hawaiian archaeology

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Volume 2

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P. Bion Griffin, Editor

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Editor's Note

We can only hope that future volumes of Hawaiian Archaeology are produced in a more timely fashion and with less pain than Volume 2. Volume 1, our society's premier issue, appeared in 1984. Volume 2 was then initiated. An editorial committee accepted papers and began the editing process. After an initial bout of editing, the papers sat while the editor, Mr. Joseph Kennedy, diligently sought funding aimed at producing a high-quality journal. A generous grant did eventually come from the Lawrence Newbold Brown Foundation, and we gratefully apply these resources to our publication. Years passed, however, and I suspect that society members began to despair of ever seeing the promised issue. I decided to re-edit the entire issue and the staff of the Department of Anthropology, University of Hawaii, assisted in this thankless and tedious task. Time and support for this work was provided me by an unlikely source, the Max Planck Institute for Human Ethology in Andechs, Germany. Without an escape from Hawai'i to Bavaria, I doubt that the days of uninterrupted editing would have been found.

Many people must be thanked for their assistance in bringing forth this volume, and for continued interest in the spirit herein embodied, the dissemination of the results of archaeological research in Hawai'i. Mr. Kennedy and his editorial committee completed much of the work. We thank the authors for their timely submissions and patience while the journal languished. The Lawrence Newbold Brown Foundation has been joined in its financial support by anonymous donors and several archaeological consulting firms, all listed on page 2 of this volume. Hardy Spoehr helped when called upon. We thank Ms. Bethany Austin for her many weekends typing the original papers into the word processor.

Volume 3 will go to production shortly. Archaeology in our state has many practitioners; we all benefit by publication of its results. We solicit and thank you for your continued support.

P. B.G

A Radiocarbon Chronology for the Upper Anahulu Valley, O‘ahu

P. V. Kirch and M.J.T. Spriggs

Penetrating the western slopes of the Ko‘olau mountains, the Anahulu Valley is the principal geographic feature of the large *ahupua‘a* of Kawailoa, in Waialua District, O‘ahu. Kawailoa, and the Anahulu Valley in particular, played a significant role in the early history of the Sandwich Islands Kingdom, for these fertile lands were among the prized holdings of the high chiefess Ka‘ahumanu (favored wife of Kamehameha I, and first "Premier" or *kuhina nui* of the Kingdom), and her successors (including Kīna‘u and Victoria Kamāmalu). Anahulu, with its irrigated taro pondfields, fishponds, and extensive dryland cultivations, not only supplied much of the material support for the chiefly establishments at Honolulu, but its population was called upon to provide produce and materials to underwrite the chiefs' considerable trade with Western fur traders, whalers, and other entrepreneurs.

Because of its direct association with the ruling houses of the early Kingdom, and owing to the establishment of a mission station at the valley mouth in 1832 (headed by the Rev. John Emerson), a rich corpus of historical documents exists for the Anahulu Valley (including government archives, mission station reports and church records, land records pertaining to the Great Māhele, and other materials). In the early 1970s, these documents attracted the attention of Marshall Sahlins, who had initiated a long-term project on the historical anthropology of the early Sandwich Islands Kingdom. Aided by Dorothy Barrère and Marion Kelly, Sahlins compiled and organized the historical materials relating to Anahulu, resulting in an extra-

Table 1 Anahulu Valley Radiocarbon Age Determinations

Laboratory No.	Site	Age B.P.	Calibrated Age Range A.D.[a]
Rockshelters			
I8400	Keae	185 ± 80	1495–1950
I8401	Keae 3	25 ± 80	1415–1675, 1710–1805
B5172	Ke'eke'e Nui	220 ± 60	1510–1680, 1705–1810
B5612	Ke'eke'e Nui	< 180	< 1770
B5613	Ke'eke'e Nui	600 ± 110	1245–1425
B5609	Ke'eke'e Nui	240 ± 50	1500–1675, 1715–1805
B5168	Kuolulo	170 ± 80	1500–1950
B5169	Kuolulo	460 ± 70	1385–1500
B5170	Kuolulo	190 ± 60	1620–1890
House Sites			
B5608	Kainiki	< 280	< 1670
B5610	Mailou	160 ± 60	1645–1950
B5171	Kaneiaulu	< 190	< 1760
Irrigation Systems			
B5605	'Ili Kaloaloa[b]	500 ± 50	1335–1480
B5607	'Ili Kaloaloa	200 ± 60	1525–1570, 1605–1815
B5604	'Ili Kaloaloa	< 280	< 1670
B5606	'Ili Kaloaloa	< 120	< 1830
B5611	'Ili Mikiai	160 ± 70	1645–1950

[a] 95% confidence intervals, after Klein et al. (1982).

[b] pre-irrigation.

ordinarily detailed picture of the social and economic structure of a valley *ahupua'a* unit.

Several excursions into the valley interior suggested the further potential for enhancing the historical analysis through archaeological investigations and in 1974 Sahlins invited the senior author to initiate such a project. Survey and excavations were carried out in 1974, and again in 1976, at 2 locations (the *'ili* of Kapuahilua and Keae) in the valley interior, with results that encouraged a more intensive study (Kirch 1979). The possibility of such an in-depth investigation of Anahulu archaeology and ethnohistory was realized in 1982, with major funding from the National Science Foundation (Grant No. BNS 82-05621). A University of Hawaii field school in archaeology was held in association with the project. Over a 4 month period a 6 km long section of the upper Anahulu Valley was thoroughly surveyed, with detailed mapping, excavations in irrigated pondfield systems, excavations of 3 rockshelter occupation sites, and excavation or testing of 8 open habitation sites.

In the course of these investigations, 17 radiocarbon age determinations were made on charcoal samples from a variety of agricultural and occupation site contexts, providing a chronological framework for the human utilization and occupation of the upper or interior Anahulu Valley. This set of radiocarbon dates is significant for at least 2 reasons: (1) few valley localities in the Hawaiian Islands are as yet associated with similarly extensive runs of radiocarbon age determinations; and (2) whereas the majority of radiocarbon dates throughout the archipelago pertain to coastal sites, the Anahulu suite relates entirely to an area of inland or interior valley exploitation and occupation.

A monographic treatment of the Anahulu Project results is newly published (Kirch and Sahlins, 1992) so our aim here is to make specific results of the Anahulu radiocarbon analyses available to the archaeological community. In this paper, the contexts of the 17 radiocarbon samples will be given only in general terms sufficient to express their overall chronological significance. Stratigraphic and other contextual details of the samples will be provided in the final project monograph.

The 17 radiocarbon age determinations from Anahulu Valley are summarized in Table 1. Two samples from Keae Rockshelter (Site OA-D6-52) were excavated in 1976 and processed by Teledyne Isotopes, Inc. The remaining 15 samples were all recovered during the 1982 excavations, and were analyzed by Beta Analytic, Inc. All samples consisted of wood charcoal, and for the 1982 samples, ^{13}C values were determined in order to correct for potential errors arising from different photosynthetic pathways (see Clark 1983 for a discussion of ^{13}C and ^{14}C pathways and their significance in Hawaiian radiocarbon dating). The third column in Table 1 presents the uncorrected ^{14}C age in years B.P.(1950) at 1 standard deviation, using the conventional Libby half-life of 5568 years. The 'Calibrated Age Range' presented in Table 1 reflects adjustments made for the ^{13}C value, as well as for secular variation in ^{14}C based on bristlecone pine calibrations, following Klein et al. (1982).

Rockshelters

Steep cliffs border the Anahulu Valley at various points, and notches cut in the bases of these cliffs by formerly higher stream levels (eroding out softer a'a clinker between layers of flow basalt) provided convenient rockshelters utilized by the Hawaiians as occupation sites. Four such rockshelters in the upper valley have been investigated: Site OA-D6-52 in 'Ili Keae, and Sites OA-D6-58 (Ke'eke'e Nui), OA-D6-36 (Ke'eke'e Iki), and OA-D6-60 (Kuolulo) in close proximity in 'Ili Ke'eke'e. All 4 sites contain stratified occupation deposits yielding faunal materials and a variety of prehistoric-type artifacts (a report on the 1974–1976 excavations at Keae Rockshelter is provided in Kirch [1979]). The upper few centimeters at all sites also yield historic period artifacts (glass, beads, gunflints).

Based on archaeological criteria discussed in detail elsewhere (Kirch 1979, 1990), these rockshelter sites provide the only clear evidence for human utilization and occupation of the upper Anahulu Valley in the prehistoric period. Although the contents of the upper deposits in Ke'eke'e Nui rockshelter are suggestive of permanent habitation, the evidence from all other rockshelter contexts indicates repeated, short-term use. We believe that throughout most of the prehistoric period, the interior portions of the Anahulu Valley were non-intensively exploited by groups who resided permanently in the lower valley or coastal sectors, and who intermittently visited and temporarily camped in the interior valley in order to plant and tend shifting cultivations (particularly of crops such as *'awa* and *olonā* which require relatively wet conditions), to gather a variety of forest materials, to hunt birds, and to exploit the stream for freshwater fish (*'o'opu*) and shrimp (*'ōpae*).

The 9 radiocarbon age determinations from these rockshelters provide a chronological framework for the prehistoric utilization of the valley interior. The oldest date range, A.D. 1245–1425, is from a large, basal earth oven in the Ke'eke'e Nui rockshelter. This shelter is not only the most attractive for occupation (large, airy, and adjacent to the stream), but contains the deepest accumulation of stratified deposits. It is therefore not surprising that it seems to have been the first such shelter to be occupied in the upper valley, sometime between the late 13th to 14th centuries. The Kuolulo shelter, situated across the valley from Ke'eke'e Nui shelter, is likewise spacious and comfortable, and an age range of A.D. 1385–1500 obtained from charcoal just above the sterile sediment underlying the occupation deposits indicates initial use beginning in the 15th century. The Keae shelter, slightly further downvalley from the above 2 sites, seems to have been first used sometime during the 15th or 16th centuries. The single age determination from the Ke'eke'e Iki site (almost immediately adjacent to the larger Ke'eke'e Nui shelter) suggests use in the 16th or 17th centuries and on into the early historic period.

In sum, based on the 9 radiocarbon age determinations from 4 rockshelters, the upper Anahulu Valley began to be exploited and temporarily occupied in the 13th to 14th centuries. This pattern of repeated, short-term, non-intensive use of the upper valley was well established by the 16th century, when all 4 rockshelters were in use, each probably being occupied by separate social groups.

Open House Sites

Open habitation terraces are found throughout the upper valley on the gentle colluvial slopes; these generally consist of some arrangement of earth-filled, stone-faced terraces supporting 1 or more stone pavements and house outlines. Many of these house sites are directly associable with residences of household groups identifiable in the early historic records, especially those of the Great Māhele or land division of 1846–1854. Eight of these sites were excavated or tested during the 1982 field season, and all of them yielded artifact assemblages containing imported Western items (glass, iron, beads, ceramics, nails, and so forth). Several sites, however, also contained artifacts of indigenous manufacture and one site in particular (OA-D6-34, identified as the 1846 residence of a commoner named Kainiki) displayed stratigraphic evidence of successive rebuilding, with the earlier phase of possible prehistoric date.

While most of the sites were single component and of obvious post-contact age, samples from 3 sites with indigenous artifacts were submitted for radiocarbon age determination. All 3 age ranges overlap the late prehistoric and early historic periods, but none of these is of such antiquity to be inconsistent with an interpretation of post-contact age. These 3 sites are all identifiable with households named in the Māhele records, and it is highly likely that all of them were first constructed after the conquest of Oʻahu by Kamehameha I in 1795 (see Kirch, 1992, for further discussion of the significance of this event in the valley's historical development).

Irrigation Systems

Most of the alluvial terraces or 'benches' in the upper (as well as lower) Anahulu Valley display archaeological evidence of former intensive, irrigated cultivation for taro, in the form of leveled, stone-faced pondfield terraces, and irrigation channels. Most of these irrigated systems were in active use at the time of the Māhele, and were claimed by *makaʻāinana* cultivators. A major objective addressed by the Anahulu Valley Project was to determine the antiquity of these systems and the temporal sequence of their development.

Excavations conducted at ʻIli Kapuahilua in 1974 suggested that the upper valley irrigation systems may be recent, and reflect an early historic intensification (Kirch 1979). In 1982 all upper valley irrigation systems were mapped, and the junior author carried out detailed stratigraphic excavations in one of the larger systems, situated in ʻIli Kaloaloa. Four radiocarbon samples from this system were submitted for dating, along with a sample of charcoal from alluvium directly underlying the main irrigation ditch in ʻIli Mikiai.

The 4 age determinations from ʻIli Kaloaloa provide an internally consistent chronology for the development of this major irrigation system. The oldest sample (B-5605) with an age range of A.D. 1335–1480, was obtained from a remnant oven or firepit situated on the alluvial flat, which was truncated by a branch canal of the irrigation system. This feature clearly pre-dates the construction of the irrigation system, and probably derives from the earlier phase of non-intensive use of the upper valley associated with the early rockshelter deposits. An estimate for the period of initial irrigation system construction is provided by the B-5604 sample, with an age of less than 140 years B.P. at 1 standard deviation, or less than 280 years B.P. at 2 standard deviations (95% probability). This sample was obtained from a deliberate cobble packing of the main irrigation ditch arguably associated with initial system construction. Sample B-5607, with a corrected age range of A.D. 1605–1815 (the alternate span of 1525–1570 is rejected here), derives from the cultivation horizon of one of the irrigated pondfields, and is thus consistent with sample B-5604 in suggesting a late prehistoric to early historic date for the construction and use of this irrigation system. These dates are further consistent with the proposition, derived from the ethnohistoric data (see Kirch, 1992), that this and other upper valley irrigation works were constructed immediately following the conquest of Oʻahu by Kamehameha I in 1795.

Sample B-5606, with an age of less than 120 years B.P. at 2 standard deviations, dates the construction of a secondary canal historically associated with a commoner cultivator (Kaneiaulu) of the Māhele era. This radiocarbon determination is entirely consistent with the historical evidence suggesting that Kaneiaulu built the branch canal no earlier that the mid-1830s.

Sample B-5611 was obtained from alluvium directly underlying the main irrigation ditch in ʻIli Mikiai, thus pre-dating the construction of the pondfield system. The corrected age of A.D. 1645–1950 is again consistent with historical evidence suggesting an early post-contact date of system construction.

In sum, the radiocarbon dates for upper Anahulu Valley irrigation systems are consistent with stratigraphic evidence and with ethnohistoric materials suggesting that these systems were relatively late developments in the valley's occupation sequence. Based on the historical data, and for reasons detailed elsewhere (Kirch, 1992), we believe that these intensive cultivation systems were constructed following the conquest of Oʻahu by Kamehameha's army in 1795, and its incorporation into the early Sandwich Islands Kingdom.

Discussion and Conclusions

As we noted earlier, the suite of radiocarbon age determinations for the upper Anahulu Valley not only provides a relatively large, and internally-consistent set of 'dates' for one locality, but is virtually unique in documenting the chronology of an interior valley, 'hinterland' region. (It should be noted that the *seaward* end of our valley study area lies 4–5 km from the coast, which is nearly the inland-most extent of prehistoric occupation in Mākaha Valley, and almost twice as far inland as occupation in the Hālawa Valley on Molokaʻi.) A brief comparison of the Anahulu radiocarbon suite with sets of radiocarbon ages for the Mākaha Valley (Green 1970) and for the Hālawa Valley, Molokaʻi (Kirch 1975) are relevant for assessing the significance of the Anahulu chronology for Hawaiian prehistory generally.

As is well known, the Hālawa Valley was settled quite early during the archipelago's prehistory, by about A.D. 650. Evidence for permanent occupation of the interior valley colluvial slopes, however, dates considerably later, beginning about A.D. 1350, with most sites in the post-1500 range. Initial use of the leeward Mākaha Valley, on the other hand, probably did not begin until about A.D. 1100 (Green 1980), with the earliest excavated archaeological features (C-shaped shelters associated with the dryland field systems), on the lower valley slopes, dating to the 13th century. Occupation of the interior portions of the Mākaha Valley, and construction of the irrigated pondfield systems, appears to have come later, in about the 15th to 16th centuries.

