relationship between environmental variability and traditional patterns of settlement and land use. Several areas of the archipelago are well known as the result of large-scale regional projects over the last twenty years (e.g., Clark and Kirch 1983; Cordy et al. 1991; Green 1980; Kirch and Kelly 1975; Ladefoged et al. 1987; Rosendahl 1972). These large-scale regional studies have emphasized the ecological, economic, and, to a lesser degree, social aspects of land use and settlement patterns. Moreover, many recent cultural resource management studies continue to focus on issues of settlement and subsistence. In this paper, we explore the relationship between environmental variability and settlement patterns in the context of Manukā Ahupua'a, Ka'ū District of Hawai'i Island. This is followed by a discussion of a more general theoretical model that may explain a variety of settlement patterns across the archipelago.

Many of the early settlement pattern studies in Hawai'i (e.g., Earle 1978; Hommon 1969; Kirch 1971; Rosendahl 1972) were guided by a model of settlement, land use, and socioeconomic relations derived from the early-twentieth-century research of Handy and Pukui (1972) in central Ka'ū, island of Hawai'i (Fig. 1). The *'ohana* model described a local kindred group related by blood, marriage, and adoption; a related community settlement pattern of dispersed residences; and an exchange network between these dispersed residences. Some *'ohana* members resided at the coast and others lived inland, and exchange commodities reflected the varied products of their respective residential localities (e.g., marine vs. upland resources) (Handy and Pukui 1972:5–6).

Handy and Pukui's study was among the first to give a central role to living Native Hawaiians, resident on their traditional lands; it was in part an attempt to counter a prevailing notion that all traditional knowledge had been lost (Barrow 1972:xi). They suggested in several contexts that the *'ohana* was a long-

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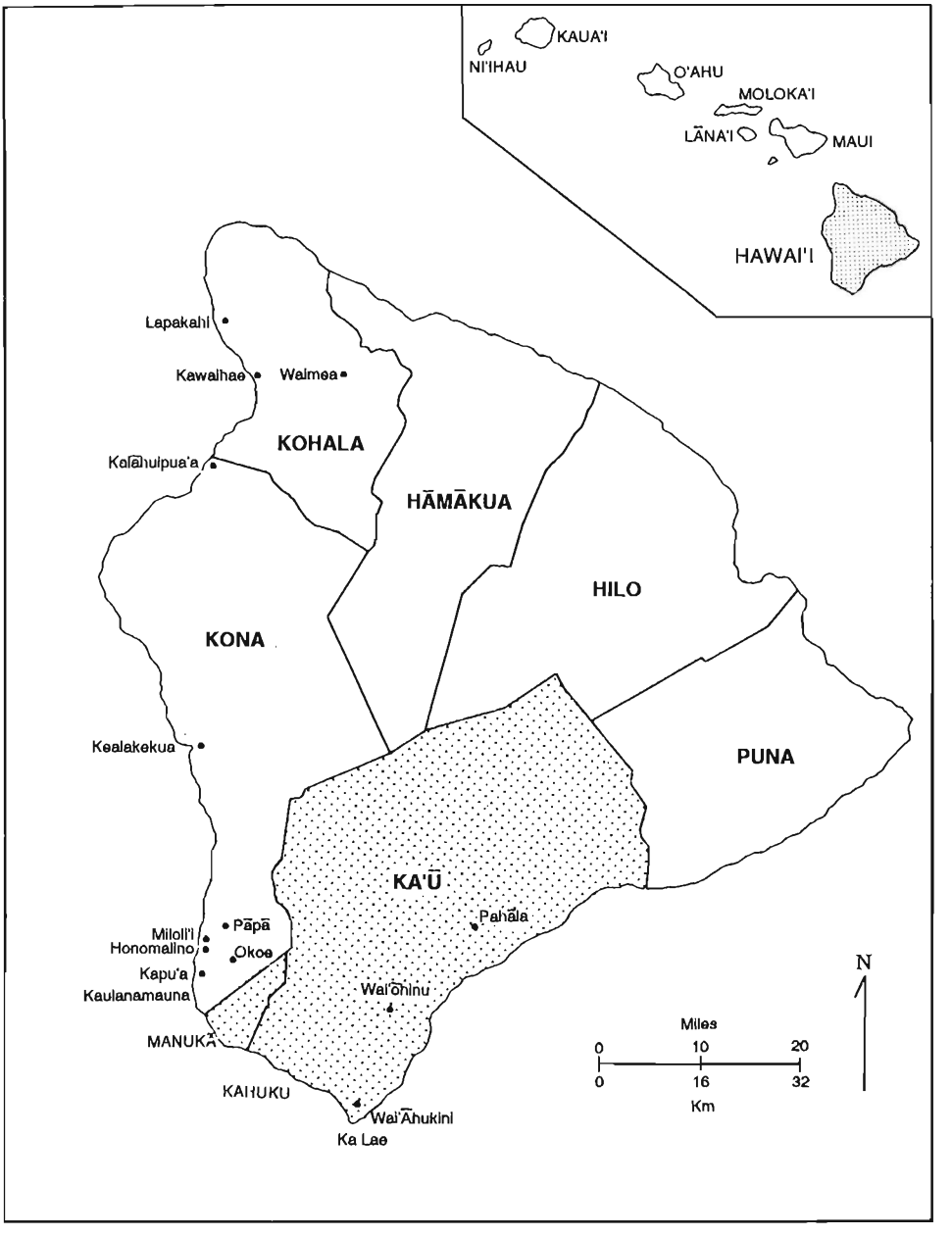


Fig. 1. Map of Hawai'i Island showing localities mentioned in the text.

standing Native Hawaiian structure (Handy and Pukui 1972:16–17, 22, 40), "a variant from the basic norm (if there be a norm) of an old Polynesian community as an aggregate or complex of families" (1972:18). They contrasted the Native Hawaiian *'ohana* with the settlement patterns and land tenure system of Samoa, where they suggested the political system was more established and land titles more permanent (Handy and Pukui 1972:1), and of New Zealand, where they

noted that fortified villages were required for defensive purposes. They also suggested that the *'ohana* was a socioeconomic structure of some temporal depth.

Although their study was limited to the Ka'ū, Puna, Hilo, and Kona districts of Hawai'i Island, Handy and Pukui suggested that the *'ohana* pattern was once widespread throughout the Hawaiian chain. References are made to *'ohana* communities on O'ahu, Kaua'i, Maui, and East Hawai'i (Handy and Pukui 1972:40). They attributed the structure of the *'ohana* to environmental features. In particular, the "extended, fragmented terrain" of Ka'ū was considered an important factor in the development of the dispersed *'ohana* community. More generally, Handy and Pukui observed that "the means of livelihood and exchange of products of sea, land, and handicraft between individuals and households were all affected by topography, rainfall and vegetation, the nature of the shore and the sea offshore, by climate and weather and the cycle of the seasons" (Handy and Pukui 1972:18). However, "for all its uniqueness" the dispersed community of Ka'ū was said to be "typical of the Hawaii Islands" (1972:22).

Both ethnological and archaeological attempts to identify the patterns Handy and Pukui described for areas of Hawai'i outside the central Ka'ū District have met with problems. Sahlins (1992:193–202) reviewed related ethnological issues and suggested that the *'ohana* was not a corporate lineage, similar to that found elsewhere in Polynesia, but rather an ego-based bilateral kindred (see also Clark 1987; Earle 1978:169). Archaeological studies have found that the permanent inland and coastal residences suggested by the *'ohana* model do not occur in some localities (e.g., Clark 1987; Earle 1978), and in other localities may be late prehistoric (e.g., Rosendahl 1972) or historic developments (e.g., Cordy et al. 1991). There are also important theoretical reasons to question how long the *'ohana* system may have been in place, even in central Ka'ū where Handy and Pukui carried out their research. In particular, scholars have become increasingly aware of the dramatic decline in Native Hawaiian populations in the first few decades of Euro-American contact (after A.D. 1778) (e.g., Bushnell 1993; Stannard 1989; see also Handy and Pukui 1972:232, 237–238); less well understood is the impact of this decline on traditional settlement patterns and socioeconomic activities (but see Kirch and Sahlins 1992; Ladefoged 1991; Sweeney 1992). Also important was the effect of Euro-American contact on traditional economic activities in terms of resource composition, productivity, and distribution (e.g., Kent 1983; Ladefoged 1993). Both the magnitude of population loss and the integration of Hawai'i into the world economy calls into question the appropriateness of Handy and Pukui's (1972) ethnographic model for the prehistoric past.

In this paper, we examine archaeological data from an environmentally marginal locality of Hawai'i, the *ahupua'a* of Manukā in the Ka'ū District. Although our studies were carried out over 15 years ago, no additional research has taken place at Manukā in the intervening period, and the area remains archaeologically poorly known. Given that Manukā Ahupua'a had no modern developments and was owned by the State, it provided an unusual opportunity to examine both coastal and inland localities that were relatively undisturbed. We use the Manukā evidence to evaluate the applicability of one component of the *'ohana* model, specifically the settlement pattern correlates, to this and other more marginal land units. Although the *'ohana* model sees little discussion these days in the archaeological literature (but see Clark 1987; Ladefoged et al. 1987;

Sahlins 1992), the work of Handy and Pukui (1972) remains a major ethnographic contribution, and it is important to understand the origins, time depth, and persistence of the land use patterns they described. The Manukā study is particularly interesting in this respect, because it lies within the general provenance of their research, the District of Ka'ū.

In the concluding discussion, we develop a theoretical model to explain the varied settlement patterns that archaeologists have found throughout the archipelago in the last few decades. The model considers how settlement patterns were affected by the spatial distribution and abundance of critical resources, broadly and qualitatively defined in terms of lands suitable for agriculture and marine sources of protein. In particular, we discuss settlement location and patterns of mobility, the latter often serving to average out spatial and temporal variation in resources.

A related archaeological consideration, one that can only be addressed theoretically in the present context, centers around the notion of residential permanence. The ability to determine archaeologically the duration of occupation is critical to discussions of the *'ohana* model and to settlement pattern studies generally. Short-term residential structures were first recognized as such during the Mākaha Valley, O'ahu, study and included C-shape, U-shape, and L-shape stone structures (Green 1969, 1970). Subsequent work has shown that morphologically similar structures were used on both a seasonal or short-term basis and for more extended or permanent habitation (Green 1980; Rosendahl 1972). Recent work has also shown that short-term habitation activities may have no architectural signature, as demonstrated by numerous examples of subsurface firepits in association with postmolds in several inland O'ahu localities along the H-3 Highway Corridor (J. Allen, pers. comm., 1993).

A more explicit classification of structures, aimed at defining duration of use, was proposed by Clark (1987; see also Cordy et al. 1991; Rosendahl et al. 1992) working in the Waimea-Kawaihae area. He identified four types of residential sites: single-use, recurrent-use, extended-use, and permanent. Although Clark (1987:193–208) clearly defined the criteria for each of these categories, Ladefoged et al. (1987) found difficulty in applying Clark's site types to a second region. Ladefoged's analysis suggests that the necessary conditions for class membership are overlapping (e.g., single-use and recurrent-use shelters can have the same morphology) or are not *unambiguously* related to duration of use (a terrace does not unequivocally reflect permanent as opposed to extended use). A further problem is that morphologically similar structures have been found to be functionally diverse—a situation sometimes resolved by excavations, but otherwise interpreted from contextual associations, both environmental and archaeological. As Ladefoged et al. (1987:102) noted, Clark's model is commendable for its clarity; however, the ambiguities that arise in application highlight the need for continued theoretical and methodological efforts in archaeological identification of residential duration at a given site and, by extension, residential mobility over the larger region.