We as yet lack direct archaeological evidence for the antiquity of human occupation along the coastal portions of Anahulu, but given the natural resources of the Waialua area in general, an early settlement date would not be surprising.[1] What can be said on the basis of the 17 radiocarbon age determinations from inland Anahulu is that exploitation of this upland region, in some kind of non-intensive pattern, began as early as the 13th century. It is perhaps significant that this is the same approximate time at which the interior of Hālawa Valley was first being permanently settled, and at which the lower valley dryland agricultural systems of Mākaha were being developed. By the 16th century, all suitable rock shelters in the upper Anahulu Valley were in use; in comparison, the upper reaches of Mākaha were at the same time being permanently settled with irrigation systems, and settlement density in the interior of Hālawa Valley had increased. The time span that we have here been considering, from about A.D. 1200–1600, falls within a phase of rapid population growth and settlement expansion throughout the archipelago, which the senior author has elsewhere characterized in culture historical terms as the 'Expansion Period' (Kirch 1985). Whereas the shorter valleys of Hālawa and Mākaha were permanently settled by the end of the Expansion Period, the upper reaches of Anahulu, between 5–11 km from the coast, continued to be utilized in a non-intensive pattern.

The permanent occupation of the upper Anahulu Valley, in a pattern characterized by open house sites on colluvial slopes and irrigated pondfields on stream flats, was not achieved until the early post-contact period. On ethnohistorical evidence, this permanent, intensive exploitation of the interior valley was a consequence of certain political events that followed from the conquest of O'ahu Island in 1795 by Kamehameha, and his reoccupation of the island in 1804. From that time until the dissolution of the traditional socioeconomic system in the aftermath of the Great Māhele, the Anahulu Valley—both coastal sectors and the upper valley—was a major source of labor and material support for the chiefly elite of the Sandwich Islands Kingdom.

Note

1. It is worth recording, for the sake of archaeological posterity, the discovery of a tanged, reverse-triangular sectioned basalt adz (by Mr. Andy Anderson of Hale'iwa) in a bulldozed midden deposit to the southwest of the Anahulu river mouth in the early 1970s. In size and morphological features, this adz was virtually identical to specimens excavated from the early sites of O18 at Bellows Beach, O'ahu, and H-1 at South Point, Hawaii, and otherwise unknown from later archaeological contexts. In the senior author's opinion, this specimen might plausibly signal of the presence of a relatively early settlement site in the Waialua region.

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Artifactual Landscape: Kahana Valley, O'ahu, Hawai'i

Patricia Price-Beggerly

Kahana Valley, Oʻahu, Haiwaiʻi, is the location of new research formulated to examine early Hawaiian settlement patterns and economic practices from an innovative perspective. The research is designed to examine the geomorphological modifications produced by Hawaiian utilization of the landscape, especially those pertaining to early horticultural activities. I consider the landscape alterations to be examples of Hawaiian artifacts, defined in the broadest sense as, "anything that has been influenced by human activity . . . plowed fields . . . polluted streams" (Rathje and Schiffer 1982).

In modeling cultural and environmental change, I postulate that Polynesian swidden agriculture deforested the slopes of wet windward valleys, thus altering the vegetation pattern from forests to grassland and ferns. The slopes were, therefore, exposed to increased rain splash and overland flow, which accelerated mass wasting, soil avalanching, and erosion of virgin soils. The transported materials were deposited on the landward portions of sand bars and dunes in coastal lagoons and bays. The former marine environments became today's marshes and alluvial plains. The alteration of the marine ecosystem to a terrigeneous ecosystem eventually destroyed the habitat of littoral fish and molluscs, both major Polynesian foods. At the same time, alluvial sediments eventually suitable for agriculture were formed.

Kahana Valley Floor Area Map
16p5 x 33p8

Study Area—Kahana Valley, O'ahu

The research is designed to verify the consequences of such events by investigation of the archaeological manifestations of human behavior in a specific environmental context. Botanical succession theory is used to explain altered vegetational components due to postulated human induced ecosystem disturbance (Margalef 1968; Odum 1971; Scott 1974, 1975, 1978; Wentworth 1943; Wirawan 1978). To address the marine to terrigeneous segment, geomorphological concepts explain a postulated embayment to lagoon to marsh to meadow sequence. The phases of this sequence are reflected in the soil and sediment regime. Settlement and other cultural adjustments to a changing geomorphology may be revealed by surface and subsurface archaeological investigation.

Kahana Valley (Fig. 1), located on the southeast portion of the Koʻolau Loa District of windward Oʻahu, is an example of a stream-eroded, amphitheater-headed valley with a meandering stream. Physiographically well defined, it extends from a crescent shaped embayed shoreline inland to the crest of the Koʻolau Range, a distance of 6.5 km. Steep ridges rise 549 m and separate Kahana Valley from Kaʻaʻawa on the east. A second group of ridges on the west rise to 355 m between Kahana and Punaluʻu.

Discussion

Botanical theory based on rainfall, orientation, elevation, and latitude suggests that the primary vegetation predating Hawaiian colonization in Kahana was a tropical rainforest which extended to the coastline (Zimmerman 1963). Thirteen plant communities, however, are presently recognized by Theobald and Wirawan (1973) in Kahana Valley. All of the communities have specimens of recently introduced species. Today, especially on the western slopes, large expanses of grass and fern dominate the slopes. *Kukui* (*Aleurites moluccana*) forests are distributed in ravines below the crest of the ridges.

Data (Fig. 2) have been gathered from 111 auger columns, 18 botanical cores, 2 backhoe trenches, 1 hand excavated stepped trench, and soil cores and percolation tests excavated by Fewell Geotechnical Engineering, Ltd. (1978).

Analysis thus far has defined the presence of at least 7 strata within the marsh area. The lowest stratum, Stratum VII, consists of fine grained marine sands, terrigenous sands and silt, and marine shells whose habitats are in sands of shallow bays (Kay 1979). This stratum was first encountered

Kahana Valley Hawaii
26 picas x 44 picas 3 pts.

Kahana Valley, Hawai'i. Patricia Price-Beggerly (1984), modified from Wirawan (1978).

400 ft (122m) contour interval.
--- Valley floor perimeter.

at a depth of 270 cm bd and was found to exist to a depth of 602 cm bd. Wood collected from this deposit was submitted to Beta Analytic, Inc. for radiometric analysis. The analysis suggests that the conventional radiocarbon age for the death of the wood was 3490 ± 80 B.P. It must be noted that this does not necessarily date Stratum VII, as the time period between the death of the tree and its deposition in the vicinity of the radiometric sample is unknown. Its state of preservation, however, does suggest that it was buried in a reducing environment shortly after death.

A second marine stratum, Stratum VI, overlying Stratum VII extends from 230 cm bd to 270 cm bd. This stratum consists of water washed stones, calcareous marine sands, terrigenous sands, pebbles, silt, clay, marine shells, *kukui* nut shells, and charcoal fragments. Marine shells collected from Stratum VI were submitted to Beta Analytic, Inc. for radiometric analysis (Sample B-6968). This analysis, which includes an isotopic fractionation correction factor, suggests that the mean date of death of the organisms represented by the marine shells in this stratum was 2680 ± 100 B.P.

The early age determination and the presence of *kukui* nut shells within the matrix of Stratum VI are of particular significance to the research. Botanical theory indicates that this plant was neither indigenous nor endemic to Hawai'i, but was introduced by early Polynesian settlers (Gutmanis 1975; Krauss 1972; Wirawan 1978). The inclusion of these nut shells in the matrix of this marine stratum, therefore, indicates human utilization of the Kahana watershed during a very early period when the bay extended inland at least 700–1050 m. The presence of charcoal suggests that cultural manipulation of land within the watershed may have been responsible for subsequent discontinuities in the sediment and soil regimes.

A third marine derived deposit (A-II) was encountered underlying alluvium in all excavation units seaward of the marsh within the western coastal to inland transect. The ground level within this portion of the coastal to inland transect varies from 2.1 to 2.7 m elevation as opposed to 1.5 to 2.4 m within the marsh area. These white marine sands have been interpreted to represent a prograding sand bar which has subsequently been covered by alluvium. Two samples of marine shell, 1 from Auger 7-80 and 1 from Auger 6B-80 were submitted to Beta Analytic, Inc. for radiometric analysis. Material collected from Auger 7-80 (B-2148) suggests an age determination of 1690 ± 80 B.P., while Auger 6B-80 (B-2149) suggests an age determination of 1500 ± 90 B.P.

The upper portions of the marsh cores overlying the 2 marine layers (Stratum VII and VI) are composed of silty clays (Stratum V), a thick peat-like deposit within a clay silt matrix (Stratum IV) which is then overlain by differing proportions of terrigenously derived sand, silt, and clay reflecting a series of depositional environments. These soil and sediment samples are presently being analyzed.

The faunal record analysis has just begun. It is possible to make some preliminary statements, however. The earliest Stratum VII contains a large percentage of *Macoma dispar*, which are described by Kay (1979:559) to be "abundant in shallow water and to depths of 20 m in silty sand in bays where there is freshwater outflow." Other species are present but poorly represented. In Stratum VI, however, large amounts of *Theodoxis neglectus* are present in proportions nearly equal to *Macoma dispar. T. neglectus* is described by Kay (1979:67) to be "found not only at the seaward edge of basalt and solution benches and in tide pools, but they form a dominant element in brackish water assemblages." A change in marine environment is suggested, therefore, by a greater number of species and more abundant populations in Stratum VI than in Stratum VII.

Radiometric Analysis

Four samples have been radiometrically analyzed by Beta Analytic, Inc. The materials submitted include both wood and marine shell. The correlation between dates inferred from marine shell and wood is unknown for Hawaiian species at this time. Recent studies have suggested that shells may be used to produce accurate chronologies if the shells are subjected to acid treatment prior to radiometric analysis. Environmental calibrations are then applied to the subsequent age determinations to correct for the Oceanic Reservoir Effect (Gillespie and Pollach 1979). Various calibration factors are used throughout the world. The calibration used by Australian and New Zealand archaeologists for South Pacific sites varies between 330 and 460 years. In all cases the calibration is subtracted from the date obtained from the radiometric analysis, thus a shell date age determination of 1500 B.P. would be adjusted to reflect a calendar date of 1050 B.P. if a 450 year correction factor was used (Bowman, 1983; Gillespie and Swadling 1979, Green pers. com., Law 1984). Calibrations applicable to Hawai'i are now being developed.

Although Klein et al. (1982) correction factors are often applied to age determinations of Hawaiian data, these correction factors have not been applied to the Kahana age determinations. This is because recent information distributed at the Trondheim radiocarbon conference indicated that correction factors based on tree ring dates obtained from North European and North American trees do not apply to other portions of the planet, especially those in the Southern Hemisphere (Tamers pers. com.).

Conclusions

Models of Polynesian migration currently suggest a colonization of Hawai'i from Eastern Polynesia *circa* A.D. 100–600 (Emory 1959, 1963; Green 1966, 1971; Kirch 1974; Pawley and Green 1975; Pearson et al. 1971; Sinoto 1962). Now, however, the age determination of Stratum VI which contains within its matrix both charcoal and *kukui* nut shells suggests the possibility of a much earlier date for initial human habitation. If this early date continues to be supported by radiometric analysis of additional samples from this stratum, reconsideration of our current understanding of the initial occupation of the Hawaiian Islands may be necessary.

Let me emphasize that caution should be exercised at this time in accepting the age determination of Stratum VI, because:

1. Only 1 sample of this stratum has been radiometrically analyzed. Before we can be confident of the extent and early date of this inferred culturally induced or culturally accelerated geomorphological alteration a wider sample of this stratum should be radiometrically analyzed.

2. As noted earlier, the calibration between age determinations inferred from charcoal samples and marine shell samples is presently uncertain for Hawai'i.

3. The charcoal in the matrix may have been the result of naturally induced fires. Such is unlikely, however, given the unlikelihood of a wet windward rainforest vegetation igniting through natural means. *Kukui* nuts may be the product of an indigenous plant species. Current botanical data, however, indicate this species is a Polynesian introduction.

To summarize, I have presented preliminary geoarchaeological data from Kahana Valley, Hawai'i, which tentatively support the hypothesis that precontact Hawaiians were adapting to self-induced large scale geomorphological change. I infer this change, which included a rapidly prograding coastline, was a result of accelerated natural erosion brought about by Hawaiian swidden technology. In other words, the early Polynesian settlers in Hawai'i may have arrived earlier than suspected, and once established may have strikingly interacted with environmental changes, some of their own manufacture.

Acknowledgements

It was not until Dr. John Chris Kraft, a geologist from the University of Delaware interested in Holocene sea level change, began his Hawaiian research in 1980 that the importance of the changing coastline became readily apparent to most Hawaiian archaeologists. I am deeply indebted to Chris for stimulating me to look at familiar phenomena in new ways.

I am especially indebted to Ande Beggerly and P. Bion Griffin; Ande for his most willing support, encouragement, and help in all aspects of the research; and Bion for hours of advising, discussion, assistance, and major improvements in this manuscript.

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To Fill a Vacuum

Robert J. Hommon

Whether by bulldozer or sable brush, the digging archaeologist spends a great deal of valuable time separating the analytically important wheat—artifacts, ecofacts and the samples that science is heir to from the huge mass of disposable chaff—the soil matrix of the site being excavated. In Hawai‘i, where small-scale handwork is the rule, the common process is to clear away the loosened and obscuring dirt generated by one's digging by scraping, sweeping, brushing and scooping it into buckets that are then carried to screens for sifting.

This scraping, sweeping, brushing and scooping by which we measure many of our days in the field is time consuming; it often damages the very context that it is designed to expose and protect; and it often results in the discovery of items of interest in screen rather than *in situ.* Further, the process is often needlessly repetitive and inefficient as excavation must be interrupted frequently to ensure that the digger can see what is being dug.

Traditionally, archaeologists have accepted these problems fatalistically or have not considered them problems at all. I would like to suggest that the time has come for archaeology, the profession that has profitably plundered bits and pieces from an enormous variety of technological and scientific fields, that has embraced the computer and the backhoe (however reluctantly), to adapt a common custodial appliance and apply it to the task of tidying up.

While brooms and brushes and feather dusters still serve important housekeeping and janitorial functions, our civilization has long since assigned the major task of ridding its living floors and activity areas of undesirable dirt and dust to that percheron of custodial technology, the vacuum cleaner. Surely this technological wonder, born with the 20th century, has proven its worth sufficiently that it may now be safely accepted into the archaeological tool kit as well.

Picture an archaeologist digging a test pit near Kailua, Kona. As she loosens the soil matrix with a trowel in one hand, she manipulates a nozzle with the other. The nozzle is the business end of a vacuum cleaner hose that leads to the machine itself squatting at the rim of the pit. A screen at the nozzle excludes everything larger than the ⅛ inch mesh size of the screen as the obscuring silts and sands are continually whipped away to the belly of the whirring beast above, or evacuated via hose to a backdirt pile some distance downwind. As the archaeologist works, she manipulates a lever that controls the strength of the suction. Thus she is able to apply a light touch to protect fragile *in situ* objects or strata in one corner of the pit and, in-another, power up to get rid of stubborn gravelsized debris.

Such a hypothetical scene requires no technological breakthrough. The machine referred to above might be a bulky barrel-like industrialstrength "vac" (used for, *inter alia*, cleaning up messes made by carpenters) or, perhaps, some version of the self-contained blowers used in yardwork. Models without a self-contained power source could be connected to one of a variety of small, compact, relatively inexpensive generators now on the market. The variable suction control might be achieved with an electrical rheostat or by varying the closure of holes in the nozzle tube.

An archaeological vacuum cleaner would not only increase the visibility of the subject matter so vital to controlled excavation but would also reduce the amount of time wasted in repeated sweeping, thus increasing the efficiency of the operator. Given the finite nature of time, not to mention money, available for archaeological research, it is time for the vacuum cleaner to come out of the broom closet in the service of science.

Though this hooveresque idea struck me several years ago, I have not yet found the opportunity to put it into action. It is my hope that this brief piece may inspire exploration by others into this uncharted void of archaeological technology. Perhaps it will encourage some field director, faced with much to do in too little time, to leap into the methodological breach to fill a vacuum.

University of Hawaii Archaeology Field Schools 1950–1984

Matthew J. T. Spriggs

Since joining the UH Anthropology Department in 1981 I have often heard the criticism by local archaeologists and others that the results of University field school courses in archaeology never get written up. This is a serious accusation as it implies that an activity little better than looting has taken place rather than a piece of scientific research involving the training of students. In researching the question it was a relief to find that most field schools *have* been written up, at least in manuscript form or are currently in active process of being written up.

The research conducted by the various UH field schools has an important place in Hawaiian and Oceanic prehistory which is often overlooked by critics of that august institution. It is all too easy to forget that no less a figure than Kenneth Emory held a joint appointment at UH and the Bishop Museum in the early 1950s, and that the 1950 excavation at Kuliʻouʻou rockshelter, which produced the first radiocarbon date for the Pacific and ushered in the "modern" era of Pacific archaeology, was a UH field school. The other excavations reported in Emory and Sinoto's (1961) *Oʻahu Excavations* were also UH field methods courses. Many of the largest research efforts in Hawaiian archaeology have also been supported by field school crews and funds—Bellows, Lapakahi, Kohala Valleys, Hālawa Valley, Anahulu and Barber's Point to name a few.

This paper hopes to serve 2 purposes, one historiographic and the other "practical." No complete listing of field schools has appeared, even Stell Newman's (1968a) "Hawaiian Archaeology: an Historical Review" being incomplete for its time. It is thus hoped to provide an overview of an under-appreciated but important force in the development of Hawaiian archaeology. The "practical" purpose is to provide a bibliography of papers resulting from past field schools and to indicate where the materials, original fieldnotes, etc. are stored so that further research on them might be encouraged.

I have not included field schools conducted by UH Hilo and Kauai Community College as these are best dealt with by members of those institutions. I have indicated other non-field school projects with a significant involvement of UH students either as volunteers or as participants in other university courses such as *Anthropology 210: Introduction to Archaeology.*

Course Description

The course currently taught as *Anthropology 380: Archaeological Field Techniques* was first reported in the University Catalog for 1949–1950 as *Anth. 270: "Archaeology.* Methods and techniques in archaeology. Excavation of prehistoric sites, preservation of materials, and interpretation of archaeological data, with illustration from Oceanic studies. Practical fieldwork in excavation and museum preparation." This remained on the books until the 1958–59 catalog where we find *Anth. 313: "Field Archeology in Oceania.* Survey and excavation of prehistoric sites. Recording and analysis of data. Supervised excavation on O'ahu and lab work at Bishop Museum." In 1959–1960 the course number was changed to *Anth. 620*, in 1960–61 the limitation "on O'ahu" was removed and in 1961–62 "Survey and" was deleted.

In 1965–66 the description and number were changed to *Anth. 720–721: Archaeological Techniques.* "Archaeological survey and excavation; weekend field trips, mapping, photography, recording. Laboratory analysis and evaluation of field data, preservation and restoration of artifacts. Preparation of materials for publication. Prerequisite: 670 [an archaeology graduate course] or equivalent, and a course in statistics." It was in this same catalog that the introductory archaeology course (*Anth. 210*) first made its appearance. In 1966–67 the course number was changed to *Anth. 520–521* and the prerequisite eased to "210 or equivalent, and a course in statistics, or consent of instructor." By Summer Session 1968 the "weekend field trips" had become "daily" and a statistics course was no longer required.

There was a further number change to *Anth. 420–421* in 1968–69, and in 1970–71 we find *Anth. 380: Archaeological Field Techniques* appearing as a distinct course for the first time with a description that has remained essentially unchanged to the present time: "Archaeological survey and excavation; weekend field trips, mapping, photography and recording. Pre: 210." The most recent Catalogs have deleted "weekend" and (for reasons which escape me) "recording."

Field Schools 1950–1984

In this checklist the first line of each entry gives the date, course number, instructor, and location of the field school. The next line contains bibliographic references, followed on line 3 by location of original materials and notebooks. Additional details are given where appropriate.

1950. Spring semester (Anth. 270). Emory. *KULI'OU'OU SHELTER (Site O1), KONA, O'AHU*

Emory and Sinoto (1961:4–22)

Bishop Museum

Artifactually rich rockshelter, basal date of A.D. 1004 ± 180 the first radiocarbon date from the Pacific. Eleven students participated in this and the subsequent rockshelter excavations. Three hundred twenty-four ft.² excavated using ¼ inch screens. In 1938 John Porteus had excavated a further 57 ft.^{2}. Present Bishop Museum site number 50-OA-A2-1.

1951. Spring semester (Anth. 270). Emory. *MAKANI'OLU SHELTER (Site O2), KONA, O'AHU*

Emory and Sinoto (1961:22–30)

Bishop Museum

Artifactually rich rockshelter. Between 1951 and 1955, 495 ft.^{2} excavated. Present Bishop Museum site number 50-OA-A2-2.

1952. Spring semester (Anth. 270). Emory. *MAKANI'OLU SHELTER (Site O2)* and *HANAUMA BAY SHELTER (Site O3), MAUNALUA, O'AHU*

Emory and Sinoto (1961:22–30, 30–33)

Bishop Museum

Hanauma Bay Shelter excavated by 6 people in 4 days, 210 ft.^{2} excavated. Small fishermen's shelter. Current Bishop Museum site number 50-OA-A1-55.

In summer 1952 Emory and William Bonk excavated on Moloka'i with a party of UH students (See Bonk 1954; also NFP 3(3) April 1952).

1952. Fall semester (Anth. 270). Emory. *MAKANI'OLU SHELTER (Site O2), O'AHU*

Emory and Sinoto (1961:22–30)

Bishop Museum

In the O2 fieldnotes further excavation is recorded in June and November 1953 and January 1954.

In 1953 Bonk and Emory started excavating at South Point, Hawai'i Island, "assisted by a group of volunteers, most of whom had previously received training in field techniques from Dr. Emory" (Spoehr 1954:21; see also NFP 5(1) January 1954).

1954. Fall semester (Anth. 270). Emory. *MAKANI'OLU SHELTER (Site O2), O'AHU*

Emory and Sinoto (1961:22–30)

Bishop Museum

Spoehr (1955:24) erroneously gave Kuli'ou'ou Shelter as the site of this field school, an error repeated by Newman (1968a:140).

In August 1954 Bonk received his M.A. and then moved to Hilo. In NFP 5(3 and 4) May 1954 it is reported that Yosi Sinoto had arrived and had been "persuaded to stay and enroll at UH." In 1955 and 1956 no course offering appears in the University Catalog but Emory and Sinoto record that 2 squares at Makani'olu Shelter were excavated by E. Sterling and Z. Brown in 1955 (1961:25) and that in November 1955 there was a UH class at Makani'olu (ibid:34). The Makani'olu fieldnotes note only 1 day of excavation in Fall 1955.

Kawēkiu Shelter, Kuli'ou'ou, O'ahu (Site O4) (current Bishop Museum site number 50-OA-A2-3) was excavated starting in November 1955 (Emory and Sinoto 1961:34–36). Site O4 fieldnotes record excavation in November 1955, April to June 1956, March and May 1957. Emory and Sinoto (ibid) note that 30 ft.^{2} were excavated (see also NFP 8(1) March 1957). The University Catalog for spring 1957 indicates that Anth. 270 was being offered. I have not located any information as to whether the course was held.

Emory (1960:5) reported that a survey of the City of Refuge, Hōnaunau, Hawai'i, was undertaken for the National Parks Service by Bishop Museum "with the cooperation of the University of Hawaii" in fall 1956 and in 1957. NFP 9(4) October 1958 notes "numerous volunteers from UH" as assisting various Bishop Museum projects on Hawai'i and Kaua'i.

Anth. 620 (the new course number for the field school) was apparently offered in Fall semester 1959 according to the University Catalog. It is not known whether the course was taught at this time.

NFP 11(2) April 1960 records that during Easter vacation 1960 the UH Anthropology Club surveyed an O'ahu Hawaiian village site at 'Ekahanui Gulch, Kunia, Wahiawā, led by William Kikuchi who graduated in January 1960. In March 1961 the UH Anthropology Club, again led by Kikuchi, conducted a survey on O'ahu at

Kapaka between Punalu'u and Hau'ula, and at about that time a "UH team" led by Emory recorded petroglyphs in Puna, Hawai'i in the path of a volcanic eruption (NFP 12(2) May 1961). Wilhelm Solheim arrived to teach at UH in fall 1961.

1962. Spring semester (Anth. 620). *KALUANUI RIDGE SURVEY AND MAUNALUA CAVE* (*Site O5*), MAUNALUA, O'AHU

Draft of part of a report by Smart and Bayard, "Hawaii Kai Excavations" held in Bishop Museum Anthropology Department

Bishop Museum (materials and field notes)

"Although small the shelter produced a diverse collection of artifacts and charcoal samples which provided radiocarbon dates: 620 ± 150 B.P. (Gak-302) and 250 ± 100 B.P. (Gak-354)" (Emory 1965:4). Excavation with volunteers continued until June 1963.

"During August archaeological excavations were made at the City of Refuge National Historical Park, Honaunau, by 10 University of Hawaii students under the supervision of Mr. Soehren" (Force 1964:30).

In August 1963 a fishermen's shelter at Ka'ena Point, (Site O14, current Bishop Museum site number 50-OA-C7-6) Wai'anae, O'ahu was investigated by Bonk and Alan Howard, the excavation being completed a few days later by Lloyd Soehren with the assistance of "several University of Hawaii students" (Force 1965:334). It was also noted (ibid) that, "The Museum provided lab. facilities and some technical assistance to the University of Hawaii students who…completed the excavation of a shelter cave discovered the year before in Maunalua, O'ahu."

Soehren excavated a vandalized rockshelter, Moanalua Cave, Kona, O'ahu (Site O15, currently Bishop Museum site 50-OA-A7-21) with University volunteers in April 1964. Materials and fieldnotes are held at the Bishop Museum.

In Fall semester 1965 Anth. 720 was offered according to the UH Catalog, taught by William Wallace. It is not clear if the course was held but from November 20–27 the Pinao Bay site (H24), South Point, Hawai'i was excavated by W. and E. Wallace, R. and E. Shutler, 3 UH graduate students and 3 volunteers (Wallace and Wallace 1969:1). The materials are at the Bishop Museum.

1966. Spring semester (Anth. 720). Wallace. *KALOKO POINT (Site O17), MAUNALUA, O'AHU* and *HALAWA CAVE (Site O16), 'EWA, O'AHU*

Wallace, Wallace and Meeker (1966), for O17; no report for O16

Bishop Museum

At Site O17 8 students participated, 100 ft.^{2} were excavated, using 0.32 cm mesh screens. A prehistoric sand dune occupation site. No dates were obtained. An adjacent rockshelter was tested, 2 m^2 excavated. Current Bishop Museum site number 50-OA-A1-56.

No fieldnotes have been located from the O16 excavations (current Bishop Museum site number 50-OA-B1-20).

1966. Fall semester (Anth. 520). Bayard. *HAWAI'I KAI (Site "O16"), MAUNALUA, O'AHU*

Bayard (1969)

UH Archaeology Repository

Site number O16 is a duplicate number. Site was the same as McAllister Site 43. An open historic occupation site. The second piece of historical archaeology carried out in Hawaii, the first being the Fredericksens' 1964 excavation of the "Brick Palace" of Kamehameha I at Lahaina, Maui (Fredericksen and Fredericksen 1965). Three students and 20 volunteers. Excavation continued at "O16" until July 1967 using volunteers from *Anth. 210.* Nine m^2 partially excavated, 3 x 0.75 m trench excavated to bedrock.

As part of an Archaeological Laboratory techniques class (*Anth. 521*) Richard Pearson, a newly arrived faculty member at UH, conducted an excavation at Cave 1, Kalaupapa, Moloka'i in November 1966 and April 1967, written up by Hirata and Potts (1967) and Pearson et al. (1974). Further analysis of the material from this site which is held at Bishop Museum is being conducted by Marshall Weisler of the University of California. Three dates have recently been obtained from this site, the earliest being 880 ± 70 B.P. (Somers 1985:43).

1967. Second summer session (Anth. 520). Pearson. *BELLOWS DUNE SITE (Site O18), WAIMĀNALO, KOʻOLAU POKO, OʻAHU*

Kirch (1974), Pearson, Kirch and Pietrusewsky (1971)

Bishop Museum

Pearson and Soehren started excavations on weekends in February and March 1967 with a crew of volunteers. The field school involved a crew of 10 for 14 working days (Pearson et al. 1971:204). One of the earliest occupation sites in the Hawaiian Islands, starting at 1600 ± 90 B.P. A total of approximately 65 m^2 was excavated.

In January and February 1968 Pearson led a team of 6 UH students in a 4 day excavation in the area around the Print Shop at the Mission Houses, Honolulu (NFP 19 1968–9:36). Warren Peterson directed the excavation, which was written up by Michael Seelye (1969). The excavation was done at the request of the Hawaiian Mission Children's Society. The material is at the Mission Houses Museum.

1968. First summer session (Anth. 520). Pearson and Newman. *LAPAKAHI, KOHALA, HAWAIʻI*

Newman (1968b, 1969, 1970), Pearson (1968)

Lapakahi State Park

Held jointly with the UH Hilo field school directed by Bonk. Funded by Division of State Parks, NSF Undergraduate Research Participation Grant. Carried out over 3 months with a crew averaging 30 students and volunteers. Excavation concentrated on Koaiʻe fishing village where occupation began at about A.D. 1300. First archaeological use of a computerized data retrieval system in Hawaiʻi and successful use of regular and infrared aerial photographs for mapping and site location.

In 1969 Pearson started excavations at the Mission Houses Basement, Honolulu, with a volunteer crew from UH (NFP 19 1968–9:38).

1969. First summer session (Anth. 420). Green. *LAPAKAHI, KOHALA, HAWAIʻI*

Griffin *et al.* (1971), Rosendahl (1971, 1972), Tuggle and Griffin (1973)

Lapakahi State Park

Forty-five participants. NSF and State Parks funding. Investigation of upland agricultural and habitation features, lowland research concentrating on structures outside Koaiʻe village and on burial features.

From June to August 1969 T. Riley, P. Kirch and G. Hendren worked in Hālawa Valley, Molokaʻi under Roger Green's direction, and were partly funded by the UH Lapakahi Project. Further fieldwork was carried out in 1970 (see Griffin et al. 1971, Kirch and Kelly 1975, Riley 1970 and 1973). P. Bion Griffin arrived to teach at UH in fall 1969.

In spring 1970 Pearson's Anth. 210 class conducted further excavations at the Mission Houses Basement, Honolulu (Pearson 1970).

1970. First summer session (Anth. 380). Griffin and Tuggle. *LAPAKAHI, KOHALA, HAWAIʻI*

Griffin et al. (1971), Rosendahl (1971,1972), Tuggle and Griffin (1973)

Lapakahi State Park

Twenty–eight participants. Additional funding by Hawaiian Homes Commission. Research continued on upland agricultural and habitation features, lowland dispersed settlement, Koaiʻe village, and surveys were undertaken beyond the borders of Lapakahi.

H. David Tuggle took up a full-time position at UH in fall 1970.

1971. Summer session (Anth. 380). Tuggle. SOHOTON AREA, SOUTHWESTERN SAMAR, PHILIPPINES

Tuggle and Hutterer (1972)

Divine Word University Museum, Tacloban

Funding by NSF Undergraduate Research Participation Program, "an innovation in that to the writers' knowledge this program of NSF had never supported archaeological research outside the United States" (Tuggle and Hutterer 1972:5). Five undergraduate students and 2 graduate supervisors.

1971. Second summer session (Anth. 380). Riley. *KAUPŌ CAVE SHELTER, WAIMĀNALO (SITE OA-3000), KOʻOLAU POKO, OʻAHU*

Student Reports in the UH Archaeology Repository by Davis, Gormley, Imamoto, Kavanaugh and Yent

UH Archaeology Repository

Cave shelter containing prehistoric and historic materials. 17.3 m² excavated. A photomosaic of the site was prepared prior to excavation at a cost of $18.

In fall 1971 Richard Gould arrived to teach at UH, replacing Pearson.

1971. Fall semester (Anth. 380). Griffin. *KAPAPA ISLAND MIDDEN, KĀNEʻOHE BAY, KOʻOLAU POKO, OʻAHU*

Report by Griffin in preparation. Student reports in the UH Archaeology Repository

UH Archaeology Repository

Small midden site and burials. Twelve m² excavated.

In Spring 1972 Gould's *Anth. 210* class excavated at Queen Emma's Summer Palace, Honolulu (Gould 1972).

1972. Summer session (Anth. 380). Tuggle. *KOHALA-HĀMĀKUA VALLEYS, HAWAIʻI*

See 1974 field school for details

UH Archaeology Repository

NSF funding. A general survey of Honokâne and Pololū Valleys (Kohala District) and Honopue Valley (Hāmākua) directed by Tuggle and Dennis Callan.

1972. Fall semester (Anth. 380). Tuggle. *BLACKBURN SITE, KAILUA (Site 50-80-11-524), KOʻOLAU POKO, OʻAHU*

Woodward (1985a) and student reports in UH Archaeology Repository

UH Archaeology Repository

Disturbed burial site, 1 infant burial recovered.