BACKGROUND TO THE STUDY

At Euro-American contact, the *ahupua'a* was a fundamental geographic, social, and economic unit in traditional Hawaiian society. Early historic sources charac-

terize the typical *ahupua'a* as extending from the mountains to the coast and out into the sea (Fornander 1918–1919; Kamakau 1968; Lyons 1875; Malo 1951). These pie-shaped units thus cross-cut several resource zones, including the upland forest (*wao*), fernlands (*'ama'u*), and offshore fishing areas, as well as several intermediate, altitudinally differentiated, cultivation zones (e.g., *kaluulu, 'āpa'a,* KULA KAI, KULA UKA) (Handy and Pukui 1972:4; Kelly 1983:47–50). *ahupua'a* were subdivided into smaller parcels known as *'ili* that were, like *ahupua'a*, generally oriented perpendicular to the coast. *'Ili* were often occupied and worked by related family groups, the *'ohana* (see Handy and Pukui 1972; Sahlins 1992:192–216). Through time, the *'ohana* was said to spread throughout the *ahupua'a* and ultimately into neighboring districts as families intermarried (Handy and Pukui 1972:5). However, there would always be a concentration of the closest related *'ohana* in the original *'ili*. Sahlins (1992:194), however, in his recent analysis of the *'ohana* maintained that there were "neither particular lands held by exclusive groups of kinsmen nor exclusive groups of kinsmen holding particular lands."

At Euro-American contact, *ahupua'a* throughout Hawai'i were organized into c.30 named districts (Hommon 1986). Each district consisted of an average of 30 to 100 *ahupua'a*, land units that were relatively self-sufficient. Some intra- and interdistrict exchange occurred, and certain key resources, such as adze-quality basalts, were widely distributed (Hommon 1986:57; Withrow 1990). Hommon (1986:61–66) argued that *ahupua'a*, as an integral socioeconomic unit, began to form after A.D. 1400, concurrent with widespread development of permanent agricultural complexes in inland areas. He further suggested that by the time of *ahupua'a* formation, corporate land-holding kinship groups had dissolved and were replaced by ego-based bilateral kin groups under the control and leadership of a multitiered nonproductive elite.

As outlined above, several large-scale settlement pattern studies in Hawai'i have identified temporal and spatial variability in Native Hawaiian land use. Hommon (1969), working at Mākaha Valley, was among the first to broadly consider the archaeological correlates of the *'ohana*. These efforts were followed by more explicit attempts on the part of Kirch (1971) at Palauea, Maui. In the dry leeward setting of Palauea, Kirch (1971) found a pattern of intermittent coastal residence focused on marine exploitation. He hypothesized that more permanent residences would be found inland, in association with agricultural fields. Rosendahl (1972), working at Lapakahi, Hawai'i, identified a pattern of primary residence based on the coast with seasonal movement inland to plant, tend, and harvest fields. Through time, there was a gradual shift in residence, such that by late prehistory, settlement patterns at Lapakahi more closely approximated the model described by Handy and Pukui (1972).

At Kalāhuipua'a, Hawai'i, a pattern similar to that of coastal Palauea was found (Kirch 1979:186). Once again, Kirch argued that the coastal residences were occupied intermittently and that more permanent settlements would be found inland in association with agricultural lands. This pattern of upland residence and farming, with repeated intermittent coastal occupation to exploit marine resources, was suggested as "a maximizing strategy in the West Hawai'i ecosystem" (Kirch 1979:186). Likewise, Sinoto and Kelly (1975:56) inferred intermittent coastal settlement at Wai'ahukini (see Fig. 1) and hypothesized that permanent residences were located at higher elevations. Notably, at the latter

three localities, Palauea, Kalāhuipua'a, and Wai'ahukini, the upland residences and agricultural components are assumed rather than demonstrated archaeologically. The Kalāhuipua'a evidence, as at Lapakahi, suggested that permanent coastal settlements and obligatory exchange relationships, if present, were historic-period developments.

In contrast to these dry leeward localities, Earle (1978), working in the wet windward district of Halele'a on Kaua'i, found a nucleated coastal pattern of residence with no inland counterpart. He suggested that the dense and rich resource base of Halele'a mitigated against permanent inland settlements and the development of exchange networks. At another windward locality, Hālawa Valley, Moloka'i, Kirch (1975:53, 178–179) found that the earliest populations were nucleated and permanently settled on the coast. After the thirteenth century A.D., people moved inland and residences were dispersed; in the historic period residences were located 200 to 300 m inland, nucleated around a local church (Kirch 1975:181).

These studies, and others since, identified two potential dimensions of variability in Native Hawaiian settlement and land use. First, they suggest that there may be spatial variability that stems from differences in the natural resource base. Second, they suggest that settlement and land-use patterns may have varied through time. In our concluding section, we provide a theoretical model of the relationship between the abundance and distribution of resources and various parameters of land use, including settlement patterns and residential mobility.

THE ENVIRONMENT OF MANUKĀ

The *ahupua'a* of Manukā is a wedge-shaped geographical unit that extends from the sea to 1685 m, terminating at a prominent cinder cone known as Pu'u Ohohia. The *ahupua'a* encompasses a total of 9836 ha, much of which is covered with rugged *'a'ā* lava flows that are inhospitable to habitation and archaeologists. Islands of older substrate surrounded by more recent lava flows (*kīpuka*) were the focus of cultural activities, both now and in the past (Fig. 2). There are 11 major *kīpuka* in Manukā (Fig. 2), but even in these localities there is little soil development.

As described below in more detail, our 1977 study concentrated on two *kīpuka*: (1) Kīpuka Mālua, a coastal area with known archaeological features (Hansen, field notes, 1961–1969); and (2) Kīpuka Kuiki, an upland locality where an agricultural complex was located during our initial reconnaissance. Both *kīpuka* are underlain by lava flows 1500 to 3000 years old and surrounded by flows 800 to 1500 years old (Peter Lipman, pers. comm., 1979). Handy and Handy (1972:569) suggested that the earliest Hawaiian settlers may have found Manukā more hospitable than at present. There is some evidence to support this notion, because the *'a'ā* flow between Manukā Bay and Kīpuka Mālua partially covers a trail (BPBM site 50-HA-B24-60) and a house site (State site 50-10-71-3683) (Hansen 1961–1969). Other areas, however, may have been surfaced with unvegetated lava for quite some time and at the coast, even the *kīpuka* are poorly weathered *pāhoehoe* lavas.

The vegetation in Manukā varies from barren lichen-covered lava to dense *'ōhi'a* (*Metrosideros polymorpha*) forests. The upland, as defined in this study, refers

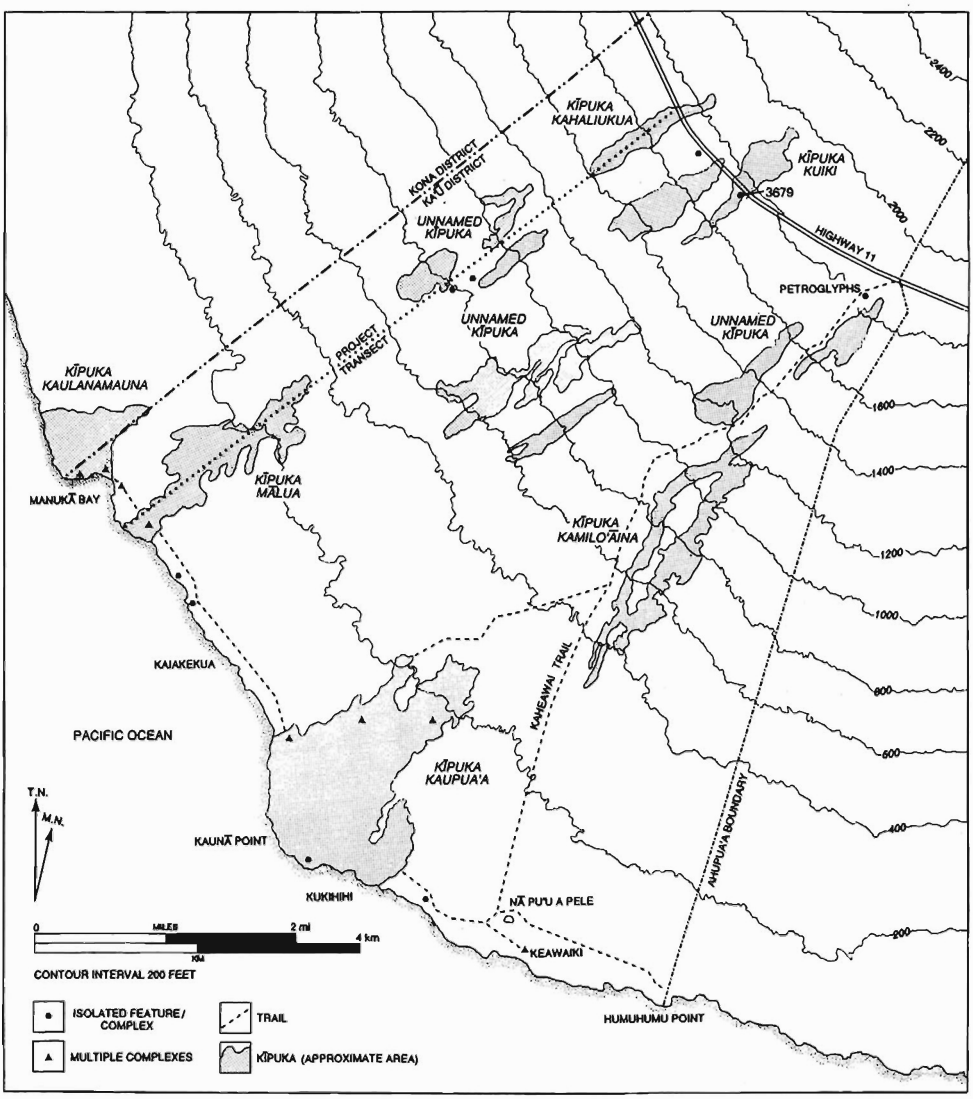


Fig. 2. Map of Manukā Ahupua'a showing location of major *kīpuka* and clusters of archaeological features.

to the mixed mesophytic zone that extends from approximately 300 to 1400 m elevation. The lava flows that surround the upland *kīpuka* support a sparse forest composed primarily of *'ōhi'a*, *alahe'e* (*Canthium odoratum*), and *lama* (*Diospyros spp.*). Within the upland Kīpuka Kuiki, the dominant species is the introduced guava (*Psidium guajava* L.), although a few native taxa are present in small numbers. The density of agricultural features within the *kīpuka* suggests that the area was extensively cleared for traditional cultivation. The general paucity of large native trees in this *kīpuka* and the dominance of a post-Contact introduction (guava) suggest that the *kīpuka* remained in agricultural production until at least 1825, when guava arrived in the Islands (Nagata 1985). Exotic grasses and scat-

tered native shrubs (e.g., *Sida fallax* walp., *Waltheria indica* L., etc.) typify the coastal *kīpuka*.