In January, 1973, UH student volunteers directed by Marti Ayres mapped the ʻĀhuimanu taro terrace system (Site 80-10-11-65), Kahaluʻu, Koʻolau Poko, Oʻahu (Silva 1973).

1972 and 1973. (Anth. 380). Sinoto and McCoy. TETIʻAROA ATOLL, SOCIETY ISLANDS

Sinoto and McCoy (1974)

Bishop Museum

Funded by Marlon Brando. During the first session "between December 28, 1972 and January 7, 1973—Five undergraduate majors from the University of Hawaii and 5 teacher-trainees from Ecole de Normale in Papeete, Tahiti, took part. Nine students—5 from the University of Hawaii and 4 from the same school in Tahiti—participated in the second session from June 29 to July 20, 1973" (Sinoto and McCoy 1974:1). Survey and excavation of *marae* and other sites.

1973. Summer session (Anth. 380). Tuggle. *KOHALA-HĀMĀKUA VALLEYS, HAWAIʻI*

See 1974 field school for details

UH Archaeology Repository

NSF funding. Intensive mapping and test excavations of agricultural systems in Honokāne and Pololū, excavations at Pololū Dune. Riley was assistant director in charge of undergraduate independent researchers.

1973. Fall semester (Anth. 380). Tuggle. *ʻĀHUIMANU TARO TERRACE SYSTEM, KAHALUʻU, KOʻOLAU POKO, OʻAHU*

Woodward (1985b) and student reports in UH Archaeology Repository

No artifactual material recovered. Excavation of pondfield soil profiles. No dating material collected.

1974. Summer session (Anth. 380). Tuggle. *KOHALA-HĀMĀKUA VALLEYS, HAWAIʻI*

Tuggle (1976), Tuggle and Tomonari-Tuggle (1980, in press)

UH Archaeology Repository

NSF funding. "Fieldwork in the summer of 1974 concentrated on excavations in selected agricultural complexes and possible habitation areas in central Pololū and lower Honokāne Valleys. The work was carried out by a small, experienced research crew under the direction of H. D. Tuggle. Supplementary research was provided by a summer field school supervised by P. Beggerly and S. Nakama" (Tuggle and Tuggle 1980:30).

Evidence of colonization of the valleys by A.D. 1600 was obtained.

1975. First summer session (Anth. 380). Cordy and Tuggle. *BELLOWS DUNE SITE (O18), WAIMĀNALO, KOʻOLAU POKO, OʻAHU*

Cordy and Tuggle (1976), Tuggle, Cordy and Child (1978)

UH Archaeology Repository

"In the spring of 1975 Tuggle directed mapping of the O18 dune and began a survey and testing of areas inland along Waimānalo Stream. University of Hawaii students participated in the fieldwork with an average of 10 students per day for the sixteen days of fieldwork (during the period from February 8 to May 6, 1975). Ross Cordy supervised portions of the test excavations during this period. The second phase of work was the testing of the O18 remnant. Cordy was field director working with twelve students for eighteen half-days during June" (Cordy and Tuggle 1976:215). Seventeen m² were excavated.

1976. First summer session (Anth. 380). Frost. *WAIMANO CAVE, PEARL CITY, ʻEWA, OʻAHU*

No report has been prepared

Materials in possession of E. Frost, Eastern New Mexico State University.

1977. Summer session (Anth. 380). Hammatt. *KUALOA EAST BEACH SITE, KOʻOLAU POKO, OʻAHU*

Gunness (this volume, in preparation)

Kualoa Regional Park

Fifteen undergraduate and graduate students. Open beach occupation site (see also 1983 and 1984).

1978. Summer session (Anth. 380). Riley. *HĀʻENA STATE PARK, HALELEʻA, KAUAʻI*

Griffin (1984), Riley and Clark (1979), Riley and Ibsen-Riley (1979)

DLNR, Division of State Parks Repository, Honolulu

Project director was Griffin. Joint field school with University of Illinois-Urbana. Eight UH students and 12 from University of Illinois. Open beach site starting at about A.D. 1000.

1979. Second summer session (Anth. 380). Davis. *BARBER'S POINT, HONOULIULI, ʻEWA, OʻAHU*

See Davis (1980) for brief description. Final report in preparation

Bishop Museum

Habitation structures and rectangular enclosure of probable late prehistoric age.

1980. First summer session (Anth. 380). Davis and Kaschko. *MOANALUA CAVE (Site O15), KONA, OʻAHU*

No report has been prepared. See Davis and Kaschko (1980) for research design

UH Archaeology Repository

Material currently being analyzed at UH Manoa.

1981. First summer session (Anth. 380). Davis. *BARBER'S POINT, HONOULIULI, ʻEWA, OʻAHU*

Final report in preparation by Bertell Davis

Bishop Museum

Habitation complex 2706 including C-shapes, platforms, and sinkholes.

In Fall 1981 Matthew Spriggs joined the UH Faculty, replacing Tuggle. Gould left in mid-1981 and was not replaced by an archaeologist.

1982. Second summer session (Anth. 380). Spriggs. *ANAHULU VALLEY, KAWAILOA, WAIALUA, OʻAHU*

Kirch and Spriggs (this volume), Kirch and Sahlins (eds.) (in preparation)

Bishop Museum

Jointly held with Bishop Museum, project funded by NSF under the overall direction of Kirch, with D. Barrère, M. Sahlins and Spriggs as research associates. UH student volunteer work continued until November 1982. Upper valley mapping and excavation of rockshelters, irrigation systems and house sites. Occupation concentrated in early 19th century.

1983. Second summer session (Anth. 380). Griffin. *KAHANA VALLEY, KO'OLAU LOA and KUALOA EAST BEACH, KO'OLAU POKO, O'AHU*

Kahana Valley: Beggerly (this volume). Kualoa: Gunness (this volume, in preparation)

UH Archaeology Repository (Kahana material) and Kualoa Regional Park

The Kahana Valley section of the field school comprised a part of Beggerly's Ph.D. dissertation fieldwork funded by NSF. The Kualoa work comprised a part of Jo Lynn Gunness' ongoing archaeological research for the City and County of Honolulu Parks Department.

1984. Second summer session (Anth. 380). Spriggs. *KUALOA EAST BEACH, O'AHU*

Gunness and Spriggs (in preparation), Gunness (in preparation)

Kualoa Regional Park

Field school held jointly with the City and County of Honolulu Parks Department under the supervision of Gunness. UH student volunteer work continued until November 1984.

Conclusion

Although further analysis could be done on the materials from nearly all of the field school sites, it can be seen that all but 6 sites have been written up in some form, most as reasonably-final reports. Of these sites, 3 are being actively worked on at the moment. There is hope that the other 3 will in the end also be written up. We should conclude that while not completely unblemished, the University has a good record of writing up its field schools, especially considering the extremely limited funds at its disposal.

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Archaeology of Kaloko: A Generalized Model of a Hawaiian Community's Social Organization and Adaptation

Ross Cordy
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A major settlement pattern project involving survey and extensive excavation was undertaken during the summers of 1970 and 1971 in a small region called Kaloko, located in the North Kona district on the west coast of Hawai'i Island (Fig. 1). Descriptive preliminary analytical reports on the project and detailed analytical-theoretical reports reconstructing social organization are presented elsewhere (Renger 1970, 1974; Kelly 1971; Cordy 1974a, 1976a, 1978, 1981; Cordy and Kaschko 1980; Tainter 1973a, 1973b, 1974, 1975, 1976; Tainter and Cordy 1977). Here our aim is to provide the initial steps for constructing a model of how Hawaiians in the Kaloko area were organized socially before contact (A.D. 1778) and how this social organization reflected adaptations to the natural and social environments, and to internal pressures. This analysis departs from typical Hawaiian ecological studies in that a greater emphasis is placed on reconstructing social organization and on conceptualizing the entire social-ecological network (social organization, population, natural environment, and social environment).

With over 60 non-abutting architectural structures, only 5 of which were radiocarbon dated, we are unable to build a picture of local social organization and its adaptation to the environmental field at any one time period, nor can we make any major statements on change in organization and adaptation. Instead, we have been forced to present a generalized model for local social structure

Location map of the ahupuaʻa of Kaloko

26 picas x 36 picas

Figure 1. Location map of the *ahupua'a* of Kaloko, Hawai'i Island showing the contact-era districts of the island.

and its adaptation to the environment for the entire prehistoric period (A.D. 1000/1150–1800). Our generalized model establishes certain basic social structure patterns and indicates areas where more data are needed.

Environmental Setting

Kaloko is a tract of land on the west side of Hawaiʻi Island (6.5 km north of the present town of Kailua-Kona). It is a tax unit (an *ahupuaʻa*) which had its boundaries fixed in 1850. The tract is a strip approximately 1.1 km wide, stretching 12.4 km inland to the 1830 m elevation of Mount Hualālai (a dormant volcano 2521 m high). Kaloko's terrain is sloping undissected lava.

Natural Environment Nearly all natural environment patterns vary as one progresses inland up the slopes of Mt. Hualālai. We divide Kaloko into 4 natural environment zones associated with terrain, soil, rainfall, and vegetation patterns. These zones are the coastal (0–15 m elevation), middle (15–275 m), lower upland (275–488 m), and upland-forest (488–1830 m) (Fig. 2). These zones can be followed through the rest of the Kona coast to the south. However, Kaloko lies at the extreme northern end of this natural environment zonation. At Kaloko the rain-inducing mountains end, resulting in a few differences from the rest of Kona. Rainfall is reduced here. Thus, the coastal and middle zones together are much wider and the upland zones, with their soil cover and adequate rainfall, are further inland and narrower than areas to the south.

The coastal zone fringes the shoreline and extends only 60–100 m inland. The shoreline is broken in the center by a large bay. To the north the coast is quite rocky, and to the south a 200 m wide submerged lava shelf is exposed at low tide. Coral reef extends about 100 m from the coast, being widest and shallowest at the mouth of the bay. Renger describes the reef marine life of Kaloko (Renger 1973). The sea is quite calm along this portion of the coast except during

Kaloko Ahupuaʻa

26 picas x 39 picas

Figure 2. The four natural environmental zones of Kaloko *ahupua'a*.

winter storms. High wave action from these storms has built up areas of coral sand and cobbles extending 75–100 m inland along the coastline. These depositional features are vital at Kaloko, for they have placed a non-lava strip along the shore and provided small access beaches to the ocean.

Soil accumulation is nonexistent in the coastal zone except for silt deposits within the bay (apparently due to Hawaiian fishpond construction). Rainfall is slight, averaging about 25 cm annually. Present day vegetation in the coastal zone is nonindigenous, consisting of a dense, narrow band dominated by *kiawe*, *koa haole*, and lantana. The nature of the precontact vegetation is unknown.

The middle zone is marked by a switch to lava terrain with no soil development and sparse vegetation. The first 1.6 km of this zone is a relatively flat plain consisting of 2 sharply contrasting subzones—an easily traversed pahoehoe lava flow in the north and a later, barren and almost impassable aʻa lava flow to the south. A number of brackish springs are found at the coastal edge of this zone; one flows about 100 m from its origin to the sea at the southern end of the tract. From this lava plain the middle zone moves up the slightly steeper Hualālai Upland slopes for another 4.3 km. Average rainfall slowly increases to about 75–100 cm at the upper boundary of the middle zone (275 m elevation). Soil and vegetation patterns change with the gradually increasing rainfall. Soils have developed at the upper edge of the middle zone, and present day vegetation gradually alters from the widely scattered xerophytic trees and grasses of the lava plain to xerophytic shrubs and grasses on the lower slopes and finally, at the top of the zone, to dense stands of *koa haole*, Christmas berry, and lantana.

The lower upland zone is the zone with maximum soil build–up and thus smoother terrain. Here rainfall averages 100–125 cm annually, and vegetation is quite lush. Extensive clearing for modern agricultural and housing purposes has taken place in this zone, and thus all vegetation is now exotic. This zone extends for 1.6 km inland and covers about 200 hectares.

In the upland-forest zone terrain becomes markedly steeper. Rainfall increases to a maximum average of over 175 cm at 800 m elevation, and this combination of rainfall and steep slope seems to account for a more rugged terrain with less soil and many small, shallow gullies. Vegetation is lush primary and secondary indigenous forest which grades into the mesophytic *'ōhi'a* forests at higher elevations. The upland-forest zone extends 6.5 km.

Social Environment Until recently, systematic study of the precontact social environment for the Hawaiian Islands was virtually nil. One major problem was determining whether the local Kaloko population was initially an autonomous political unit and if so, when it became part of a larger political unit, such as the large chiefdoms found at European contact. This is a vital problem, for the Kaloko population's interaction with other social segments would have varied markedly depending on whether it was independent or but part of a larger polity.

It is hypothesized that Hawaiian societies were originally small (e.g., 500–1,500 people under 1 chief) and then developed into larger, more stratified societies (Cordy 1974a, 1974b). The size and nature of Hawaiian societies prior to A.D. 1400–1450 are unknown, but in either case (simple-ranked or complex-ranked) chiefly residences or burials should be present among the archaeological remains. As will be seen, prior to A.D. 1400–1450 no evidence of the presence of chiefs' residences or burials exists in Kaloko. This indicates that Kaloko was part of a larger society, and the chief managing Kaloko's affairs dwelled elsewhere. New data suggest that by A.D. 1400–1450, societies on Hawai'i Island were district-sized, complex-ranked polities which developed into multi-district societies (or perhaps an island-wide society) after A.D. 1400–1450. This is based on work in 16 North Kona communities located adjacent to Kaloko to the north and in 4 Kohala and Hāmākua communities (see Cordy 1981:176–184; Tuggle 1976).

These patterns indicate Kaloko was part of a wider society throughout its occupation and was ruled by at least 1 non-local overlord at all times. By analogy with contact era data, several overlords may have administered Kaloko at one time, arranged in a hierarchical interaction pattern (e.g., a low chief or *konohiki* managing the land for a high chief who in turn owed duties to the paramount) (Sahlins 1958; Malo 1951; Kamakau 1961; Ii 1959). Each of these overlords of Kaloko would provide leadership in political and religious interactions at different levels in return for tribute, corvée labor and warriors. The paramount would be the decision-making focus in interactions with other independent polities and the most important deities.

In addition to this political-control aspect of the social environment, interaction with neighboring communities undoubtedly occurred throughout Kaloko's occupation. This would involve marriage, trade, friendship, and visitation. The extent and nature of such interactions are again largely unknown (cf. Cordy 1974a).

There is one final aspect of the social environment which was important in precontact adaptations—the realm of the spirits. At contact this realm was subdivided into ancestral and place spirits. Interaction with ancestral spirits took place on hierarchical levels. Each residential group formally interacted with their ancestral spirits at their own men's houses (cf. Malo 1951; Campbell 1967; Kamakau 1964). In addition, ceremonial interaction with the overlord chiefs' ancestral spirits occurred in a hierarchical fashion (e.g., communities interacting with their respective local chief's ancestral spirits, with their respective overlord "district" chief's ancestral spirits, and with their respective paramount chief's ancestral spirits) with the respective chief or his intermediary as the contact of influence with the spirits (cf. Fornander 1969, II; Ii 1959; Malo 1951). Lavishness in ceremony and in architectural loci for the interaction increased and access to the interactions decreased with the hierarchical levels. As polities may have been smaller in the past, fewer levels of chiefs may have existed and interaction patterns with ancestral spirits may have differed. Again, we know only that large polities were in existence by A.D. 1400–1450.

Table 1 Site Types at Kaloko and Excavation Sampling

Site Type (site number)[a]	Excavated Sites/Total Sites Coast	Middle	Upland
Fishpond (11, 17)	1/1		
Isolated Platforms (21, 26, 33, 39, 55, 62, 64, 78, 80)	2/5	3/4[b]	
Pavings (18, 51, 58)	1/3		
Enclosures			
A. Complexes of tiny enclosures filled artificially with soil (48, 66, 67, 69–73)	4/4		
B. Enclosures less than 10m² (7, 57, 88)	2/2	0/1	__[b]
C. Enclosures greater than 10 m² (4, 22, 23, 24, 28, 31)	1/6	__[b]	__[b]
Complexes (enclosures & platforms) (3, 12, 15, 16, 25, 34, 42, 65)	6/6	2/2	
Trails			
A. Inland (30, 46, 81, 89, through middle zone jeep road)	0/4		
B. Local Coastal Network (36, 41,43, 44, 45, 49)	0/1		
C. Extralocal Coastal (coastal jeep road)	0/1		
Modified Brackish Pools (37, 38, 47,54)	0/4		
Tube Shelters (35, 40, 48, 35, 56, 59, 60, 61, 63)	2/4	3/4[b]	
Small Open-air Shelters (52, 53)	0/2		
Cairns (1, 82, 84)	0/3	__[b]	
Terraces	numerous[b]		
Walls	numerous[b]		
Cemetery (14)	1/1		

[a] Site numbers from Renger 1970. Those underlined were excavated.
[b] Data in Renger (1973); Unavailable at time of writing.

At contact, various locales had their resident place spirits, and interaction with these spirits usually occurred only when at that locale (cf. Menzies 1920:156–157). All social ranks seem to have had similar forms of interaction with these spirits. As place spirits are persistent throughout the Hawaiian traditions and throughout much (if not all) of Polynesia, we conclude that such spirits were always part of the social environment at Kaloko during human occupation, although undoubtedly individual spirits, their locations, and interaction patterns changed through time.

Introduction to the Excavation Data

Thirteen classes of non-portable architectural structures (each class being a site type) were identified from 1970 and 1971 survey data (see Table 1 for a list of types). This survey included the entire coastal zone, the entire lower portion of the middle zone, and a stratified random sample of 100 x 100 m quadrants in the remainder of the middle zone and the upland-forest zone. The lower upland zone has long been destroyed by post-contact agricultural and housing activities, but contact era historical data for Kaloko and neighboring areas partially fill this gap.

During the 1971 season, excavation of 9 of the 13 classes of sites was undertaken. Trails, modified brackish pools, small open-air shelters, and cairns were not excavated. Numbers of sites sampled are listed in Table 1. Most of the structures were excavated with a randomly selected 10% sample of 1 m² grids. Exceptions occur as follows:

(1) The fishpond wall was cross-cut in excavations run by William Kikuchi of Kauai Community College.

(2) Structure C–6 of site 42 was completely excavated in hopes of yielding more data for living area analyses. No real gain over the 10% sample was achieved.

(3) Upland walls and terraces were crosscut without using a 10% sample.

Table 2 Historic Sites and Structures

Site	Structure	Site Type
12	All structures	Complex
15	All structures except H15 Building Stage 1	Complex
16	All structures	Complex
22	———	Enclosure < 20m²
23	———	Enclosure < 20m²
25	Structures H3, C40, C42	Part of a Complex
26	Building Stage 2	Isolated Platform
28	———	Enclosure < 20m²
31	———	Enclosure < 20m²

Table 3 Radiocarbon Dates

Site	Structure	UCLA #	BP Age	Mean AD	Range
Cluster A					
25	H22	1781A	700 ± 50	1250	1200–1300
25	C41	1781B	520 ± 50	1430	1380–1480
15	H53	1781E	530 ± 60	1420	1360–1480
Cluster C					
42	C5	1781D	400 ± 60	1550	1490–1610
Cluster D					
3	C25	1781C	870 ± 80	1080	1000–1160

[a] Dates were processed by UCLA Isotope Lab in June 1972.

(4) Sampling of the cemetery varied from 20% to 100% for the various subtypes of burials (see Tainter 1973a). A 10% sample was chosen as a convenient sample size with which to recover the greatest range of data.

Excavation revealed that the structures in the Kaloko sites nearly all had but 1 building stage. Rather than building new structures over old ones, the living surface of the original structure was reused. Only sites 3, 15, 25, 26, and the fish-pond showed signs of multiple building phases. Our concern is with precontact patterns, so historic and prehistoric structures and building phases must be distinguished. This is done using 2 relative dating techniques—artifact classifications and architectural classifications. Historic artifacts are highly preservable (e.g., iron objects, pottery, ceramic beads, buttons), and sites dated to the historic era almost always contain some historic artifacts. We assume the absence of such artifacts indicates prehistoric occupation and a mixture of historic and prehistoric artifacts indicates both prehistoric and historic use of a living surface. Sites with only historic artifacts are accordingly interpreted as historic in nature. Additionally, high (>1 m tall), well-built (vertical with right angle corners), enclosing walls of houses and compounds have been found to be historic traits (Rosendahl 1972:76; Tuggle and Griffin 1973:22–23; Kirch and Kelly 1975:151; Cordy 1981:148–155). Table 2 lists all sites, structures, and building phases which are solely historic. All the other sites and structures are considered to have been used in prehistoric times. Exact artifacts are noted in Renger (1973). All sites have the characteristic high walls of historic times except for sites 25 and 26.

We have 5 radiocarbon dates for 4 pre-contact sites, and only 2 dates overlap at 1 standard deviation (Table 3). Volcanic glass samples were submitted to UCLA for additional absolute dates (by hydration analysis), but all the dates were quite late (after A.D. 1840), and in comparison with artifact content and radiocarbon dates, they were contradictory to what would be expected. Thus, these hydration dates are not considered accurate. This creates a serious problem, for there is no way to establish contemporaneity of living surfaces without absolute dating. This is the reason we have been unable to make detailed statements on social structure at different time periods or on changes. The resolution of the hydration dating problems should have alleviated part of this problem, but due to persistent laboratory problems, the question remains unanswered. The volcanic glass samples are now unavailable, and the reliability of glass dates is questionable.

Table 4 Permanent Habitation Structures

Site Type	Site Number	Area of Structures (in m²)
Isolated Platforms	15(H15)	24
	21	23
	26	22
	33	24
	39	24
	62	17
	64	39
	78	26
	80	20
Pavings	18	19
	58	57
Enclosures	24	27
Complexes	3	224
	25	125
	34	1,800
	42	288
	65	238

Brief Summary Of The Model

(Hypotheses are numbered in parentheses.)

On the basis of our analysis, we conclude Kaloko was a community (3) of several local residential groups (2) with constituent households (1). One household headed each residential group (4). Adaptation to the natural environment consisted of agriculture (9), livestock (11), and marine (12, 13) subsistence, water usage (14), and use of raw materials from various zones (15). Agricultural adaptation to the natural environment (10) and adaptation to the social environment of ancestors (8) was associated with the residential group. At least between A.D. 1490–1610, 1 residential group was of higher social rank than the others, and its senior (and/or wealthiest) household was the chief of the community (5). The community chief (whether absentee or locally resident) during all time periods controlled community-wide affairs (5,6) and adaptation to the more powerful ancestors of ruling chiefs (8). Also this chief was the political link to other communities and to higher and more powerful chiefs in the polity of which Kaloko was but a small part (6). The residential groups in the community also maintained links outside the community, but these were predominantly small-scale affinal links to adjacent or nearby local residential groups (7).

Supportive Arguments

The prehistoric structures (determined by what little chronological control we have) are lumped into 6 basic functional types: (1) subsistence, (2) temporary habitation (<15 m² and found isolated or associated with similar structures), (3) permanent habitation (>19 m² and found isolated, with similar structures, or with similar structures and small, special purpose structures associated with permanent housing), (4) communication-transportation (trails), (5) burials, and (6) boundary structures (cairns). Specifics of this division will be discussed below.

Social Structure

Hypothesis 1: Households. Four of the 16 architectural structure classes (isolated platforms, pavings, subclass C of enclosures, and complexes) are placed into the functional class of permanent habitation structures. The basis for this classification can be shown with archaeological evidence (Cordy 1981:62–71). For example, when the structures found at ʻAnaehoʻomalu and Lapakahi are analyzed, their floor areas reveal a bimodal pattern. There are structures less than 16 m² and structures greater than 24 m². A similar bimodal pattern is suggested for the structures at Mākaha. Archaeological research at Mākaha and Lapakahi has shown that the small structures are often C-shaped and L-shaped walls, which are usually solitary and found among inland fields, along trails and, in some cases, in coastal areas (Green 1968, 1970; Rosendahl 1972; Tuggle and Griffin 1973). These structures frequently exhibit complex internal stratification (e.g., firepits and lens-

Kaloko map with fishpond
26 picas x 30picas 8 pts

Figure 3. Site map of the coastal portions of Kaloko *ahupua'a*.

es). The same kind of excavation evidence has been recovered from caves (e.g., H–8, the 'Anaeho'omalu caves) (Emory et al. 1969; Barrera 1971). These patterns are suggestive of repeated short-term use. Indeed this has been the interpretation of such structures at Lapakahi and Mākaha (Rosendahl 1972).

On the other hand, research at Lapakahi, 'Anaeho'omalu and Mākaha has revealed that the larger structures generally lack complex internal stratification (Cordy 1981:62–71; Tuggle and Griffin 1973; Barrera 1971; Green 1968, 1970). They are usually found on the coast, either alone or associated with other structures that lack complex internal stratification. These patterns are suggestive of permanent residence sites (sometimes with small special purpose buildings as constituent structures).

This archaeological evidence can be strengthened when historical data in the form of ethnoarchaeological models are added. Historic data indicate that short-term habitation structures were caves, platforms, pavings, and low enclosures which were small and found along trails, among inland agricultural fields, and on the coast (Cordy 1973, 1981:54–71). Permanently inhabited structures were platforms, pavings and low enclosures which were larger (>19 m²), located predominantly on the coast, and associated often with small, special purpose structures that were part of the permanent settlement (e.g., work and storage structures) (Cordy 1973, 1976, 1981:54–71). These ethnoarchaeological models closely match the archaeological patterns and provide a strong argument of a dichotomy between permanent and short-term sites in the Hawaiian Islands. This pattern extends back to A.D. 850–900 at 'Anaeho'omalu.

At Kaloko this patterning is also quite clear. Small structures with short-term occupation characteristics are found in the inland fields, along inland trails and on the coast. These are interpreted as field, rest, and fishing camps (respectively). Kaloko sites with permanent characteristics are found in the coastal zone, on the interface of the coastal and middle zones, or at the seaward edge of the middle zone. These permanent sites include 9 isolated platforms, 2 pavings, 1 isolated enclosure of sub-class C, and 9 complexes of enclosures and platforms (see Table 4, Fig. 3). Each of the isolated permanent sites are interpreted as the dwellings of households on the basis of their spatial isolation and the presence of only 1 dwelling structure.

Further analysis of the permanent dwelling complexes was undertaken using several surface-feature variables.

(1) Complex area.

(2) Number of structures in complex.

(3) Total area of structures in complex.

(4) Average area of structures in complex.

(5) Total area of structures/total area of complex—yielding the amount of the site occupied by structures. Values near 0.00 indicate much open space.

(6) Population estimate (1 person/10 m^2 of structure).

Table 5 lists the data and clusters the data into 2 groups sharing similar variable values.

Site 34 is unique in having 2 structures of a size substantially above that of habitation structures documented historically or archaeologically (Cordy 1981:76–83). Its population estimate based on surface area is also dramatically above any for a habitation structure. We conclude it is a special purpose structure. In fact, site 34's features match the historic models for only 1 type of structure, the temple (Cordy 1973).

The remaining complexes are remarkably alike in having more than 2 structures, reasonable population sizes, and open areas. In fact, they are even more alike when their constituent structures are analyzed (Table 6). All contain 1 large structure and a number of smaller ones. Some of the smaller structures have the same range of floor-areas as the dwelling structures of the isolated households. Thus, they are also interpreted as dwelling structures. Others of the smaller structures have floor-areas in the short-term range. These are interpreted as special purpose structures associated with permanent settlement (e.g., work areas). The large structures in these complexes are quite different and suggest some kind of special purpose interpretation.

Comparison to historically based ethnoarchaeological models (Table 7) indicates a similar but more detailed interpretation. The smaller houses of permanent size range match the sleeping house model. The larger structures of sites 3, 42, and 65 match the men's house model. Site 25's larger structure matches a canoe-house model. A canoe-house is a male-oriented structure which could serve as a men's house; site 25's canoe-house may have served as a men's house (Cordy 1976).

We now interpret these complexes as households, based on spatial isolation, the small number of sleeping houses, and their close spatial association of the constituent structures. This also fits historic models which have close spatial association as the main criterion of households (see Cordy 1976, 1981:71–84). At this point, we now have a settlement pattern of 16 isolated, permanently occupied households—4 of which possessed several dwelling structures and a men's house.

Hypothesis 2: Local Residence Groups. Spatial analysis of all households indicates they tend to cluster into 4 groups—each group consisting of a number of single-dwelling households and 1 multi-dwelling household with an associated men's house (see Fig. 3). These groups (labelled A–D) are:

A—Complex 25, sites 15, 18, 21, 24, 26, 78.
B—Complex 65, sites 58, 62, 64.
C—Complex 42, sites 33, 39.
D—Complex 3.

These spatial clusters are interpreted as evidence of former local residence groups. Historic models substantiate this claim (Cordy 1976, Cordy and Kaschko 1980:405–406). Men's houses were vital structures for every household, for here offerings to, and ceremonies involving, family ancestors were given. It was also the locus of eating and leisure for men. At contact, several neighboring

Table 5 Cluster Analysis of the Permanent Dwelling Complexes

	Variables					
	(1)	(2)	(3)	(4)	(5)	(6)
Complex	Area (m^2) Complex	Structures in Complex	Total (m^2)	Mean Structures Size	% Area Occupied by Structures	Population of Site Area Est.
34	I(1800)	III(2)	I(1800)	I(900)	I(100%)	I(180)
42	I(1200)	I(9)	II(288)	III(32)	II(21%)	II(29)
3	II(800)	II(3)	II(224)	II(75)	II(28%)	II(22)
65	III(270)[a]	II(5)	II(228)	III(48)	I(88%)[a]	II(24)
25	III(300)[a]	II(3)	III(125)	III(42)	II(42%)[a]	III(13)

[a] In these complexes it was difficult to delimit site area due to terrain. More likely the areas were larger and the areas occupied by structures were near 20–30%.

Table 6 The Nature of the Structures in the Complexes

Site	Structures	Characteristics	Area (m^2)
Large Structures			
3	C-1	Platform with raised internal platform & unworked coral on the surface	144
25	R-2	Long, narrow, open-ended enclosure	70
42	C-8	Low, partial enclosure	80
65	C-36, C-37	Platform with raised internal platform	130
Small Structures			
3	C-2, C-3	2 platforms	r=30–50[a] m=40
25	C-41, C-43	2 platforms	r=20–35 m=28
42	C-4, C-6[b], C-7, C-102	1 platform & 2 enclosures	r=25–66 m=41
65	C-29, C-33	2 enclosures	r=36–56 m=46
Smallest Structures			
42	C-5, C-9, C-11	2 platforms & 1 L-shaped wall	r=4–15 m=8
65	C-34, C-35	1 platform & 1 enclosure	8

[a] r = range of the areas; m = mean of the areas.

[b] C-6 contained a large earth-oven.

Table 7 Ethnoarchaeological Models for Permanent Structure Types[a]

	Structure Types		
Traits	Men's House	Canoe House	Sleeping House
Area[b]	Larger Houses[c] (65–180 m^2, mean=92 m^2)	Larger Houses (37–96 m^2, mean=64m^2)	Smaller Houses (15–68 m^2, mean=32m^2)
Unique traits	In some cases, unworked coral or internal raised platform	Long, narrow open-ended enclosure	
Associated structures	Other permanent structures	Other permanent structures	Solitary or with other permanent structures
Number of Identified Archaeological Cases	15	13	92

[a] Cordy (1973, 1976a, 1981).

[b] The numbers in parentheses are areas of archaeological structures that matched the historical patterns, and thus these areas are incorporated in the models. The structures are at Lapakahi, Anaehoʻomalu, and 8 *ahupuaʻa* in North Kona (see Cordy 1981). The number of these structures per structure type are listed in the final row of the table.

[c] Permanent houses were noted to be as small as *circa* 24–28 m² (Samwell 1967:1176) and as large as *circa* 84 or 91–120 or 170 m² (Samwell 1967:1176; Cook 1944:337). This supplies a rough scale for "smaller" to "larger."

households often shared a men's house, and by doing so formed a local residence group in which men participated in religious, eating and leisure activities (Campbell 1967; Ii 1959; Cordy 1976). These groups have been assumed to be kin groups corporate in land holding (e.g., Handy and Pukui 1958; Kirch 1971). More recently collected ethnographic data (Sahlins 1971; Earle 1973) indicate that at contact such residential groups were not corporate in regard to land holding. The term residential groups avoids these recently uncovered problems.

Maximal synchronic population estimates for each of these groups can be calculated by using structure area. This yields populations of 27 (area A), 36 (B), 33 (C), and 22 (D). It is vital to note that these maximal estimates assume all of each group's households were occupied at the same time. It is quite likely this was not the case, but without additional dating control, determinations cannot be made. We offer no solution to the problem here other than suggesting that residential groups ranged from 20–35 persons.