Rainfall in the *ahupua'a* averages 760 mm annually at the coast and 1270 mm a year at Manukā State Park (540 m elevation). There are several indications that water resources may have once been more plentiful in the area. Based on over 40 years of rainfall records, Manukā State Park caretaker Adolf Johansen (pers. comm., 1977) observed a considerable decrease in precipitation in the recent past. This decrease may be related to the loss of forest cover in adjacent *ahupua'a*. George Schattauer (pers. comm., 1977) noted that the area below the highway in Miloli'i Ahupua'a (see Fig. 1) was "taro country" before forest clearance in upper Pāpā Ahupua'a destroyed the fog bank in the 1950s. The numerous dead tree ferns (*Cibotium* spp.) in upland Manukā also suggest a relatively recent change in rainfall patterns. Several traditional wells are known within the *ahupua'a*, although none of them are presently operative.

Manukā has a long-standing reputation as excellent fishing grounds, considered by some to be among the finest fishing localities in the Islands (State of Hawai'i, General Lease File no. 3340, n.d.*a*). Most of the coastline consists of vertical cliffs directly exposed to open sea swells. The marine substrate is predominantly massive basalt boulders, and depth drops quickly with distance from the shore. The offshore fish community is diverse; among the more common piscine families observed by the project marine biologists were Acanthuridae, Carangidae, Elopidae, and Labridae (C. Baldwin, pers. comm., 1977).

ETHNOHISTORIC ENDPOINT

Manukā was most likely settled after A.D. 1600, when there was an archipelago-wide expansion into arid and marginal lands (Hommon 1986; Kirch 1985:303–306). According to family genealogies (M. Schattauer, pers. comm., 1977), Kainakuawalu, his wife Ohelehuaikamoku, and a group of their people came from Lauehu, Lāhainā, Maui, to settle Manukā and other Ka'ū *ahupua'a* in the mid- to late 1700s.

Early historic-period visitors to the area generally traveled along the coast, either by trails or over water. Their accounts provide insights into local activities and settlement patterns before significant Euro-American intrusions. The first historic account of Manukā was given in 1794 by Archibald Menzies, surgeon and naturalist for the HMS *Discovery*: "About noon we came to a small village named Manu-Ka where we found our chief Luhea's residence, and where we landed before his house at a small gap between the rugged precipices against which the surges dashed and broke with such violence and agitation and with such horrific appearance, that even the idea of attempting chilled us ... (1920:178)." Menzies traveled from Manukā south to the *ahupua'a* of Pākini (just north of Ka Lae; Fig. 1) and was particularly impressed by the desolation of the area, observing that "... the country between this [Pākini] and Manukā, the place we left in the morning, is one continued tract of loose, rough and peaked lava, the most dreary and barren tract that can possibly be conceived ..." (1920:181). Menzies's observations also provide a rough population estimate for the area. He noted that 50 to 60 people (most likely men) assisted in landing his canoe at

Manukā Village, suggesting that the total population could have been on the order of 150 to 180 people (Sinoto and Kelly 1975:93).

Other visits were made by missionary William Ellis in 1820 (1963:126), missionary printer Elisha Loomis shortly thereafter, and Samuel Hill in 1849. All provide rather stark descriptions of the region, suggesting that Manukā Ahupua'a was one of the less desirable places in which to live. Loomis (1937:14) and Hill (1856:240) observed that residences were concentrated on the coast, fish was the primary source of protein, and inland areas were used for farming sweet potatoes and dry taro. Upon arriving at a settlement a few miles north of Manukā Bay, Loomis found "... to our disappointment ... the men were mostly absent in the interior and would not return till towards evening," suggesting that the travel between coastal residences and inland fields was frequent and within a day's walk.

In 1848, the traditional Hawaiian system of land tenure was replaced by one of private ownership in a legislative action known as the Mahele, literally "the division." Unlike the neighboring *ahupua'a* of Kapu'a, no land claims were awarded in Manukā, although requests were made (Kingdom of Hawai'i n.d.*a*). Several subsequent requests to lease Manukā lands were also made by Native Hawaiians in the late 1800s (Kingdom of Hawai'i n.d.*b*). In the Mahele, Manukā was designated government property, as was the adjacent *ahupua'a* of Kaulanamauna. A poignant letter to the Minister of Interior in 1867 (Kingdom of Hawai'i 1867) describes the plight of Manukā residents who were unable to secure lands elsewhere: "We will not surrender the lease of said land, because, we have no kuleanas [land claims], and no purchased lands, so that we can give it up, you keep us in mind, the poor ones without land, or it will be acquired by the Foreigners, and we will then become wanderers."

There are several other indications that people continued to reside here and farm the upland areas during the historic period. Plants introduced after Euro-American Contact, in particular rose apple (*Syzygium jambos*), mango (*Mangifera indica*), and coffee (*Coffea arabica*), are scattered throughout the upland region, although not found within the mapped portion of Kīpuka Kuiki. These species were introduced in 1825 (Nagata 1985) and demarcate areas of historic activities, including habitation and agriculture. In an unnamed *kīpuka* north of Kīpuka Kuiki, for example, mango trees mark the location of several walled structures with historic artifacts. Two graves with simple headstones in Manukā State Park also indicate historic-period activities, as does a burial cave with historic grave goods (State site 50-10-72-3679) across the highway. Hansen (in State of Hawai'i n.d.*c*) also identified a historic house site with burial features to the north of Manukā, on the seaward side of the Māmalahoa Highway.

Information on historic-period settlement and economy is also provided by Manukā's census and tax records. An early census in 1835 recorded 117 people for Manukā, including 45 adult males, 40 adult females, and 32 children (*Ke Kumu Hawaii* 1835–1836:198). A rough approximation of the local population is also provided by tax records, which begin in 1855 (Table 1). Adult males over the age of twenty, dogs, horses, and mules were taxed. For Manukā Ahupua'a, the records vary from one adult male in the years 1855, 1856, and 1861 to 14 in 1869. Overall, they suggest that relatively few family groups were resident in

TABLE 1. MANUKĀ TAX RECORDS, 1855 TO 1875[a]

YEAR	ADULT MALES	HORSES	MULES	DOGS
1855	1	0	0	0
1856	1	0	0	0
1857	3	0	0	0
1858		— no record —		
1859	4	2	0	2
1860	3	3	0	0
1861	1	1	0	0
1862	9	14	0	2
1863	11	12	3	3
1864	10	18	12	5
1865	12	22	23	3
1866	12	18	23	4
1867	7	12	19	0
1868		— no record —		
1869	14	17	17	11
1870	12	24	21	5
1871		— no record —		
1872	6	10	17	4
1873	8	16	24	6
1874	13	29	27	4
1875	12	26	19	5

[a] *Source:* Kingdom of Hawai'i 1855–1875, Tax Records.

Manukā. The very low figures in the earliest years may indicate inefficient methods of tax collection rather than actual number of male residents. However, these very low figures may also reflect historic-period population loss. Numbers of Native Hawaiians declined dramatically in the early nineteenth century from Euro-American diseases (Bushnell 1993; Stannard 1989), and a smallpox epidemic in the years immediately preceding the Manukā tax records (1850 to 1854) was particularly devastating (Bushnell 1993:210; Schmitt 1973:15). In Ka'ū, the disastrous famine of 1845–1846 forced several residents to leave (Kelly 1980:54), and emigration to O'ahu was a factor in many rural areas (Schmitt 1973:16). The evidence also suggests a major population decline between 1835, when 40 adult males were recorded, and 1855–1861, when less than five adult males were recorded.

Beginning in 1862, Manukā's population began to increase. If disease were the primary factor involved in the early-nineteenth-century decline at Manukā, 1862 may mark the beginning of population recovery. However, the records indicate that post-1862 increases are at least in part related to a migration of people into Manukā from the adjacent *ahupua'a* of Kahuku. In 1869, Kahuku Ahupua'a was devastated by a volcanic eruption, a series of intense earthquakes, and a tidal wave. In the following year, several Kahuku names appear in the Manukā tax records. In addition, census information for the district at large indicates that population recovery did not occur until after 1872, whereas records from North and South Kona suggest that recovery did not take place until after 1890 (Schmitt 1968:71).

The tax records also indicate the number of dogs, horses, and mules kept by the Manukā inhabitants. Dogs were kept in part to herd and capture feral goats, which numbered in the thousands (Kingdom of Hawai'i n.d.*b*). Beginning in 1863, there was an increasing number of transport animals (horses and mules). By 1874, a total of 29 horses and 27 mules were taxed but only 13 residents. This high ratio of transport animals to people may indicate that Manukā was a way station for travelers between the more populated areas of Kona and Ka'ū. Although a circumisland "belt" road was built in the late 1830s, it was not a well-used route of travel between Kona and Ka'ū until the late 1850s to early 1860s (Apple 1973; Kelly 1980). In addition, Sinoto and Kelly (1975:98; see also Kelly 1980:17–18) noted that after 1850, inland roads became the preferred routes of travel in the Ka'ū District, as population centers grew at Kahuku, Wai'ōhinu, Hīlea, and Pāhala.

SURVEY PROCEDURES AND RESULTS

Before our study, three archaeological surveys had been carried out in Manukā by Reinecke (1930), Hansen (1961–1969; Emory 1970), and the Hawaii Statewide Inventory Team (State of Hawai'i n.d.*c*). As a result of these studies, the coastal features of Manukā were moderately well documented.

For our research, we initially carried out a reconnaissance survey in the upland portion of the *ahupua'a* to determine the nature and extent of archaeological remains in this previously unsurveyed area. Aerial photographs, ground reconnaissance, and vegetation patterns were used to identify areas of human activities. Two transects, both extending from sea level to approximately 560 m, were also traversed (Fig. 2). One of these transects corresponds to the Kāheawai Trail; the other was established by the overall project for the dual purposes of inventorying cultural remains and biological sampling. We also traversed the entire coastline to confirm previous findings.

Based on our reconnaissance, two *kīpuka* were selected for more detailed survey and recording. Kīpuka Mālua covers an area of roughly 88 ha, of which the seawardmost 10 ha were intensively surveyed for archaeological features. The *kīpuka* is a relatively unweathered *pāhoehoe* flow surrounded by more recent *'a'ā*. Kīpuka Mālua lies south of Manukā Bay, separated by two more recent *'a'ā* flows. Kīpuka Kuiki commences at approximately 595 m (1950 ft) above sea level and narrows down to a point at approximately 460 m (1500 ft). We only mapped that portion of the *kīpuka* below the Māmalahoa Highway. *'A'ā* flows surround the *kīpuka* on all sides, and the soils within are described as thin, organic, and well drained (U.S. Department of Agriculture Soil Conservation Service 1973:32).

The definition of a *feature* used herein follows Sweeney (1992); the term refers to structures that are not linked morphologically to any other structures. *Components* are subunits of space within features that are morphologically distinct from other spaces but always contiguous to one another. The definition of a *complex* follows Ladefoged et al. (1987:38; see also Sweeney 1992:42) with some modifications. A complex consists of three or more components or features separated from other complexes or features by more than 20 m.

Previous work and our own reconnaissance indicated that the archaeological

remains of Manukā are concentrated in two localities, along the immediate coast and in the uplands adjacent to or within fertile *kīpuka*. Between the coast and the uplands, a distance of 8 to 9 km, is a barren zone where only a few archaeological features are found, and those are often in association with coastal-inland trails. This "barren zone" has been described in the literature (e.g., Kirch 1985:282) for other areas of Hawai'i Island as well. At Manukā, archaeological features are also rare above 650 m (2130 ft) elevation where unweathered *'a'ā* fields predominate. Drawing on the field notes of Hansen (1961–1969), the Hawaii Register of Historic Places (State of Hawai'i n.d.*c*), and our own survey at Kīpuka Mālua, Tables 2 and 3 summarize the currently identified coastal archaeological sites in terms of form, function, number of features, and size. Given that we are often drawing on the field notes and illustrations of others (Reinecke 1930; Hansen 1961–1969; State of Hawai'i n.d.*c*; Emory 1970), recorded without our specific analytical definitions in mind, additional study may find that the actual number of components or features is greater than that indicated here.

In using these previous observations, determination of residential use is based on the presence of faunal remains (bone and shellfish), artifacts of a domestic nature, pebble pavements, and the presence of hearths. Sites identified as shrines included both platforms and enclosures, the latter occasionally constructed without an apparent entrance; a religious function is suggested primarily by the presence of elongate waterworn boulders placed in upright positions at prominent locations. Burials are tentatively identified based on unusual structural features (e.g., associated cairns), an absence of faunal and artifact materials, occasionally spatial isolation from other structures, and the presence of coral cobbles.

Chronological associations are based in large part on the presence or absence of historic-period artifacts and fauna (e.g., goat bones). Ladefoged (1991; also Ladefoged et al. 1987) and Sweeney (1992) offered additional criteria by which historic-period use may be indicated. Working in the Puna District of Hawai'i Island, Ladefoged (1991) found that historic residences were more likely to have a greater number of components per feature; as a corollary, activity areas were less spatially discrete as well. Sweeney (1992) elaborated on Ladefoged's study using data from Lapakahi and Mākaha Valley. In these two widely separated localities, she found that complexes occupied in the historic period not only had more components per feature, but were also larger than prehistoric residences. In particular, complexes with three or more components and exceeding 300 m^2 in area were more likely to have been historically occupied, as independently indicated by historic artifacts and ethnohistoric documentation (Sweeney 1992:46).

Coastal Archaeological Remains

The coastal features of Manukā are clustered at Keawaiki and within or adjacent to the *kīpuka* of Kaulanamauna (Manukā Bay settlement), Mālua, and Kaupua'a (Kaiakekua settlement) (Fig. 2). Manukā Bay is the largest concentration of structures in this *ahupua'a* (State sites 50-10-71-2146, -2148, -2149, -2151, -2152, -3660, and -3661) and was referred to as a "village" by Menzies (1920:178). Hansen (1961–1969) recorded roughly ten habitation complexes. The small number of archaeologically recorded complexes suggests that the 50 to 60 people

TABLE 2. SUMMARY OF COASTAL SITES OF MANUKĀ

STATE SITE NO.	BISHOP MUSEUM NO.	PRIMARY FEATURE	NO. OF FEATURES	PRIMARY FUNCTION	AREA M^2
Manukā Bay, general					
-2146		Petroglyphs	12	Undetermined	
-2148		Platform	?	Undetermined	?
-2149		Platforms		Habitation	?
-3661	B24-2	Stepped terrace	2	Shrine	59
South Manukā Bay (Complex 50-10-71-2152)					
-2151	?				
-3675	B24-20	Platform	1	Habitation	92
-3682	B24-30	Enclosure	4+	Habitation	31
-3683	B24-31	Platform	1	Habitation	47
	B24-35	Enclosure	2	Habitation	12
	B24-37	Enclosure	1	Habitation	38
	B24-39	Platform	1	Habitation	67
	B24-40	Platform	1	Habitation	26
	B24-41	Platform	1	Habitation	?
	B24-42	Platform	1	Habitation	47
	B24-43	Platform	1	Habitation	80
	B24-44	Platform	1	Shrine	21
	B24-34	Vault	1	Burial	1
-3660	B24-1	Paved ramp	1	*Hōlua* slide	
-3674	B24-19	Petroglyphs	25	?	
-3689	B24-21	Enclosure	1	Goat trap?	
	B24-32	Platform	1	?	22
	B24-33	Walled pit	1	Well	
	B24-36	Enclosure	1	Animal pen?	19
	B24-43	Cairn	1	Marker	3
-3681	B24-29	Paved trail	1	Travel	
	B24-38	Paved trail	1	Travel	
-2163	B24-60	Paved trail	1	Travel	
Kīpuka Mālua (State Complex 50-10-71-2153) (see Table 3)					
Kaiakekua (Complex 50-10-71-2159)					
-3662	B24-3	Enclosure	5	Habitation	734
-3685	B24-5	Enclosure	2	Habitation	24
-3664	B24-6	Enclosure	2	Habitation	355
-3666	B24-8	Platform	2	Habitation	21
-3684	B24-4	Platform	1	Burial	7
-3667	B24-9	Enclosure	1	Habitation	?
-3668	B24-10	Enclosure	1	Habitation	32
-2158		Cave	1	Well	
		Trail[a]	1	Travel	
-2157		Platforms	2	Burial	48
Kīpuka Kaupua'a, inland					
-2160		Platforms	6+	Habitation	c. 20
-3688	B24-18	Cave	1	Habitation	
-3690	B24-25	Cave	1	Habitation	
-3691	B24-26	V shape	1	Goat herding	
-3689		V shape	1	Goat herding	
-3669	B24-11	Petroglyphs	+	Undetermined	

(*Continues*)

TABLE 2. (*continued*)

STATE SITE NO.	BISHOP MUSEUM NO.	PRIMARY FEATURE	NO. OF FEATURES	PRIMARY FUNCTION	AREA M^2
Kaunā Point					
-3663	B24-7	Enclosure	1	Shrine	14
Other					
-3669	B24-11	Petroglyphs	+	Unknown	
-2154		Enclosure	2	Habitation	?
-2155	B24-56	Platform	2	Habitation	480
-2155	B24-57	Shelter	2	Habitation	
-2155	B24-58	Trail	1	Travel	
-2156	Reinecke 88 shelters		3+	Habitation	?
Keawaiki (Complex 50-10-71-2161)					
-3672	B24-13	Platforms	3	Habitation	?
		Enclosures	4	Habitation	?
-3673	B24-14	Platforms	3	Habitation	?
		Enclosures	2	Habitation	?
-3671	B24-16	U shape	1	Habitation	16
-3686	B24-12	Paved ramp	1	Canoe ramp	
-3670	B24-15	Trail	1	Travel	
-3687	B24-17	Well	1	Well	

[a] Reported in the Hawaii Register of Historic Places (State of Hawai'i n.d.) but not assigned a State number.

(men?) who assisted Menzies in landing his canoe may have come from not only Manukā Bay, but also from other settlements along this coast. The undated, but relatively recent, lava flow that flowed directly into Manukā Bay covered at least one, and probably more, Native Hawaiian residences. Other features found at Manukā Bay include a stepped terrace shrine, a burial platform, a historic goat corral, petroglyphs, stepping-stone trails, and a well. We saw few indications of coastal agriculture, contrasting with surveys in other arid lowland habitats (e.g., Allen 1984; Graves 1990; Ladefoged et al. 1987). Among the notable features at Manukā Bay is a traditional Hawaiian sledding (*hōlua*) ramp (State site 50-10-71-3660). The *hōlua* slide is built on an *'a'ā* flow, is over 10 m long, and is well preserved except for its lower end, where it is truncated by a jeep road.

Both prehistoric and historic habitation is indicated at Manukā Bay. One complex (50-10-71-3682) has a large enclosing wall, typical of historic-period residential compounds or *kuleana*, and numerous historical artifacts were recorded (Hansen 1961–1969). The Site 3682 wall surrounds several features (platforms and terraces) that, as a whole, cover a fairly large area.

Kīpuka Mālua (State site 50-10-71-2153) lies c. 800 m southeast of Manukā Bay (Fig. 3) and is separated from Kīpuka Kaulanamauna by two *'a'ā* flows, one fairly recent and the other two somewhat weathered. It is unclear whether the structures of Kīpuka Mālua represent a separate community, distinct from Manukā Bay, or were socially and temporally related to this larger community before the intervening *'a'ā* flows. Hansen (1961–1969) recorded 29 architectural features

TABLE 3. SUMMARY OF STATE OF COMPLEX 50-10-71-2153 IN KĪPUKĀ MĀLUA

PROJECT DESIGNATIONS[a]	BISHOP MUSEUM NO.	FORMAL DESCRIPTOR	FUNCTIONAL DESCRIPTOR	AREA M^2
Complex 1: Residential Complex				
Feature A				
Component-1	B24-46	Platform	Habitation	
Component-2	B24-46	Enclosure	Shrine	21.4
Component-3	B24-47	Platform	Burial	43.5
Component-4		Platform	Habitation	31.5
Component-5	B24-46	Enclosure	Undetermined	3.6
Component-6	B24-48	Ramp	Walkway	
Component-7	B24-48	Enclosure	Habitation	12.2
Component-8	B24-48	Platform	Habitation	15.5
Component-9		Platform	Habitation	26.7
Component-10		Level area	Undetermined	3.0
Feature B		Trail	Travel	
Feature C	B24-50	Platform	Burial?	8.1
Feature D	B24-49	Platform	Burial?	16.8
Feature E	B24-48	Basins	Undetermined	
Complex 2: Burial(?) Complex				
Features A–D	B24-53	Mounds	Burial?	
Feature E		Enclosure	Burial?	68.0
Complex 3: Petroglyph Complex				
Features A–V	B24-24	Petroglyphs	Undetermined	
Complex 4: Burial(?) Complex				
Feature A		Platfrom	Burial?	13.5
Feature B		L shape	Undetermined	
Site 5		Platform	Shrine	16.5
Complex 6: Storage Complex				
Feature A	B24-45-A	Enclosure	Canoe shed	32.4
Feature B	B24-45-B	Enclosure	Habitation	20.0
Feature C	B24-45-C	Enclosure	Canoe shed	32.8
Feature D	B24-45-D	Enclosure	Habitation	7.8
Feature E	B24-45	Enclosure	Undetermined	171.8
Feature F		Platform	Undetermined	10.0
Complex 7: Residential/Burial Complex				
Feature A		Platform	Undetermined	16.0
Feature B		Platform	Shrine?	12,0
Feature C	B24-55	Cave	Shelter	
Feature D		Cairn	Undetermined	
Feature E		Rock mound	Undetermined	
Feature F		Paved area?	Undetermined	
Feature G		Wall segment	Undetermined	
Feature H		Enclosure	Undetermined	60.5
Feature I		Paved area?	Undetermined	
Feature J		Enclosure	Habitation?	62.4
Feature K		Paved area?	Undetermined	13.0
Complex 8: Burial? Complex				
Feature A		Enclosure	Undetermined	2.3
Feature B				
Component-1	B24-54	Enclosure	Burial	110.0
Component-2		Wall	Undetermined	
Feature C		Filled cavity	Ritual?	