Hypothesis 3: Community. All the above residential groups are seen to have been part of a Kaloko community at some point in the past. John Papa Ii (Ii 1959:110) noted Kaloko's existence as a community in 1812, and oral history mentions it during the reign of Lonoikamakahiki in the early 1600s (Kamakau 1961:56). The residential groups of Kaloko are spatially isolated from the Honokōhau sites to the south by a large expanse of rough aʻa lava (cf. Emory and Soehren 1961; Cluff 1969). A similar large unoccupied area separates Kaloko sites from the Kohanaiki sites to the north. In addition, the Kaloko-Honokōhau boundary seems to have been marked at some point in time, for 12 large cairns (ranging from 1.5 m high and 1.8–4 m in diameter) are set in a rectangle around a brackish pool 0.4 km from the coast (Emory and Soehren 1961:28). The presence of unworked coral about the cairns indicates a religious function (Cordy 1976). This fact plus the similarity of the cairns to descriptions of other Hawaiian politico-religious boundary markers (Menzies 1920:179) and their location on the border of political units existing at contact suggest these cairns were political and religious boundary markers.

The claim that Kaloko was integrated as a single community is even stronger when internal variables are considered. Only 1 precontact burial area has been found to date (site 14). In addition, only 1 large temple (site 34) is present where religious functions for a social entity larger than the local residence group would occur. The temple and the cemetery are connected to each other and to all residential group areas by a local trail network which does not stretch outside of the Kaloko area. These facts indicate Kaloko was a community which interacted in day-to-day affairs. We thus suggest Cluff's (1969) reorientation of the Kaloko-Honokōhau boundary is incorrect and that the boundary line should be that followed by Emory and Soehren (1961).

Maximal synchronic population estimates for the community of Kaloko are 118 based on permanent structure surface area. Again, this assumes all the residential groups existed at any one time period at maximal size, an unlikely assumption. Our dating control is extremely limited, but we can make a few statements. The group about area D was present at about A.D. 1100 (structure C-2 of site 3) and was still there later as evidenced by a second rebuilding phase at site 3. The group at area A was present *circa* A.D. 1200–1300 (structure H-2 of site 25) and still existed *circa* A.D. 1360/1380–1480 (structure C-41 of site 25 and structure H-5 of site 15). The group at area B is undated. The group at area C was present *circa* A.D. 1490–1610 (structure C-5 of site 42). This tentatively suggests that some of the groups were not contemporaneous.

Historical data indicate only 13–20 adult males lived in Kaloko between A.D. 1840–1849 (Kelly 1971:6–10). If population had not been altered too greatly in this area and if one assumes 4 more people as well as each male (wife and 3 children), the contact population of Kaloko seems to have been 65–100. Most of these people were buried at local Christian churchyards (Kelly 1971). This figure is not far off the settlement pattern figure. Population around 1840 was down 30% to 40% from contact (Schmitt 1971) for the Hawaiian Islands as a whole. Thus, if the 1840 Kaloko figures were adjusted, they become 93–167 which is even closer to the settlement pattern estimates. However, without time control, we again offer no exact estimate, rather we suggest community size probably ranged somewhere between 60–100 after A.D. 1200–1300, when at least 2 local residential groups were present.

Also the question of when Kaloko became a distinct community is uncertain without better time control. Between A.D. 1000–1500, if site 3 was the only site present, Kaloko may have been an outlier of an adjacent community. After A.D. 1200–1300 with 2 residential groups present, Kaloko's population size suggests Kaloko was a distinctive community.

Hypothesis 4: Residential Group Leader/ Hypothesis 5: Community Chief. Within the last 2 structural levels (local residence groups and community) distinctive grades of social ranking can be recognized. Two categories of data yield evidence relating to rank differentiation: residential structures and burials. A single interpretive framework can be applied to both of these data categories. This framework can be most clearly presented within the context of mortuary data.

In any system of hierarchical ranking, increased relative ranking of status positions will positively covary with increased numbers of persons recognizing obligatory status relationships with individuals holding such status positions. Binford (1971:17, 21) has observed that such a larger array of status relationships will entitle persons of rank to a larger amount of corporate involvement in the act of interment, and to a larger degree of disruption of normal community activities for the mortuary ritual. Expanding upon this, we may observe that both the amount of corporate involvement, and the degree of activity disruption, will positively correspond to the amount of energy expended in the mortuary act. Directionally, higher social rank of a deceased individual will correspond to greater amounts of corporate involvement and activity disruption, and this should result in the expenditure of greater amounts of energy in the interment ritual. Energy expenditure in turn should be reflected in such features of burial as size and elaborateness of the interment facility, method of handling and disposal of the corpse, and the nature of grave associations.

This proposition linking energy expenditure in mortuary ritual to the rank of the deceased has been subjected to ethnographic verification. In a sample of 103 ethnographic cases, the energy expenditure argument was not contradicted in a single instance (Tainter 1975). This result suggests that the analysis of energy expenditure will provide a valid criterion for determining rank grading in mortuary data. Reversing the reasoning just outlined, when sets of mortuary data cluster into distinctive levels of energy expenditure, this occurrence will signify distinctive levels of social involvement in the mortuary act, and will reflexively indicate distinctive grades or levels of ranking.

Much the same interpretive framework can be applied to the analysis of residential structures. In addition to mortuary ritual, it would also be expected that persons of higher rank would be entitled to greater amounts of social involvement and energy expenditure in residential construction.

If the Kaloko households identified previously, are ranked in terms of energy expenditure, 3 distinctive levels can be observed. Sites 42, 3, 65, and 25 have greater amounts of energy expended in residential housing seen in the construction of men's houses. In addition, the restriction of men's houses to these sites and the fact that each residence group had only 1 men's house suggests these households held positions of higher rank or prestige in their respective local residence groups. This argument is supported when we consider that men's houses functioned in the sphere of social and religious integration. The households possessing men's houses must therefore have filled an integrative role in their residence group's affairs. Furthermore, since each of these households had more than 1 dwelling structure in contrast to the other households, they were probably of larger size than was typical for the community. Such larger size suggests a larger array of social relationships which would have been significant in the maintenance of a position of rank.

Moving to the community level, a marked distinction is evident in social ranking. Site 42 involves almost a quantum jump in energy expenditure, for prior to construction of its houses the entire surface area of 1,200 m^2 was formed by constructing a terrace against a low pahoehoe lava ridge. This terrace is over 1 m high in places along its inland face. The size of this terrace indicates that a large amount of energy expenditure and disruption of normal communal activities were involved in its construction. This suggests that the site 42 occupants were probably of the highest rank in the local community, having a greater number of people recognizing status obligations to them. In addition to energy expenditure measures for social ranking, historical models (Cordy 1973, 1976, 1981) indicated that chiefly households in Hawai'i had a large number of houses (5–10 or 12), while the households of commoners consisted of but 1 to 3 houses. Site 42, with 10 houses, closely fits the model for chiefly social rank.

Thus, 3 social rank grades are visible in housing, but what of their temporal placement? Site 42 was constructed at one time, but how long was it occupied? Our 1 radiocarbon date (for C-5 of site 42) indicates it was occupied between A.D. 1490–1610. Site 25 of the second rank grade almost overlapped site 42 in timespan (A.D. 1200–1480) as did the lowest rank grade (structure H-5 of site 15, A.D. 1360–1480, assuming all of site 25's structures were used contemporaneously). This suggests that perhaps in the later 1400s, and after, all 3 rank grades were present, indicating a marked dichotomy in social ranking like that found at contact between chiefs and commoners with the household at site 42 definitely holding a chiefly rank. We conclude that site 42's household head regulated politico-reli-

Table 8 Kaloko Burial Classes

Class	Cases	Volume (m^3)[a]	Facing
H	1[b]	43.8	Present
A	5	13.5–21.7	Extensive
B	11	6.3–9.8	Extensive
D	7	5.3–8.6[c]	Variable
C	3	1.4–3.2	Present
E	25	0.5–1.0	Absent
F&G	65	(No associated mortuary platforms)	

[a] These mortuary platforms were of highly irregular shapes and were constructed upon a flow of uneven a‘a lava. For these reasons, platform volumes can be computed only very roughly.

[b] In the original analysis of the Kaloko cemetery (Tainter 1973), 2 structures were interpreted as mortuary class H platforms. It now seems possible that 1 of these was not a mortuary platform, but a structure of some other function that had an interment placed within it. This intrusive burial has now been assigned to the crevice class of disposal (F).

[c] Although 1 class D structure was slightly larger than some of the class B structures, it is ranked lower due to the considerably greater expenditure required for the detailed facing found on the B platforms.

gious functions in the community *circa* A.D. 1490–1610 by analogy to the contact model of local chiefs (cf. Sahlins 1958; Handy and Pukui 1958; Cordy 1974a, 1974c). The presence of the temple (site 34) near site 42 may be seen as indirect evidence of this decision-making power.

What of social ranking pre-A.D. 1490–1610? The lower 2 rank grades were present between A.D. 1360 and 1480 (complex 25 and site 15), and from A.D. 1000–1160 to A.D. 1360–1480 this pattern is also suggested, for cases of Rank Grade 2 are present, at complexes 3 and 25. In sum, if site 42 is assumed to not have yet been built, then the pre-1490 social ranking in Kaloko would seem to be a 2 level system (Ranks 2 and 3) with less separation between ranks (seen by less energy expenditure differences). This suggests the community was controlled by a chief who dwelled elsewhere.

Finally, what of post-1490–1610 social ranking at Kaloko? Historic data show that at contact the community chief (*konohiki*) did not live at Kaloko, being instead with his overlord chief at the court of the paramount chief (Kelly 1971:16–17). This was a common pattern historically and archaeologically (Earle 1973; Ii 1959:Ch. 8; Cordy 1981). Thus, it seems quite likely that the community chief did not reside at Kaloko except on rare occasions. Site 42 may also have been evidence of the first and last time the chief controlling the community was permanently in residence.

Burial data augment this picture of rank grading. From the Kaloko cemetery, 8 distinctive classes of burial have been recognized. These seem to be grouped into 7 distinctive levels of energy expenditure (6 levels of burial platforms, ranked in terms of size and elaborateness, and burials placed in lava caves or crevices without an associated mortuary structure), and thus may reflect 7 distinct grades of ranking. These burial classes have been described elsewhere, (Tainter 1973a) and are summarized in Table 8.

Within these 7 rank levels, a sharp contrast can be discerned between the amount of energy expended on the construction of platforms, and the comparative lack of energy expended on the interment of individuals in caves and crevices. Following the energy expenditure argument, platform burials can be interpreted as individuals holding status relationships with lower ranking social units, while cave and crevice burials (F and G) seem to represent persons of the lowest status who lacked the right to large-scale social involvement and activity disruption for their inhumation. In sum, a dichotomous distinction between high and low ranking persons is evident in both the mortuary and residential data. However, the correspondence between mortuary platform classes and specific residential loci is uncertain due to a lack of temporal control.

Adaptation to the Social Environment

Hypothesis 6: The Community Chief as the Link to Other Communities or Larger Level Politics. At contact in Hawai‘i, interaction between communities or between a community and its overlords (district and/or paramount chiefs) was almost solely through the community's chief. As an appointee of community overlords, the community chief collected taxes, workers for corvée labor, warriors for battle, etc. on the demand of the overlord (cf. Sahlins 1958). In turn, he was also the access link for the community to make requests of the overlord if need be. We have noted that Kaloko was never an autonomous polity. Instead, Kaloko was managed by a resident or absentee chief. We conclude that this chief was the decision-making link to other communities or to higher overlords. We suggest by analogy to contact era data that his role was largely political. Other than perishable status goods being presented as taxes to overlords, (cf. Cordy 1974a) no evidence exists that the chief coordinated any medium- or large-scale trading, for nonperishable exotic items (e.g., adze basalt and volcanic glass) are present only in small amounts (e.g., 92 small volcanic glass pieces in 26 structures, each piece weighing < 1 gm).

Hypothesis 7: Local Residence Groups' or Households' Links to Different Communities. Contact era historical data contain references to marriages occurring between households or residence groups of neighboring communities (cf. Sahlins 1971). Data on the frequency of exogamous marriages are rare. One of us (Tainter) has previously analyzed this problem with data from the Kaloko cemetery. Historical evidence was cited which suggested that burial caves were used exclusively for the interment of co-resident consanguines with affines excluded from such features (Kamakau 1964:40; Handy and Pukui 1958:5). In 2 caves at Kaloko the ratio of 17 adult males to 20 adult females was suggested to indicate a nearly balanced pattern of post-marital residence with the husband's and the wife's natal unit (Tainter 1973a). However, since this interpretation did not take the possibility of endogamous marriages into account, it is currently undergoing revision. The question of patterns of post-marital residence might be resolved by analysis of nonmetric osteological characteristics (cf. Lane and Sublett 1972; Buikstra 1972).

Again social interaction between communities at these low levels of social segments is hypothesized not to have involved trade, for exotic products are not present in large amounts at Kaloko and because neighboring areas contained similar resources.

Hypothesis 8: Links to the Ancestors. As noted above, ancestors were a vital aspect of the precontact Hawaiian social environment. The hierarchical nature of ceremonial requirements in association with social ranking was also noted. At Kaloko we have noted that each residential group (one of which was the chief's) had 1 men's house. Also, it was noted that these structures were the loci for each residential group's interaction with their ancestors. The use of coral offerings at only 1 men's house (site 3) suggests different religious patterns (either in offerings or deities) between people once living in area D and the other 3 areas. In addition to these men's houses, the presence of a temple (site 34) strongly suggests a spatial locus for interaction with the paramount's ancestors, and possibly the district and community chiefs' ancestors as well. This conclusion is made by analogy to the contact era situation where historic data indicate that only the paramount initiated construction of temples of such size (Cordy 1973, 1974d).

Besides these interactions with ancestors closely associated with social groups, spirits of different locations (e.g., certain trees, caves) were worshipped. Historic models indicate solitary upright stones are the only archaeological implication for such interactions (Cordy 1973). In the upland-forest zone of Kaloko, one such stone was found (Renger 1973:117) and is interpreted as evidence of interaction with a spirit associated with that place.

Adaptation to the Natural Environment

Hypothesis 9: Location and Nature of Agricultural Areas. Agricultural features are indicated by (1) terraces and low walls, (2) small earth-filled enclosures, and (3) historical data. In the lower upland-forest zone (488–550 m elevation) of rough terrain and higher rainfall, terraces, small piles of stones, and low walls across gullies were scattered about with little discernible order. The terraces and low walls are interpreted as agricultural water and soil control devices, whereas the stone piles are seen to be evidence of clearing of stone for agricultural planting. The area in which these features are found covers 75 hectares, but the actual area under cultivation would have been somewhat less. In addition, a few structures of C-, L-, and rectangular shape were also found scattered among these agricultural features. The area of the structures ranged from 8 to 15 m^2, and on this basis we conclude that they were temporary use structures. This argument is strengthened by contact historical data from other Kona coast areas to the south of Kaloko, where a few structures for temporary use were scattered among the upland fields (Cordy 1973b, 1981:55–71).

The upland zone from 275 to 488 m in elevation would appear to be the most favorable area in Kaloko for aboriginal cultivation—having soil, rain, and relatively smooth terrain. Yet this area has been destroyed by post-contact activities. However, historical data indicate this indeed was the agricultural focus of Kaloko. Archival data dating from about A.D. 1850 show 12 commoner households received rights to plots of farmland which they had used in the past (Kelly 1971:6–8,16). These plots ran predominantly inland-upland between 335–549 m in elevation. They were long, narrow parcels that ranged from 0.7 to 2.8 hectares in area with a mean of 1.2 hectares. Some of these households had held their land since at least A.D. 1839 (Kelly 1971:16).

No historical data specifically on Kaloko agricultural practices are available prior to A.D. 1830, but we consider the above data reliable for precontact Hawaiian agricultural practices as cash cropping did not begin in the Kaloko area until the 1880s (Kelly 1971:13) and, as elsewhere, the only changes in traditional practices other than cash cropping were increases or decreases in production (cf. Cordy 1972). Pre-1830 agricultural data exist for areas 6.5 km to the south of Kaloko, areas which possessed the same terrain and climate and were in the same chiefdom. Analogy to these data can be made (data compiled in Cordy 1970, 1973). In the upland zones of this neighboring area, low-walled farm plots with scattered temporary-use house sites were present. In these plots were grown year-round the entire range of Hawaiian crops (e.g., sweet potato, dryland taro, bananas, breadfruit).