(*Continues*)

TABLE 3. (*continued*)

PROJECT DESIGNATIONS[a]	BISHOP MUSEUM NO.	FORMAL DESCRIPTOR	FUNCTIONAL DESCRIPTOR	AREA M^2
Complex 9: Burial? Complex				
Feature A		Platform	Undetermined	8.4
Feature B		Platform	Burial?	10.0
Complex 10: Residential Complex				
Feature A		Enclosure	Undetermined	36.0
Feature B		Cache	Storage	
Feature C		Platform	Burial?	
Feature D		Platform	Burial?	20.0
Feature E		Cache	Storage	
Feature F				
Component-1		Enclosure	Habitation	90.0
Component-2		Enclosure	Habitation	31.5
Feature G		Enclosure	Habitation	4.5
Feature H		Enclosure	Habitation	8.7
Feature I				
Component-1		Enclosure	Habitation	8.3
Component-2		Enclosure	Habitation	7.5
Feature J		Rockshelter	Shelter	
Site 11		Cave	Shelter	
Site 12		Cave	Shelter	
Complex 13: Residential Complex				
Features A–I	B24-51	Cave	Shelter	
Features A–I	B24-52	Cave	Shelter	
Site 14		Cave	Shelter	
Complex 15: Residential Complex				
Feature A	B24-23 (-3677)	Cave	Shelter	
Feature B		Cave	Shelter	
Site 16		Cave	Shelter	
Complex 17: Residential Complex				
Feature A		Platform	Burial?	14.3
Feature B		Cave	Shelter	
Feature C		Cave	Shelter	
Feature D		Platform	Habitation?	12.0
Feature E		Paved area	Undetermined	1.5
Feature F		Paved area	Undetermined	10.5
Feature G		Platform	Undetermined	15.8
Feature H		Cave	Shelter	
Feature I		Cave	Shelter	
Feature J		Cave	Shelter	
Feature K		Platform	Habitation	16.5
Complex 18: Residential Complex				
Feature A		Petroglyphs	Undetermined	
Feature B		Cave	Shelter	
Feature C	B24-22 (-3676)	Enclosure	Shrine	21.6
Feature D		Enclosure	Undetermined	132.0
Feature E		Cave	Shelter	
Feature F		Enclosure	Shrine?	7.8
Feature G		Aligment	Undetermined	

(*Continues*)

TABLE 3. (*continued*)

PROJECT DESIGNATIONS[a]	BISHOP MUSEUM NO.	FORMAL DESCRIPTOR	FUNCTIONAL DESCRIPTOR	AREA M^2
Feature H		Cave	Shelter	
Feature I		Enclosure	Animal pen?	47.5
Feature J		Filled area	Undetermined	6.0
Feature K		Platform	Undetermined	4.0
Feature L		Cave	Shelter	
Feature M		Cave	Shelter	
Complex 19: Residential Complex				
Feature A		Cairn	Undetermined	
Feature B		Cairn	Undetermined	
Feature C		Cairn	Undetermined	
Feature D		Enclosure	Shelter	21.0
Feature E		Paved areas	Habitation	120.0
Complex 20: Residential Complex				
Feature A		Walls (2)	Undetermined	
Feature B	B24-59	Shelter	Habitation	
Feature C	B24-59	Platform	Habitation	9.0
Feature D	B24-59	Platform	Habitation	7.0
Complex 21: Residential Complex				
Feature A		Enclosure	Shelter	
Feature B		Enclosure	Shelter	
Complex 22: Residential/Burial? Complex				
Feature A		Filled crevice	Burial?	
Feature B		Cave	Shelter	
Feature C		Cave	Shelter	
Site 23		Cave	Shelter	
Complex 24				
Feature A		Cairn	Undetermined	
Feature B		Cairn	Undetermined	
Not seen	B24-58	Trail	Travel	
Not seen	B24-56	Plaform	Habitation	56.0
Not seen	B24-57	Enclosure	Habitation	?

[a] Features as defined in text and identified by the authors.

and components in this area, and our study added another 77 features and components. The Kīpuka Mālua structures are limited to the seawardmost 10 ha of the *kīpuka* and are concentrated in four areas. Altogether we recorded 11 distinct residential complexes, several possible burial features, three probable canoe sheds, at least two shrines, and over 22 utilized shelter caves (some with multiple entrances).

Several of the Kīpuka Mālua sites are found along the immediate coast, the most prominent of which is a large complex (Complex 1) with contiguous and free-standing platforms and enclosures (pl. I), as well as nine pecked bowls. Nearby is a field of 25 petroglyphs (Complex 3) composed largely of human figures. Complex 1 is atypical in its size and architectural complexity, and may have functioned as a chiefly residence or a men's house. Northwest of Complex 1 is a series of structures that include three probable canoe sheds (Complex 6). To the southeast are several poorly preserved features (Complex 7) that appear to include

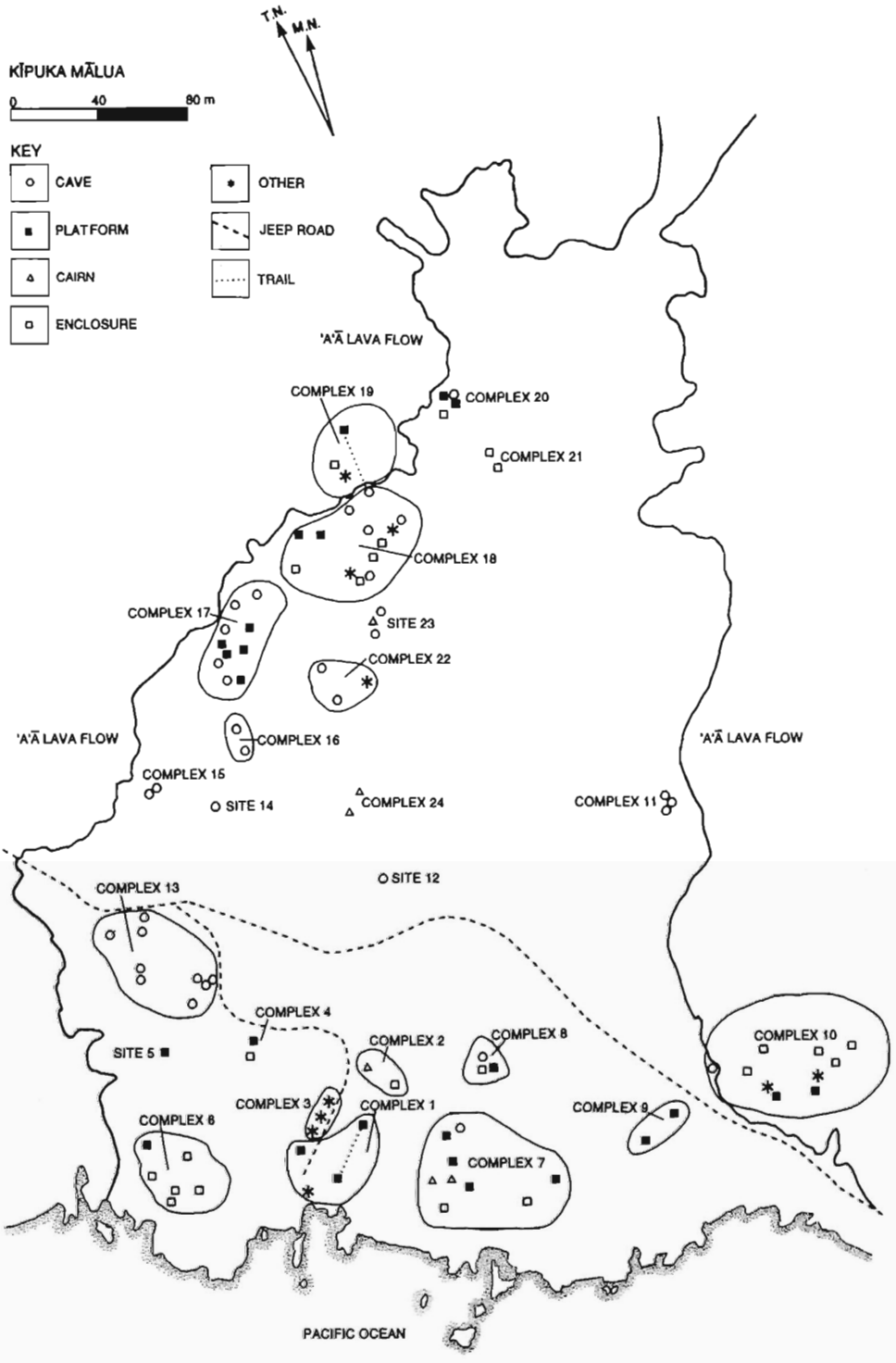
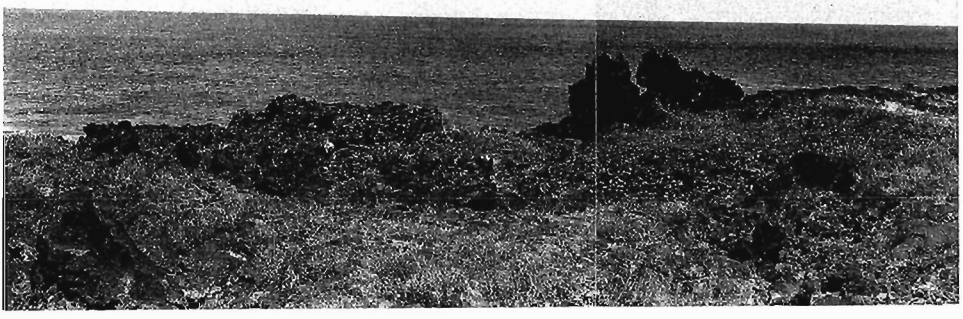


Fig. 3. Distribution and formal characterization of archaeological features in State Complex 50-10-71-2153, Kīpuka Mālua.



Pl. I. Kīpuka Mālua Complex 1, looking seaward.

habitation structures and, inland from these, two possible burial features (Complex 9).

A second concentration of sites is found on top of the *'a'ā* flow to the southeast (Complex 10). Most of these appear to be residential in function, but one burial may also be present. This complex of platforms, shelters, and C shapes are interconnected physically and by trails. Marked variation in the density of faunal remains indicates functionally distinct activity areas.

Another concentration of features is found near the edge of the northeast lava flow. Complex 19 lies on top of the *'a'ā* flow, but Complexes 17 and 18 are on the *kīpuka* floor, centered around natural shelter caves. All three complexes appear to be primarily residential in function, and Complex 18 includes a shrine.

Several natural lava-tube shelters are also found in Kīpuka Mālua. Complex 13 with nine shelters lies near the present-day jeep road as it enters the *kīpuka* from the northeast. The amount of deposit within the shelters varies considerably, from small amounts of fauna (shellfish, fish bone, mammal, and bird) and flora (e.g., *Aleurites* nutshells, gourd fragments) to what appear to be substantial cultural deposits. Several artifacts were noted, including coral and sea urchin abraders, fishhook fragments, and cut bone. In a few cases, the shelters have structural features, both internal (e.g., alignments) and external (e.g., filling in of crevices). Most of these natural shelters appear to have been for short-term use, as inferred from their small size, the minimal structural alterations, and the absence of other nearby structures. The faunal and artifact contents indicates that they were used in conjunction with exploitation of marine fauna. Complex 20 is a shelter tube with two contiguous platforms, the latter features suggesting that the site was used on a more long-term basis.