On the basis of this analogy and the later historical data noted above for Kaloko, we conclude that the upland zone and the lower upland-forest zone were the agricultural center of Kaloko. The upland zone (at least from 300–488 m elevation) was completely divided into farm plots, while plots became more scattered and irregular in the more rugged terrain on the edge of the forest. Some house sites were present and used temporarily. A rough idea of total possible area under cultivation can be obtained, for the upland zone covers an area of 200 hectares and the 490–550 m elevation part of the upland-forest zone covers 75 hectares. Total area is 275 hectares, and actual cultivable area would be expected to be less than that figure due to terrain factors.

No agricultural features are found in the middle zone of Kaloko until the coastal zone interface. Indeed very few architectural remains are found in the middle zone away from the coastal zone interface. Only 7 lava tube shelters, 3 platforms, and 1 L-shaped enclosure are present (Renger 1973). They are small in area (<10 m^2), and this along with the fact they are located along the inland trails leads us to conclude these structures were rest stops when travelling along the trails.

Just inland of the interface of the coastal and middle zones, however, small enclosures with their interiors dug below ground level and artificially filled with soil are found. These are considered to be agricultural in function. These enclosures occur just inland of the permanent dwelling sites and are described in detail elsewhere (Renger 1970:24–27). They are mostly oval and range from 2 to 11 m long by 1.5–6 m wide with walls .3–.5 m wide and rarely above 1 m high. Soil fill is up to 20 cm deep. Two major clusters of these enclosures are along Trail 3—site 66 having over 40 enclosures and site 67 about 10 (see Fig. 3 for location) (Renger 1970:21, 27–29). Two smaller clusters occur. One (site 48) with 2 enclosures just inland on Trail 4, and the other (site 69–73) with 7 enclosures was in a sink in the a'a lava over 360 m inland of site 48 on Trail 4 (Renger 1970). The crops that were grown in these enclosures are unknown. The low rainfall and the minimal soil depth suggest a shallow-rooted, hardy cultigen. The walls of the enclosure may have functioned as a windbreak. This makes paper mulberry a possibility.

Hypothesis 10: Use of Agricultural Areas Associated with Local Residence Groups. We suggest that members of each local residence group held use rights to adjacent portions of the upland agricultural areas. There are 4 narrow trails running into the uplands from the coast, one of which branches over 1.6 km inland (see Fig. 3). Trail 1 begins near site 78 at the present jeep road 183 m inland of site 25. Trail 2 extends from site 12 at the south end of the fishpond. Trail 3 underlies the present Kaloko jeep road and passes by site 65, the burials and the small agricultural enclosures, and Trail 4 extends inland between sites 42 and 3. No dates exist for these trails. Yet in 1888, we know Trail 2 was in use (Kelly 1971:15), and as site 12 is historic and as Trail 2 runs into site 12, we conclude Trail 2 is historic. The other 3 trails are postulated to be of precontact age.

Trails can serve a number of functions—the foremost usually being transportation links. All of these trails run inland through the middle zone and into the upland zones, all being vital resource areas (thatching grass, agricultural products, and forest products, respectively). All of these trails also start near coastal complexes (Trail 1 near site 25, Trail 3 near site 65, and Trail 4 near sites 3 and 42). Thus, we postulate that these trails were links between residential groups and their associated farm areas. Similar trails connecting coastal sites with upland farm sites are found in the Kohala district on Hawai'i Island, (Kaschko 1973; Cordy and Kaschko 1980:209, 413–415) adding credence to this conclusion.

The enclosures at the coastal-middle zone interface are also linked with coastal residences by trails (see Fig. 3).

Hypothesis 11: Livestock. Data on livestock raising are extremely scanty. Remains of pig and/or dog were found in some sites. In addition, site 57, an enclosure of small area and surrounding a depression in the coastal zone, is interpreted as a livestock pen. The sunken nature of this site precludes a dwelling function. This pen was probably used either for pigs or dogs at certain, unknown times. The social units with which livestock are associated is unknown.

Hypothesis 12: Marine Resources. All sites included mollusk and fish remains to varying degrees (Renger 1973). We have not yet identified species remains and compared them to species distribution along the coast, so no conclusion on usufruct zones can be made.

Hypothesis 13: Fishpond Resources. The large fishpond at Kaloko (covering 3.8 hectares) was constructed at some unknown date. It was present in 1812 (Ii 1959:110) and is noted in traditions during Lonoikamakahiki's reign in the early 1600s (Kamakau 1961:56). At contact, we assume, only chiefs could use fish raised in such a pond (e.g., Kikuchi 1973, 1976). Again we have not yet identified fish remains from our sites to ascertain who actually consumed pond fish.

Hypothesis 14: Water Resources. Potable water is scarce in Kaloko. However, a number of brackish pools are present near the coastal-middle zone interface as well as 1 spring in the same area which sends a small rivulet 100 m to the coast just south of site 3. These were the drinking water sources of Kaloko's population. Modifications frequently are found at these brackish pools with either small cleared areas about them or large lava slabs tilted over them for shade (e.g., sites 37, 38, 47, 54) (Renger 1970). Short trails lead to several of these pools, particularly near sites 3 and 42.

Hypothesis 15: Local Raw Materials. Sources of raw material for stone adzes (basalt) and abraders (coral) are uncertain without analysis of the tools; they may have been local or exotic. The middle zone may well have been the source of thatching materials, as it presently contains scattered grass and possibly did so in the past. The upland-forest zone is suggested to be the logical source for forest products such as wood of various sizes and vines crucial to the manufacture of housing, weapons, digging sticks, fishing nets and lines, and canoes.

Table 9 1978 Hydration Dates from Kaloko

Sample number	Source	Rind (μ)	Quality	A.D. Date Range
D13–42, Structure 14				
1	Pu‘uwa‘awa‘a	4.3 ± 0.3	Good	1588–1638
2	Pu‘uwa‘awa‘a	3.8 ± 0.3	Fair	1631–1681
D13–34, Upper Platform				
1	Surface Flow	3.6 ± 0.3	Good	1648–1698
2	Surface Flow	2.5 ± 0.3	Good	1741–1791
3	Surface Flow	2.0 ± 0.3	Poor	1784–1834

Table 10 New Structures and Sites at Kaloko, 1977 Fieldwork

Site Number-Structure Number	Discussion
42–14	*New structure.* Rectangular alignment on pahoehoe lava near site 42's terrace. 72 m². Function uncertain.
3–4	*New structure.* Platform. 30 m². Function = sleeping house.
3–5	*New structure.* Platform. 35 m² Function = sleeping house.
150	*New site.* 3 Platforms. 30 m north of D13–3 along the shore road in *kiawe* thicket.
–1	Platform. 20 m². Sleeping house.
–2	Platform. 20 m². Sleeping house.
–3	Platform. 12 m². Special purpose structure.

On the basis of inland trail directional tendencies, it is further suggested that local residence groups held use rights to the forest land to the interior of their upland fields.

Conclusions: The Generalized Model for Kaloko

Social Organization

Throughout its span of occupation Kaloko was but part of a larger society. Kaloko was apparently a unified community after A.D. 1200–1300. When initially occupied (A.D. 1000–1500), it may have been an outlier of another community. Nevertheless, from its initial occupation, Kaloko had 1 or more internal local residence groups containing constituent households. By A.D. 1200–1300 at least 2 residential groups were present in the community, and by contact (*circa* A.D. 1778) at least 4 residential groups had dwelled in the area. Each residential group performed religious functions as well as being a leisure unit. Members of the group held use rights to adjacent farm lands and probably to areas where forest and marine resources were located. Within each residential group, 1 household seems to have been dominant, being the spatial focus for its group's religious activities. It is suggested that such dominance was a function of consanguineal seniority and/or wealth.

In addition to this horizontal homogeneous patterning, a hierarchical pattern existed at Kaloko. A chief controlled the political and religious functions of the community. Before and after A.D. 1490–1610 apparently this chief dwelled elsewhere. Between A.D. 1490–1610, this chief resided in Kaloko, and evidence indicates that during this time period the chief was of a markedly different social status, similar to the contact situation.

Due to lack of chronological control, we cannot give exact population figures for social components through time. However, we can state that the community seems to have gradually grown in size but could never have been larger than 118 and most likely was about 60–100 in size. The

Table 11 New Population Estimates for Kaloko

Household	Population	Household	Population
Cluster A		*Cluster C*	
25	12	42	18
15	6	33	6
18	6	39	
21	6		
26	6		
24	6	*Cluster D*	
78	6	3	24
80	6	150	12
Cluster B			
65	12		
58	6		
62	6		
64	6		

size of residential groups obviously varied, but probably ranged from 20–35 people. Household sizes varied, but maximum size seems to be about 29 with a range of 1–29.

Adaptation to the Natural Environment

Nearly all archaeologically and ethnographically documented permanent Hawaiian settlements had 4 general subsistence subsystems (fishing, mollusc-echinoderm collection, agriculture, and livestock), and Kaloko was no exception. At Kaloko, agricultural exploitation was year-round rainfall agriculture, predominantly limited to the upland zone (maximum area under cultivation being *circa* 275 hectares) where soil and rainfall were adequate. Each local residential group's members held use rights to adjacent areas of the upland, and within these areas each household farmed small plots. Some had small temporary shelters for use when tending fields. Within these plots the entire range of Hawaiian crops were cultivated. In addition, some crops (perhaps paper mulberry) were grown just behind the coastal settlement on a small scale in artificially made environments. Members of spatially associated residential groups held use rights to these crop areas. How livestock were raised at Kaloko is uncertain. They were at least kept on the coast for periods of time.

Marine resources were the common protein source. It is uncertain if marine resource areas were divided among residential groups. Artificial raising of fish occurred in a fishpond constructed in Kaloko's bay. At contact in other areas, such pond fish were reputedly for chiefly consumption only, but this has not been ascertained at Kaloko.

Potable water was available only in brackish pools near the coastal settlement. Various pools are directly linked to households by trails. Raw materials from the middle zone (e.g., thatching grass) and from the upland forests (e.g., vines and wood) were also crucial resources, and it is suggested each residential group held rights to the raw materials contiguous to their inland trails. In sum, adaptation to Kaloko's natural environment predominantly was associated with the residential group, for this group was associated with agricultural areas and probably to marine, forest and middle zone resource areas in which its members held use rights. Livestock was raised by unknown social segments. Actual resource collection occurred at the household level. Social rank may have influenced this adaptation if the fishpond resources were restricted to the local chief and if the local chief had rights to land plots in other residential groups' agricultural areas.

Adaptation to the Social Environment

Adaptation to social entities equal to or larger than the community level was achieved through the community chief. Such adaptations were largely political and religious. No evidence for medium or large-scale exchange of non-perishable products exists.

Adaptations between lower social segments undoubtedly also occurred, but our data are scarce. Some indication of affinal ties to neighboring communities' households or residence groups is suggested, indicating kin network ties at these lower social segment levels. Again no evidence of medium or large-scale trading or exchange of non-perishable products within such networks exists.

Adaptations to the influential realm of the ancestors were achieved at 2 levels. Each residential group worshipped their specific ancestors separately, and the entire community worshipped the ancestors of their overlord chiefs (particularly the paramount). At least 1 residential group had different patterns of interaction with its ancestors as seen in religious offerings. In addition to the ancestors, interaction with at least 1 supernatural spirit associated with a locale in the upland-forest area occurred.

Acknowledgments

We were fortunate enough to undertake this project at the request and with the support of the Kona Coast Company. The help and aid of Mr. Dennis Haserot was invaluable. We note the present ongoing debate over the status of the Kaloko-Honokōhau area, and while not necessarily agreeing with the developer's stand, we must acknowledge their concern and outpouring of money to allow us to recover the data we did. Also, we acknowledge the constructive comments offered by Dr. H. David Tuggle.

Postscript

This paper is more than a decade old. It was completed in 1975, with slight revisions in 1977. The paper has been submitted to make it more easily available. It has not been revised for this publication except for minor editorial revisions and some updating of references. It is also important to emphasize that this is not a paper intending to present the detailed site information at Kaloko. That is covered elsewhere. This paper was written as a summary document.

Since the last version of this paper was written in 1977, several new interpretive analyses have been written. Also, some new fieldwork and dating was done. Further discussion is needed to bring the reader up-to-date. During June of 1977, 2 of us returned to Kaloko (myself and Robert Hitchcock). Our purpose was to surface collect volcanic glass from site 42 (the high ranking site) and from site 34 (the temple) for dating. We did this, collecting 2 samples from site 42 and several from the upper platform of site 34. These samples were thin-sectioned at the University of Hawaii's Department of Anthropology Archaeology Lab by Larry Olson in 1978. Results are presented in Table 9 below. The dates for site 42 overlap with the radiocarbon date and suggest that occupation at this site continued into the mid-1600s. The large temple saw use from the A.D. 1600s through the A.D. 1700s.

This fieldwork also found a number of new structures and 1 new site. This was possible because it was extremely dry, and thick vegetation had died off.

Table 10 presents this information. The new site (D13–150) is clearly a permanent residence, based on traits noted in the Kaloko paper. It would be associated with site 3's local residence group (Group D) following this paper's methods.

One analysis that has affected the interpretations at Kaloko is my Ph.D. work (Cordy 1978, 1981)—particularly the section on population estimates. It was suggested that Captain James King's 1779 population estimate of 6 persons per sleeping house was a more sensitive indicator of population. Accordingly, all household population estimates change (see Table 11). Maximal local group estimates become as follows: A=54, B=30, C=30, and D=36. The maximal population estimate for Kaloko changes to 150.

Additionally, my thesis work focused on reconstructing social echelons (strata). A wider data base made it clear that D13–42 was the site of a high chief's household. Its labor expenditure measure (1000 m^3) was vastly different from Lapakahi's low chief's household (224 m^3) and those of commoner households (rarely exceeding 40 m^3) (Cordy 1978, 1981).

In 1976, Joseph Tainter published an article attempting to reconstruct local groups from the spatial patterning of burials in the cemetery (Tainter 1976). The information in this article was not included in our 1975 synthesis or the 1977 rewrite.

Clearly, analysis at Kaloko is not complete. We realized this when we first completed our synthesis in the early 1970s. More dating is needed, and more work is needed in inland areas. Certainly other research emphases can be followed up. *Ross Cordy*

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The Kualoa Archaeological Research Project, 1975–1985: A Brief Overview

Jo Lynn Gunness

Kualoa Regional Park, as part of the *ahupuaʻa*[1] of Kualoa, is listed on the National Register of Historic Places as being of Statewide significance. The entire *ahupuaʻa* was placed on both the State and National Registers in October of 1974 on the basis of its mythological and legendary importance to the Hawaiian people. Since December of 1974, the Kualoa Regional Park area (which encompasses approximately ¼ of the entire Kualoa *ahupuaʻa*) has been the focus of on-going archaeological research conducted under the auspices of the City and County of Honolulu, Department of Parks and Recreation. The purpose of this paper is to provide a brief overview of that work.[2]

Physical Environment

The Kualoa *ahupuaʻa* is located on the windward (northeast) coast of Oʻahu Island, Hawaiʻi. The *ahupuaʻa* consists of a broad, flat plain bounded on the north by the *ahupuaʻa* of Kaʻaʻawa, on the east by the Pacific Ocean, on the south by Kāneʻohe Bay, and on the west by the *ahupuaʻa* of Hakipuʻu and Mōliʻi Fishpond, a prehistorically built fishpond which is still being operated today. Politically, the ridgeline forming the boundary between Kaʻaʻawa and Kualoa (Kalaeokaʻoʻio) also marks the boundary between the districts of Koʻolau Loa to the north, and Koʻolau Poko, of which Kualoa is the northernmost *ahupuaʻa*, to the south.

The nearly vertical ridgeline, called Palikū, which forms the northern boundary of Kualoa is a section of the caldera rim of the extinct Ko'olau volcano, which reaches an elevation of 579 m at the peak known as "Pu'u Kanehoalani." The ridge's talus slopes drop steeply to the flat plain which forms the Kualoa peninsula, approximately 61.6 hectares of which comprise Kualoa Regional Park—the focus of the present archaeological investigations.

Situated about 400 m off Kualoa Point is Mokoli'i Island (Chinaman's Hat), a sea stack formerly a part of the Ko'olau rim. A broad, shallow reef extends out to Mokoli'i Island, beyond which the reef drops off into open sea.

The reef, the rocky shoreline of Mokoli'i Island, and remnants of a now destroyed fishpond wall off Kualoa Point provide a habitat for a wide range of marine fauna which have been exploited since prehistoric times.