At Kaiakekua, Hansen (1961–1969) recorded approximately six residential complexes, a well, and a probable burial platform. The Statewide Inventory recorded another six habitation platforms roughly 500 m inland from the coast in this section of the *ahupua'a*. The largest Kaiakekua complex (State site 50-10-71-3662) was occupied historically, as indicated by the presence of Euro-American artifacts. The large size and numerous components of Site 3662 also suggest his-

toric occupation, as discussed above. Historic-period occupation at Kaiakekua is also indicated by a 1928 letter from J. M. Kalaniweo (State of Hawai'i n.d.*a*), which describes a wood-frame house being moved from here in 1928.

Keawaiki (State site 50-10-72-2161), located at the south end of the *ahupua'a*, lies on a rugged *'a'ā* flow but is a place where a canoe landing is possible, as the literal translation, "small passage," suggests. Ellis (1963:126) recorded Keawaiki as an "emergency canoe landing," and the stone-paved ramp leading to the water was most likely used for launching and landing canoes. Other structures in the area include two small habitation complexes, one single-feature habitation site, and a traditional well. A stepping-stone trail leads to the nearby cinder cone Nā Pu'u a Pele, and from this locality trails run north, south, and inland, the latter joining the Kāheawai Trail.

Upland Archaeological Remains

The agricultural areas of Manukā are also concentrated within *kīpuka*. In addition to Kīpuka Kuiki, which was partially mapped in detail, three other upland *kīpuka* with agricultural features were identified: Kīpuka Kamilo'āina, Kīpuka Kahaliukua, and an unnamed *kīpuka* south of the project transect, between c. 260 m (850 ft) and 350 m (1150 ft) elevation (see Fig. 2). Agricultural features are also found in the portion of Kīpuka Kuiki above Manukā State Park.

The most well-developed agricultural complex identified during the upland reconnaissance lies in the portion of Kīpuka Kuiki below the Māmalahoa Highway. It is interesting that the name of this *kīpuka* translates as "to quilt," possibly a reference to the pattern of agricultural plots and suggestive of historic-period use. This complex was mapped in detail and includes loosely mounded rock ridges, modified lava channels, rock mounds of various sizes, walled areas, and faced, soil-filled terraces (Fig. 4). Because traditional agriculture is archaeologically poorly known in this southern part of Hawai'i Island, the Manukā system is described here in some detail.

The Kīpuka Kuiki field system is incompletely partitioned into a series of individual fields by terrace facings and ridges of loosely mounded rocks. The size of these individual fields ranges from c. 10 by 15 m to 20 by 50 m. The loosely mounded ridges range in height from 40 to 70 cm and in width from 1.5 to 2 m. In general, they crosscut the topographic contours of the land. Wall faces are occasionally distinguishable, but for the most part, the ridges appear to be loose piles of rocks. Whether this is an artifact of time or indicative of the original construction techniques is uncertain.

Rock mounds are concentrated in the central and eastern two-thirds of the *kīpuka*. They fall into three size classes: small mounds, 1–1.5 m in diameter and 30–50 cm high; medium mounds, 1.6–2.5 m in diameter and 51–70 cm high; and large mounds, 2.6–4 m in diameter and 71–100 cm high. These rock piles are closely associated with the mounded ridges. The smaller mounds appear to be arranged in rows; the larger mounds are less frequent and located at irregular intervals.

The southwestern portion of the *kīpuka* is characterized by a series of partially faced, soil-filled terraces (pl. II). The terrace faces range in height from 35 to 85 cm. In a single example, several mounds were built on the surface of the terrace.

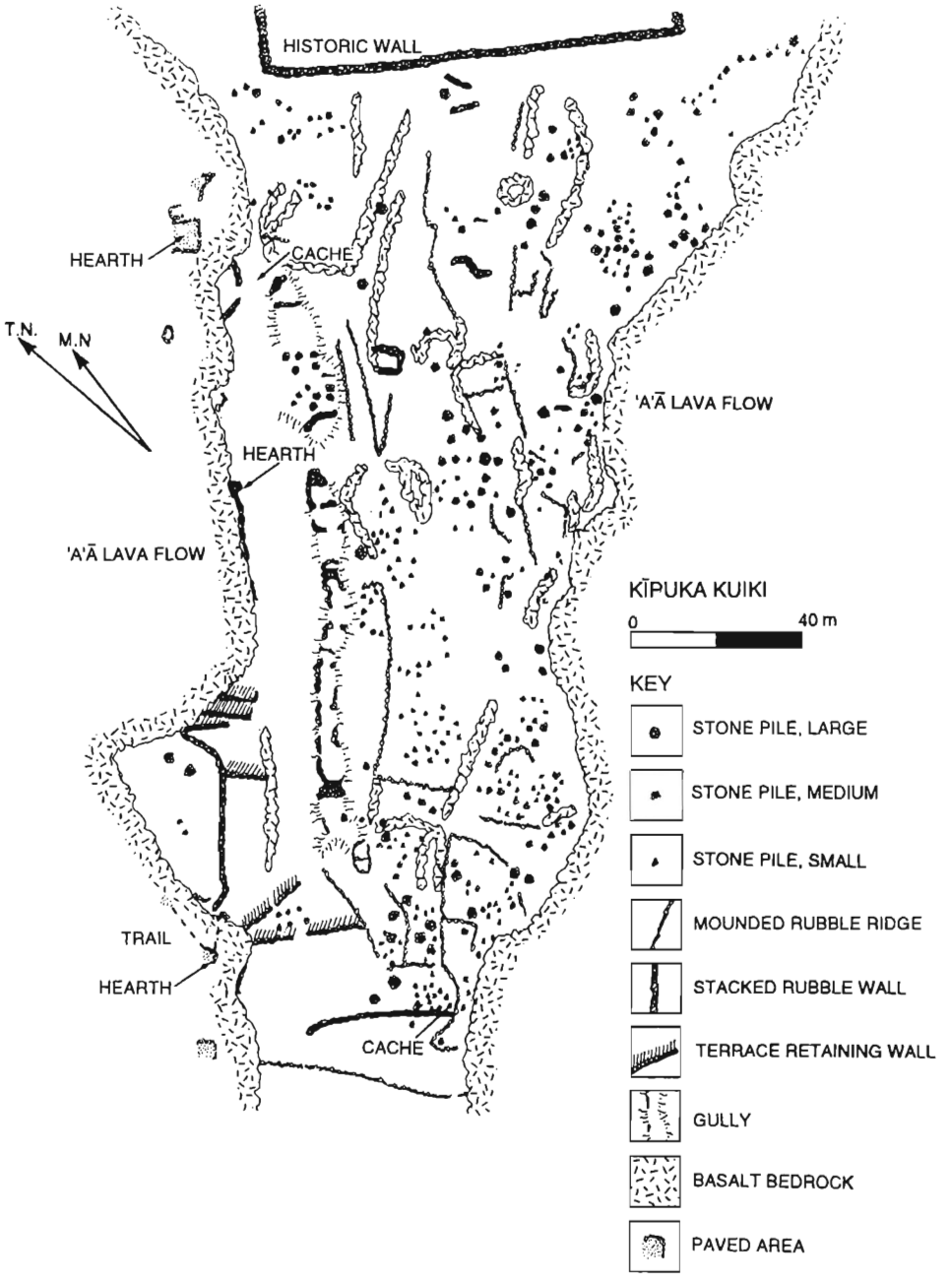


Fig. 4. Kīpuka Kuiki agricultural system; note scattered residential features along northwestern edge of *kīpuka*.

Pl. II. Example of agricultural terrace feature in Kīpuka Kuiki.

Two natural lava channels within the *kīpuka* are modified, one by short, discontinuous, revetments. The other extends for c. 100 m along the length of the agricultural complex and is extensively modified (pl. III). This larger channel varies in depth from 1 to 2.5 m and in width from 4 to 8 m. Two walls, topped with flat *'a'ā* slabs, span the channel and may have served as pathways from one side of the agricultural complex to the other. Ten smaller subdivisions between these larger revetments are suggested by rubble alignments that extend out from the channel walls but do not reach completely across. The steep sides of the lava channel are elaborately faced in places (pl. III).

The agricultural features of Kīpuka Kuiki are similar to those described ethnographically from the Kona District of Hawai'i. Menzies recorded the dryland agricultural complexes of Kealakekua Bay in 1794, noting the following: "In clearing the ground, the stones are heaped up in ridges between the little fields and planted on each side, either with a row of sugar cane or the sweet root of these islands (*Dracena ferra*) [syn. *Cordyline fruticosa* (L.) A. Chev.] where they afterwards continue to grow in a wild state, so that even these stony uncultivated banks are by this means made useful to the proprietors, as well as ornamental to the fields they intersect" (1920:75). Menzies also observed that sweet potatoes were planted "... three or four feet apart and earthed up around their stems in much the same manner as the common potatoes are treated in England" (1920:75).

The low-mounded ridges of the Kīpuka Kuiki field system were most likely depositories for unwanted rocks. Plantings on these ridges would have acted to reduce transpiration from the fields, an important consideration in an area like Manukā where precipitation quickly percolates through the porous substrate.

Pl. III. Constructed wall and other modifications to this natural topographic feature at southwest end of largest lava channel in Kīpuka Kuiki.

The large mounds of Kīpuka Kuiki may also be the result of field clearing, and in this sense are functionally analogous to the ridges.

The small mounds, in contrast, are more uniform in size and spatial distribution. Many of these mounds currently support sizable trees (c. 20 cm in diameter), attesting to the favorable growing conditions they provide. Mounds of similar size and construction have been recorded ethnographically for the cultivation of sweet potato (e.g., Handy and Handy 1972:131–132; Wilkes 1845:188), pumpkin (Sinoto and Kelly 1975:146–147), and watermelon, and all three cultigens were historically grown in nearby Kapu'a Ahupua'a at comparable elevations (Kingdom of Hawai'i n.d.*a*). The Kapu'a Land Commission testimonies also record the cultivation of taro, hala (*Pandanus*), gourd, banana, sugarcane, yams, and arrowroot in this upland region. In the vicinity of Manukā State Park, and further inland, Handy and Handy (1972:569) observed feral taro, native Hawaiian banana, and sweet potato, including one variety of the latter that was considered to be distinct to the area.

The function(s) of the Manukā terraces and the modified lava channel are more ambiguous. This area was known for dryland taro cultivation, and the terraces may have been used for this crop. Local resident George Schattauer (pers. comm., 1977) noted that upland areas of both Honomalino and Pāpā Ahupua'a (see Fig. 1) were considered "dryland taro country," and the latter was once extensively terraced at c. 730 m. The Kīpuka Kuiki lava channels, providing moister microenvironments, may have been used for a crop with higher water requirements, as for example *'awa* (*Piper methysticum*).

A few habitation structures were also identified at Kīpuka Kuiki (see Fig. 4).

These were limited to the lava flow along the northern periphery of the *kīpuka*, were small in size, and represented minimal labor investments. They include leveled areas, low terraces, and low enclosures, commonly in association with stone-lined hearths. No faunal materials or artifacts were observed in association with the structures. Altogether, three such complexes, consisting of one to three features, were recorded. In two cases probable animal pens are found on the *kīpuka* floor nearby.

SUMMARY OF MANUKĀ ETHNOHISTORIC AND ARCHAEOLOGICAL STUDY

Spatial and Functional Patterns

The archaeological study demonstrates the important role *kīpuka* (islands of older substrate surrounded by more recent lava flows) played in shaping land-use patterns at Manukā. In the uplands, *kīpuka* were favored for agricultural activities. These arable lands were at a premium, to the extent that residences were situated on the adjacent *ʻaʻā* flows despite the greater labor investments needed to make these rugged *ʻaʻā* surfaces habitable. At the coast, *kīpuka* were the primary residential localities, offering smoother (i.e., *pāhoehoe* as opposed to *ʻaʻā*) living surfaces, shelter caves, and often protected bays and inlets (in part formed by the extension of *ʻaʻā* flows into the sea). Areas outside of *kīpuka* along the coast saw little habitation, despite equal proximity to important marine resources.

Archaeological evidence suggests that throughout prehistory, human activities at Manukā were focused on the coast. Four coastal concentrations of sites were recorded, one each at Manukā Bay (Kīpuka Kaulanamauna), Kīpuka Mālua, Kaiakekua (Kīpuka Kaupuaʻa), and Keawaiki. The sites found at Manukā Bay, Kīpuka Mālua, and Kaiakekua suggest relatively permanent residences, by virtue of the following: (1) the abundance of features within each of these localities (temporary habitation features more often being found in isolation or in small groups); (2) greater architectural complexity of individual features (i.e., more features and components); (3) the larger area or volume of the structures, reflecting greater labor investments; (4) more formal and well-constructed architecture (although original form can be difficult to discern); (5) specialized architecture, such as the *hōlua* slide at Manukā; and (6) the abundance of associated faunal remains. In contrast, the sites at Keawaiki, and many of the small shelter caves of Kīpuka Mālua, were more likely occupied on a recurrent but short-term basis. Archaeological excavations would strengthen these observations (e.g., Kirch 1985:248–251) but probably not substantially change the overall pattern as described herein.

In all four coastal localities, a marked degree of nucleation is apparent (see also State of Hawaiʻi n.d.*c*). This nucleation is in part a reflection of the apparent preference for the smoother *pāhoehoe* substrates found within *kīpuka*, as opposed to adjacent *ʻaʻā* flows. However, even within the large *kīpuka* of Kaupuaʻa, habitation sites are nucleated in two localities rather than widely dispersed along the *kīpuka* coast. The Manukā evidence demonstrates how a strong environmental constraint may produce nucleation that might not occur under more amenable environmental conditions. However, nucleation is in general a poorly measured concept in Hawaiian archaeology, one that warrants closer examination.

The upland portion of Manukā (i.e., above 300 m) was primarily used for agriculture. Lands within *kīpuka* were modified to various degrees for plant cultivation and possibly animal husbandry, as indicated by walls, terraces, mounds, enclosures, and, in some cases, feral cultigens. The latter, and mid-nineteenth century Land Commission records from nearby localities, indicate that a range of traditional crops could potentially have been grown in upland Manukā, including staples such as dryland taro and sweet potato. A small number of residential sites were also identified in the upland area. These were dispersed, often located at the edge of *kīpuka*, and suggested relatively low labor investments for their construction. Upland residence and agriculture is also recorded at comparable elevations in nearby Kapu'a Ahupua'a (Kingdom of Hawai'i n.d.*a*), where eight of the nine Land Commission Awards were located.

Between 50 and 300 m elevation, archaeological features are rare to absent. This barren zone has been described previously for other areas of Hawai'i Island, and in the Manukā case correlates with vast expanses of poorly vegetated *'a'ā* flows. Archaeological features are also scarce above 650 m elevation, a second area of rough lava and little vegetation.

Demographic Trends

The number of archaeological structures recorded throughout the *ahupua'a* suggests that Manukā's prehistoric population was never large. An early historic-period account of 1794 suggests a local populace at Manukā Bay on the order of 100 to 150 people (Menzies 1920); this may have included people from neighboring communities. Somewhat larger populations may have lived here in the prehistoric past, as Menzies's observation was made 16 years after Euro-American diseases had greatly reduced Native Hawaiian populations (Bushnell 1993; Stannard 1989). By 1835, Manukā's population had declined to 117, and by 1855 it appears to have been reduced by half or more.

Temporal Trends

Although radiometric evidence is lacking, family genealogies, coupled with archaeological models of sociopolitical development, suggest that permanent settlement of Manukā dates to about the late 1600s to mid-1700s. It was during this period that populations expanded into some of the more marginal environments of Hawai'i (Hommon 1986), particularly dry leeward localities and areas with limited agricultural potential.

At Manukā, the architectural construction techniques, feature and complex size, and associated artifact assemblages all suggest that most of the coastal structures were built and used before Euro-American Contact. Prehistoric use of the uplands appears to have been mainly for agricultural activities and *possibly* some short-term use of adjacent *'a'ā* flows for habitation. Apparently, movement between upland and coastal localities was on a short-term, possibly daily, basis. No large upland residential population, such as that hypothesized by Kirch (1971, 1979) and Sinoto and Kelly (1975) at Kalāhuipua'a, Palauea, and Wai'ahukini was found at Manukā.

In the mid- to late 1800s, residential use of the coast continued to a limited

degree, minimally at Manukā Bay and Kaiakekua. Agricultural use of the inland *kīpuka* also continued, as indicated by historic plants (both economic and otherwise) found in several upland localities. In the case of Kīpuka Kuiki, the *kīpuka* name suggests that the area was used historically, and the predominance of the Euro-American-introduced guava suggests that the agricultural complex was not abandoned until after 1825. Historic burials, widespread historic plant introductions commonly associated with residences (e.g., rose apple, mango), and structures with historic artifacts all suggest historic-period use of the uplands for residential purposes, probably on a more permanent basis than in the prehistoric past. Tax records from 1855 to 1875, coupled with demographic and economic trends seen elsewhere in West Hawai'i, intimate that the mid-1800s may have seen a reorganization of economic activities around the inland belt road (e.g., the present Māmalahoa Highway). During the late nineteenth century, Manukā may have served as a way station between centers of commerce in Ka'ū and Kona.

When compared with the Handy and Pukui (1972) model of traditional Hawaiian settlement patterns, the Manukā evidence is not congruent. Primary residences were apparently on the coast before Euro-American intrusions, and the inland area appears to have seen little residential use except possibly that of a temporary nature. Evidence from the historic-period is more ambiguous, and the local population may have been quite small, as a result of emigration and declines from introduced diseases. However, there are some suggestions that settlement patterns changed in the historic-period, coming to more closely approximate the Handy and Pukui (1972) *'ohana* model.

MODELING TRADITIONAL HAWAIIAN SETTLEMENT AND LAND USE

Handy and Pukui's (1972) early-twentieth-century ethnography of the Hawaiian family system, or *'ohana*, was a landmark study. The *'ohana* model, the outgrowth of this work, has figured in both anthropological and archaeological investigations of traditional Hawaiian kinship, economics, and settlement patterns (e.g., Clark 1987; Heighton 1971; Hommon 1969; Kirch 1971; Rosendahl 1972; Sahlins 1992). Studies in other localities, however, found significant departures from the *'ohana* model as described by Handy and Pukui. In addition, recent increased awareness of post-Contact population loss and historic-period economic transformations raises further concerns as to the temporal depth of the Ka'ū family system that Handy and Pukui (1972) documented. It is, thus, an appropriate juncture to reexamine the *'ohana* model and its archaeological expression in particular. In this concluding section, we offer a more general theoretical model that accounts for both residential patterns associated with the Ka'ū *'ohana* system and those observed at other localities across the Hawaiian archipelago.

Role of Environmental Variability

Studies in behavioral ecology suggest several features of human settlements that are shaped by environmental variables, including residential location and patterns of mobility. Although nonhuman species and human foragers are the best studied, the ecological principles identified by behavioral ecologists have applica-

bility to agricultural populations, like those of prehistoric Hawai'i, as well (e.g., Preucel 1990; Vickers 1989). As Kelly (1992:51) suggested, factors that affect the success of foraging, such as time, return rates, costs, and risks, are equally relevant to horticulturalists.

It is not surprising that settlement patterns are strongly affected by the location and abundance of subsistence resources or, in the case of agriculturalists, of habitats suitable for plant cultivation. Behavioral ecologists and ethnographers have found that clumped and abundant resources tend to result in comparable and coincident residential patterns (e.g., Birdsell 1953; Boone 1992; Cashdan 1992; Harpending and Davis 1977; Whitlam 1981; Williamson and Sabath 1982). Alternatively, if resources are patchy, then dispersed residences may be more cost-effective. In both cases, these patterns reflect strategies to minimize travel time to critical resources or habitats. As favored habitats fill, factors such as defensibility of the home base and avoidance of other groups' territories may become increasingly important in shaping settlement patterns, as discussed below.

Although the relationship between resource availability and settlement patterns is strong, the distribution and abundance of critical resources is rarely homogenous, coincident, and coeval. Consequently, human populations develop a variety of strategies for dealing with spatial and temporal variability. Among these strategies are variation in group size, group aggregation (e.g., dispersed or clustered), mobility, exchange, resource intensification, and storage practices. Of particular relevance to discussions of Native Hawaiian settlement patterns is the strategy of mobility, given widespread archaeological evidence that many Native Hawaiian habitation features were occupied on a seasonal or otherwise short-term basis (e.g., Clark 1987; Kirch 1985:248–257; Ladefoged et al. 1987).

Mobility is a particularly useful strategy for mitigating resource variability in time or space. Theoretically, mobility can serve to increase return rates on spatially dispersed resources, average out temporal variations in abundance, or mitigate the effects of resource loss or failure. The importance of mobility in patchy environments is well recognized for hunters and gatherers. However, mobility may also be a strategy for agricultural populations attempting to match resource availability. Binford (1980), and more recently Kelly (1992), recognized that mobility may vary in both form and scale. Residential mobility may include cyclical shifting of residences, cyclical shifting of territories, or permanent population movements (migration). Residential mobility may also occur at varied demographic (individual to entire population) and geographic (intraterritory to wholesale migration) scales. Alternatively, a single residential base may be maintained, with movement between resource zones on a daily or otherwise frequent basis, a strategy Binford (1980) referred to as "logistical mobility" (see also Kelly 1992). As defined by Binford (1980), logistical strategies involve skilled collectors seeking out specific resources and frequently utilizing temporary field camps. Although his discussion was aimed at hunter-gatherer groups, logistical strategies may also occur among agricultural populations.

The strategy of mobility has significant costs and, in many contexts, may not be worthwhile. Consumers must weigh the costs of moving, relative to the benefits of greater access to particular resources. Among those costs are the potential risks that a requisite return rate will not be realized, as well as the loss of resource(s) the group is leaving. Other costs relate to the loss and subsequent re-

building of the residence itself, the amount of goods that must be moved, and the distance these goods must be carried.

Under ideal conditions, such as an environment where resources are abundant, diverse, and geographically compact, mobility has little advantage (see also Cashdan 1992:245–246). When habitats that supply both carbohydrates and protein are coincident or contiguous in their distributions, then mobility is unnecessary or greatly reduced (e.g., some windward Hawaiian valleys). Under these conditions, we should expect comparatively early development of relatively stable residential units (see also Rafferty 1985:122–127). In contrast, the benefits of mobility are realized in environments where the key resources zones are patchy or dispersed or in environments of overall low productivity. Rafferty's (1985:123) more general model of the development of sedentariness suggests that environments where resources are moderately dispersed, productivity is low, and diversity is high will lead to sedentary but dispersed settlements, perhaps not unlike the patterns described by Handy and Pukui (1972) for central Ka'ū. In environments where resources are geographically dispersed and both productivity and diversity are low (e.g., Manukā Ahupua'a), Rafferty (1985) predicted residential mobility. To this we add the possibility of logistical mobility, as appears to have been the case at Manukā in the prehistoric period. Particularly in areas of low productivity, shifting residences or logistical mobility may have been the only means of maintaining a viable subsistence economy.

Conditions of Change

Although resource abundance and distribution may play a significant role in initially defining population distributions and residential patterns, several conditions may alter these patterns (Cashdan 1992; Cohen 1977; Rafferty 1985). Among the more important are changes in population density, competition, and environmental deterioration, conditions that are often interrelated. Once the best areas are settled, competition increasingly may become a critical factor, especially in areas of dense and predictable resources (Dyson-Hudson and Smith 1978; Fretwell 1972). Habitats of this kind are not only frequently the object of competitive aggressiveness, but they are also the easiest to defend (Boone 1992:317). Intergroup competition may lead to use of less-productive habitats (e.g., lava fields, dry inland areas, etc.) and to restricted mobility, which in turn favors stable residential units, sometimes in less than ideal localities. Cashdan (1992: 263–264) noted that one competitive strategy is to keep land in continuous cultivation as a means of defense and control. Permanent residences adjacent to, or coincident with, key resource areas also facilitate access, control, and defensibility, and may be an expected late prehistoric pattern in Hawai'i given evidence for competition (Hommon 1986; Kirch 1985). As a whole, these factors suggest that information on the social and political relationships between co-residents is critical to a complete understanding of settlement patterns (see also Cashdan 1992:258).

Exchange

As discussed above, expanding populations and increased competition may limit access to key resources. Consequently, mobility may become an increasingly

costly and unfeasible strategy for averaging over spatiotemporal variation. Under these conditions, residential and logistical mobility may be replaced by exchange and similar forms of social interaction (e.g., Braun and Plog 1982; Cashdan 1987; Rautman 1993). It is important to note, however, that exchange may also provide access to resources in contexts where populations are small. Hunt (1989), for example, argued that exchange in the context of Pacific Island colonization acted as a buffer against demographic instability by ensuring access to reproductive partners. The exchange relationships detailed in the *'ohana* model probably not only increased access to geographically dispersed resources, but also buffered against environmental and social perturbations. Rautman's (1993) work offers further insights as to the conditions that may shape the direction and extent of interaction. She suggested that social interaction driven by resource variability will be affected not only by distance to reliable alternatives, but also by dissynchronous periods of low productivity. The inland-coastal direction of *'ohana* interaction follows predictions of the Rautman (1993) model, in that interaction occurs between localities where resources were either dissimilar in kind or differentially available.

New Resources

Residential patterns may also be altered by new resources (e.g., Anthony 1986; Boone 1992). Anthony (1986), for example, considered the introduction of the horse to the Plains Indians and its impact on the size and structure of both human populations and their utilized resources. The horse increased the competitive advantage of the Plains Indians, led to larger groups, and favored more aggressive strategies. Changes of similar magnitude and scope stemmed from Euro-American intrusions into the Hawaiian Islands. The archaeological record, bolstered by recent historical analyses, increasingly points to new patterns of territoriality, altered population distributions, and changes in agricultural production following Euro-American Contact (Kirch and Sahlins 1992; Ladefoged 1993; Reeve 1987). Among the new resources entering the Hawaiian Islands were economic plants such as watermelon, pumpkin, coffee, and citrus fruits (see inventory in Nagata 1985) and animal domesticates such as horses, mules, and goats. These new resources increasingly figured into both the indigenous subsistence system and new economic opportunities with foreigners (see also Sahlins 1992).

Summary of the Model

To summarize the foregoing discussions, the model being developed here predicts that colonization proceeds clinally, from areas of high to low productivity. In areas of moderate to low productivity, residential and logistical mobility may appear and will be negatively correlated with resource productivity. Mobility may also be an important strategy when key resources are concentrated but dispersed (e.g., central Ka'ū District).

As all environments fill and population density increases, competition will become more prominent. Through time, competition, in various forms, will lead to permanent residences across most or all environments. Efforts to increase productivity within a given area may also lead to decreases in both residential and logistical mobility. In areas of low productivity or where resources are dispersed,

increases in population density and competition may lead to exchange replacing mobility as a strategy to even out temporal and spatial variation in resources. Exchange and other forms of social interaction can be expected to flow across dissimilar environments.

In the historic period, conditions for reduced mobility will intensify, particularly with the advent of new (foreign) competitors. The establishment and use of permanent residences continues to have the benefit of controlling access to critical resources, a factor of heightened importance during the development of private land ownership in Hawai'i after 1848. Exchange may continue to play a prominent role in evening out spatial and temporal resource variations, although the commodities and directions of exchange will most likely be altered and cash economies will increasingly dominate.

Archaeological Patterns

In the Hawaiian case, the important role of resource distribution and abundance in determining settlement patterns is manifest in several forms. At the scale of *ahupua'a*, archaeological studies have shown that human activities were concentrated in the areas of greatest productivity, often along the coast or in fertile, well-watered upland and inland areas. This was also the case in marginal environments like Manukā, where all human activities were focused within *kīpuka*, the high resource areas of the *ahupua'a*, but residences were associated with the coastal *kīpuka* (highest resource areas).

Tuggle (1979:181–182) also called attention to the relationship between resource abundance and residential patterning at the scale of district. These larger land units traditionally were configured so as to center around resource-rich areas, with district boundaries in areas of low productivity. Tuggle further observed (see also Hommon 1986:65) that the size of the embedded land units (*ahupua'a*) was negatively correlated with productivity (both terrestrial and marine), such that those in the district centers were generally the smallest and those at the district peripheries were often large, apparently to compensate for low productivity. Tuggle (1979:182) further suggested that population density was greatest within district centers. Earle (1978:160–162) demonstrated this relationship statistically on Kaua'i, showing a strong positive correlation between historical population size and resource abundance (measured in terms of square kilometers of alluvial soils and inshore marine areas) across several *ahupua'a*.

The relationship between Hawaiian settlement locations and permanence, and resource abundance and distributions, is intuitively reasonable. Nevertheless, description and measurement of resources and their spatiotemporal variation warrant improvement. Cashdan (1992:237–244; see also Rautman 1993) highlighted several key variables that require attention to fully understand settlement patterns. These include homogeneity (or heterogeneity), the magnitude of spatiotemporal variation, predictability, frequency or scale of variation (e.g., distance between clumps), and co-occurrence of resources.

Another critical methodological issue centers around the criteria by which duration of site use is identified archaeologically. Past efforts have focused on aspects of site structure, including stratigraphic indications of multiple occupations and the size, complexity, and diagnostic features of site architecture. An-

other productive avenue of research, particularly for sites with no architectural component, lies in analysis of spatial and compositional patterning of the associated artifact and faunal assemblages. Allen (1992) and others (e.g., Thomas 1989) demonstrated that the abundance and diversity of artifacts, faunal remains, and features (e.g., pits, postmolds, and hearths) vary in patterned ways with site function and duration of use. As the criteria for identifying residential duration are improved, the relationship between environmental variability and duration of site use should be examined more critically.

There is also archaeological support for the temporal patterns suggested by our model. Notably, several models of Hawaiian sociopolitical development (e.g., Cordy 1974; Hommon 1976; Kirch 1985) make similar predictions, namely that early Hawaiian settlements were concentrated in windward localities and other well-watered environments. As expected, most well-documented early sites have been found in areas rich in both marine and terrestrial resources, including sites at Bellows Beach (O'ahu), Kawai Nui Marsh (O'ahu), Hālawa Valley (Moloka'i), and Hanalei Valley (Kaua'i) (Kirch 1985:67–88). At Hālawa Valley (Kirch and Kelly 1975) and Hanalei (Earle 1978), where intensive studies have been carried out, there are few indications that residential mobility was ever a strategy. In fact, Earle (1978:165–166) argued that the compact nature of Hanalei's resources mitigated against mobility, specialization, and exchange.

Beginning around A.D. 1400, populations began to expand into inland areas of the Hawaiian Islands (Hommon 1986). More marginal environments, particularly those lacking areas suitable for agriculture or with less predictable rainfall, began to be settled by A.D. 1600 (Hommon 1986; Kirch 1985). It is in these more marginal environments that the evidence for residential and logistic mobility is the strongest. Rosendahl's (1972) studies at the dry leeward locality of Lapakahi suggest that early settlement was based on the arid coast, beginning about A.D. 1300. The adjacent uplands were used for dryland (probably sweet potato) cultivation, and the residential features observed here appear to have been temporary rather than permanent, possibly used on a seasonal basis. Only in the late prehistoric to early historic period did permanent residences develop in these inland areas (Rosendahl 1972). Cordy et al. (1991) found a similar pattern at Kaloko, Hawai'i, and Green (1980:71–79) suggested that permanent residences appeared in the lower portions of leeward Mākaha Valley after the fifteenth century A.D.

Our Manukā research suggests that use of the inland areas for permanent residences did not occur until the historic period. Here, as elsewhere in Hawai'i (e.g., Cordy et al. 1991:421, 580; Rosendahl 1972), new resources and new economic opportunities significantly affected traditional subsistence economies and, by extension, patterns of residence. This was especially the case after the mid-1800s, when there was an economic shift from provisioning ships in transit to exportation of produce (Ladefoged 1993) and private land ownership was established. At Manukā, horses and mules may have been particularly important in altering residential patterns as they opened new routes (inland) of travel and replaced traditional coastal trails and over-water routes.

Questions arise as to why exchange between coastal and inland communities, as documented by Handy and Pukui (1972), would persist in the historic period, given evidence for a major population decline. These smaller populations might be expected to translate into a decrease in competition and greater availability of

resources. Under these conditions, we might expect to see a return to a more mobile life-style. Although this could be the case, we suggest that other historic-period developments, such as changes in the land tenure system and new economic opportunities, worked to maintain residential stability.

Returning to the Handy and Pukui (1972) model, recent archaeological studies have demonstrated a diversity of settlement patterns across the archipelago. These seem to correlate closely with environmental variability, although factors of competition probably became increasingly important in late prehistory. During this late prehistoric period, the socioeconomic system described by Handy and Pukui (1972) may have begun to develop in some areas, as increases in population density limited mobility. We suggest that the *'ohana* should be viewed as the endpoint of a settlement process initially structured by resource abundance, modified by population growth and increased competition, and strengthened by historic-period socio-economic developments. Better resolution on the origin and development of Native Hawaiian land use patterns and socio-economic systems, however, will come from refined measures of resource variability, site permanence, and socio-economic interaction.

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ABSTRACT

Environmental variability and patterns of Native Hawaiian land use are examined from the perspective of a relatively marginal locality on the island of Hawai'i. The traditional land unit of Manukā Ahupua'a is covered with large expanses of poorly weathered lava flows, but the coastal waters are rich in marine life. Traditional land use was centered within and near *kīpuka* (islands of older substrate surrounded by more recent lava flows). Changing patterns of land use, residence, and mobility are examined. Evidence from Manukā is compared with the early-twentieth-century *'ohana* model and found to be at variance. A more general theoretical model that addresses the relationship between environmental variability and an array of traditional Hawaiian residential patterns is proposed. KEYWORDS: Hawai'i, settlement patterns, traditional land use, mobility, environmental variability, *'ohana.*