Kualoa in Ethnohistoric Records

The Kualoa area is rich in oral traditions which give insight into its place in the island's culture. Kualoa (literally "long back") was in ancient times called Palikū ("vertical cliff"); being named for the ridgeline which forms the land division's northern boundary (Pukui, Elbert and Mookini 1974).

It is said that the goddess Haumea, and her husband Wākea—the progenitors of the Hawaiian people—made their home at Palikū (*Hoku o Hawaii* 1928; Sterling and Summers 1978:183–184). It was from the cliffs that Haumea battled the warriors of Kumuhonua; and from here that Haumea, Wākea, and all their followers were washed to sea by a great tidal wave:

They swam in an effort to save themselves, until they were almost exhausted. Kamo'awa, Wākea's *kahuna*, taught Wākea how to cup his hands together to represent a *heiau*, then he caught a *humuhumunukunukuapua'a* fish [a form of Kamapua'a or Lono, god of storm and rain] and stuck it head first into the cupped hands to represent a pig. Then the followers swam around Wākea in procession, dedicating the "*heiau*." As soon as this ceremony was finished, the sea washed them ashore (Handy and Handy 1972:449 from *Hoku o Hawaii* March 12, 1928; see also Sterling and Summers 1978:183–184).

As a result of this event, here was built the high shrine to Lono, the god of storm, who save Wākea and Haumea in the flood and was thereafter served by what Malo (1903, p.210) refers to as "the separate order" of priests, the Mo'o Lono (Mo'o-kuauhau-o-Lono, or genealogical-line-of-Lono). "The priests of this ritual were also said to be of the order of Paliku" (Handy and Handy 1972:447).

Numerous specific geographical points around Kualoa are associated with other Hawaiian mythological figures—many of them tied to the legends of Pele, the volcano goddess, and her sister, Hi'iaka (both daughters of Haumea). Hi'iaka is said to have fought and killed a huge *mo'o*, or dragon at Kualoa. Part of his tail became Mokoli'i Island, and his body became the foothills below the Kualoa cliffs (Beckwith 1970, Fornander 1880, Mitchell 1973, Raphaelson 1925). And Kamapua'a, the half-man, half-pig being is said to have once hidden from Pele in a hollow at Kualoa, and later made the holes which can be seen today in the Kualoa ridge (Sterling and Summers 1978:182–183).

Another story tells that Kualoa was the home of a young shark demi-god who lived in a pond [or spring in another version of the story] at the end of Kualoa Point, and who was fed fish and taken care of by the people of the land. In return, he protected the people from sharks when they went out on the reef to collect food. One day a new *konohiki* (the headman of the *ahupua'a* under the chief) came to Kualoa, and because he wanted to keep all the fish for himself, he refused to let the people feed the shark god. In time, the shark god's father came passing by, and discovered his son wasting away. When he learned of the *konohiki's* stinginess, he was very angry, and caused a great tidal wave that washed away the *konohiki* and destroyed the pond [or spring] (Paki 1972, Raphaelson 1925). And since that time, people have had to be wary of sharks when they go out on the reef at Kualoa.

Kamakau (1964:73–74) also tells of a shark that lived in the waters of Mokoliʻi, at Hakipuʻu and Kualoa. This shark had only 1 tooth, and nipped like a crab to warn swimmers of the presence of dangerous sharks.

Kualoa is said to have been a very sacred place. Many authors record that all canoes lowered their sails when passing Kualoa, in respect for its sacredness (Alexander 1899, Fornander 1880, Thrum 1911); and even Kamehameha I is said to have followed this custom. Handy and Handy, in speculating on the reasons for this ritual, recall the manner in which Haumea and Wākea were saved from the sea by creating a "*heiau*" to Lono. They say this custom, which was carefully followed by all passersby, would seem to justify the conclusion that it was at the base of the cliff called Palikū that the ancient *māpele* shrine dedicated to Lono was located. This undoubtedly was the sea of the hierarchy of the priestly order of Lono, to which Malo referred. . .where was transmitted orally "the genealogy of Pali-ku" by and to the Moʻo-Lono. It is not unlikely that the long chant describing the birth and exploits of Kamapuaʻa, who was identified with Lono, was composed and recited here (1972:448).

Kualoa is where the "sacred drums of Kapahuula and Kaahuulapunawai" were located; and it is where whale ivory washed ashore—called "*palaoa-pae.*" (Whale ivory was highly prized for its use in the manufacture of the *lei niho palaoa*, or whale-tooth pendant, the symbol of high chiefly rank.) For these reasons, the possession of the lands of Kualoa by Oʻahu's chief was considered to be a symbol of sovereignty and independence for Oʻahu (Kamakau 1961, Westervelt 1926, Fornander 1880). *Ka Nai Aupuni* (1906) states: "If Kualoa should be taken, ½ of the island of Oʻahu, and all the pink dyed tapas of Koolauloa were to be taken also." Kamakau (1964:18) and Thrum (1911:152) both list the entire *ahupuaʻa* of Kualoa as a *puʻuhonua*, or place of refuge.

Fornander (1880), Raphaelson (1925), and Mitchell (1973), also record that Kualoa was the site of a training school for young chiefs. Here they were trained "in the arts of war and the ancient traditions of Hawaiian chiefs" (Raphaelson 1925).

In addition, Kamakau records that Kalaeokaʻoʻio, the dividing point between Kaʻaʻawa and Kualoa was the traditional ending place for the *makahiki*[3] processions and was where the wealth collected during the *makahiki* circuits was distributed (1964:20–21).

Historic Land Use

Diverse historic land use on the Kualoa peninsula has had a major influence on the nature of archaeological remains now found in the area. Land Commission records and testimony show that on November 20, 1850, when Dr. Gerritt P. Judd purchased Kualoa from Kamehameha III, 25 Land Commission-awarded native *kuleana* (small plots of land) existed within the present park boundaries, including 14 houses. The *kuleana* were grouped in 2 areas—6 houses along the northern portion of the east beach; and 8 houses, and 8 taro and sweet potato plots near the northwestern corner of the park.

Between 1850 and 1860, Dr. Judd practiced diversified farming at Kualoa. In 1860, he deeded Kualoa to his son Charles H. Judd and his son-in-law Samuel G. Wilder, who planted Kualoa in sugarcane and built a sugar mill (approximately 0.8 km toward Kaʻaʻawa from the present park entrance). For building materials they used nearby abundant basalt rocks and burned locally available coral for lime. In 1868 Wilder's 9-year-old son fell into a vat of boiling syrup at the mill and died. This tragedy, combined with low sugar prices and a poor quality of cane, caused Judd and Wilder to close down the mill in 1871, and Kualoa became a ranch under the direction of Charles Judd.

In 1916, the Morgan family (a descendant branch of the Judd family, and present owners of Kualoa Ranch) built a small bathhouse of basalt rocks on the south beach of Kualoa Point between ʻApua and Mōliʻi Ponds. With this exception, between 1871 and the late 1930s the majority of the Kualoa Point area was used principally for grazing of horses and cattle. Following this period, a number of land-altering activities took place in several areas. All of these activities required bulldozing to one extent or another.

In the late 1930s an emergency airplane landing strip with grass surface was laid out along the east beach of Kualoa's peninsula. With the coming of World War II, the U.S. Army took over Kualoa Ranch. In 1941 the landing strip was bulldozed to 1829 m long and 46 m wide, a steel landing mat was put down, and grass was planted in the mesh. The landing strip ran from near Kualoa Point, parallel to the beach, across the highway, and a short way toward the mountains. Other modifications of the land associated with World War II included a series of cement "pillboxes" along the coast and eastern side of Mōliʻi Pond, and a coral-paved motorpool and camouflaged plane parking area in the central portion of the park.

After Kualoa was returned to the control of Kualoa Ranch, the Morgan family, in 1957, built a home near the southeast corner of Mōliʻi Pond, just to the south of the stone bathhouse.

In 1966, the City and County of Honolulu began acquisition from the Morgan family, through condemnation proceedings, of the approximately 61.6 hectares at Kualoa Point for a City and County park. In 1974 the process of land acquisition was completed and the City undertook a program of development which included bulldozing and clearing of areas along the beach that would be planted in grass for public use; and the installation of 4 comfort stations—3 on the east beach and 1 on the south beach. In addition, a tree nursery was developed in the north-central portion of the park, in an area which had for many years previous been plowed and planted in corn.

Previous Archaeological Work

J. G. McAllister (1933) recorded 4 archaeological sites in the Kualoa Park area. The first, Mōliʻi Fishpond (Site 313), is the large fishpond immediately west of, and adjacent to the park. The pond encompasses 50 hectares and was formed by enclosing a bay-like area with a stone wall approximately 1,200 m long. Just east of Mōliʻi Pond he recorded, but did not assign a site number to a smaller pond (ʻApua Pond). The walls of ʻApua Pond consist of a sand embankment and a stone wall on the sea side.

The third site, Koholalele Pond (Site 312), is located in the center of the park. He recorded the pond as being 885 feet long and 30 feet wide on the northeast end with the southwest third being considerably wider, measuring 85 feet.

The fourth site, Niuolaa Heiau (Site 310), is recorded as located in the northwest corner of the park. Although the location was pointed out to him by a local informant, nothing remained of this *heiau* at the time of McAllister's survey.

Beckwith mentions a *heiau* of Pahulu "on the Kaneohe side of the Judd place, about 600 feet away from the old sugar mill and out in the water toward Mokoliʻi" (Beckwith 1970:108). However, this site is not recorded by McAllister and it, too, apparently no longer existed at the time of his survey.

Local residents report that in bulldozing for the Kualoa airstrip, a number of human burials were disturbed. Unfortunately, no records were kept concerning the discovery and disposal of these burials.

In 1974, as part of the Statewide Inventory of Historic Places, the entire *ahupuaʻa* of Kualoa was placed on both the State and National Registers of Historic Places.[4] As mentioned in the introduction, it was listed as being of Statewide significance, on the basis of its mythological and legendary richness. At the same time, Mōliʻi Fishpond was listed as being of National significance for its excellent state of preservation and its potential for interpretation.

Because of Kualoa's placement on the National Register of Historic Places, the City and County of Honolulu was required to conduct an archaeological survey of the Kualoa Park areas scheduled for development at that time. As a result, William Barrera, Jr. (1974) conducted a reconnaissance survey with subsurface testing of the beach areas which had already been developed (primarily bulldozed and grassed). Excavating 51 1 m^2 test pits, Barrera discovered a discontinuous intact cultural layer with numerous features including pits, post molds, fire pits and 1 human burial. Artifacts associated with the cultural layer included an *'ulu maika*, fishing equipment, several adzes and adze fragments, hammerstones, choppers, basalt flakes, and volcanic glass. Three dates obtained from the volcanic glass were reported as A.D. 1639, 1646, and 1668. Based on his findings, Barrera recommended that further archaeological work be done at Kualoa.

Kualoa Archaeological Research Project

The Kualoa Archaeological Research Project (KARP) was established in December 1974 as a result of Barrera's recommendations, and the availability of Comprehensive Employment Training Act (C.E.T.A) funds to support a long-term archaeological project. Under the co-direction of Stephan D. Clark and Robert D. Connolly III, the project had 2 primary goals: (1) to determine the nature and extent of archaeological remains within the park area, in conjunction with priority park area development plans; and (2) to support and enhance the park's cultural and environmental programs through archaeological research and interpretive inputs (Clark and Connolly 1975, 1978). Between January 1975 and September 1979 the archaeological staff completed a surface survey of virtually all areas of the park, conducted subsurface test excavations in 5 areas of the park scheduled for immediate development activities, and did archaeological monitoring and recording while the development was underway. During the summer of 1977 a University of Hawaii archaeological field school was also conducted at Kualoa.

C.E.T.A. funding was eliminated in September 1979, and the full-time archaeological project was terminated at that time. Unfortunately no detailed archaeological report covering KARP work during these years was prepared before the project terminated; although a number of brief reports, including archaeological information were submitted to the City and County of Honolulu, Department of Parks and Recreation (Clark and Connolly 1975, 1978; Connolly 1977, 1978), and to the U.S. Army Corps of Engineers (Gunness 1978).

Since October 1979, archaeological work at Kualoa has been done by this author either on a part-time and/or voluntary basis, or on a temporary contract basis. Between October 1979 and May 1985, as a part-time employee, I was primarily charged with maintaining conservation of the artifacts and records collected during the previous years of the project. However, because both erosion and park maintenance and development activities continued, an attempt was made, on a voluntary basis, to keep up with and record data that might affect interpretation of the prehistoric use of the area. This included monitoring bulldozing whenever possible, continuing the surface collection and recording of artifacts and features eroding out of beach sites, and recording and salvaging burials that occasionally also erode out of the beach. During this period, 2 additional University of Hawaii archaeological field schools were conducted at Kualoa in the summers of 1983 and 1984. Since May 1985, this author has been employed on a full-time basis doing extensive field testing in conjunction with ongoing park improvement activities; and with the process of reporting on the previous years of archaeological work (Gunness 1986, 1987).

This paper provides brief descriptions of some of the more important archaeological discoveries made at Kualoa Park between January 1975 and December of 1985. See Gunness 1987 for more detailed information on KARP work. For site area locations refer to Fig. 1.

Fig 1 Moli'i Pond map
34 picas x 23.5 picas

Figure 1. Locations of archaeological sites at Kualoa Regional Park.

Mokoli'i Island

Nine large grindstones made from basalt boulders have been mapped and recorded on the west shore of Mokoli'i Island. They range in size from .80 m to 1.5 m in diameter, and have from 1 to 4 oval-shaped depressions worn in their surfaces. One boulder has 2 historic petroglyphs in addition to 2 grinding surfaces.

The archaeological staff also discovered several small veins of fairly poor quality volcanic glass near the back side of the island in 1977. These appear to be the remnants of an exhausted volcanic glass quarrying site, and preliminary analysis indicates that this was probably the source of much of the volcanic glass excavated in the park proper.

Offshore Fishpond Wall A survey on the reef offshore of Kualoa Point verified the existence of remains of a previously unrecorded fishpond wall. This wall, part of which is still visible at low tide, can be seen clearly in outline on a 1945 aerial photograph of Kualoa, where it appears as a dark shadow on the lighter-colored coral and sand reef. While an accurate map of the wall has not yet been made, a general description can be given.

The fishpond wall is constructed of basalt rocks and boulders and a few large coral chunks, ranging in diminishing size from 1 m in diameter to fist-sized pebbles. The easternmost portion is considerably broken down, and its rocks have been scattered over a wide area of the reef where the water is between 25 and 80 cm deep at low tide. The southernmost, and most central portion, broadens out into a platform measuring nearly 20 x 20 m, and is paved with fist-sized pebbles. This area is approximately 2 m high on the inland side, and in some places on the seaward side stands almost 3 m from the sand bottom. This platform area may have been the location of a guard or caretaker's house. The westernmost portion of the wall can be seen above the water at low tide about 500 m from the present southern shore. This portion measures from 2 to 3 m in width along its length.

The construction of this fishpond wall, and its probable destruction by a tsunami prior to about 1850, is believed to have had a major influence on the long-term accretion and erosion forces operating on the Kualoa shoreline (Connolly 1977, Gunness 1987).

'Apua Pond Wall (Site 1A–1) In April 1975, surface survey approximately 152 m east of the Kualoa Park offices located what appeared to be a discontinuous stone alignment running for an undetermined distance in a north-south direction. Thirty-six 1 m² test pits were excavated along the length of what proved to be the western portion of the sea wall of 'Apua Pond. The marine sand matrix surrounding the wall contained quantities of historic rubbish such as rusted metal fragments and bits of broken glass. These historic materials were distributed throughout the profile, from the surface to the base of the excavations at the water table (approximately 1 m below surface). No prehistoric remains, except the wall itself, were found during these excavations.

The archaeologists eventually uncovered approximately 72 m of the wall, including 1 *makahā,* or sluice gate, toward the southernmost end. The wall is constructed of basalt boulders and coral chunks ranging in size from 20 to 80 cm in diameter. It is 1.2 to 1.5 m in width and stands slightly more than 1 m above the water table. However, its true height is probably 1.5 to 2.0 m. Excavation could not proceed below the water table but probing indicates at least 2 additional courses of rock beneath the water.

Stone Bathhouse Area (Site 1A–2) In late 1976, it became necessary to clear *koa haole* from around the *mauka* side of the old stone bathhouse built by the Morgans. The bathhouse is located just to the east of the park offices and south of the south beach access road. The archaeological staff was requested to do testing in the area prior to grubbing.

Three 1 m² test pits were laid out in the "backyard" of the bathhouse, at the foot of the back steps. The excavations, which were eventually expanded to a total of 17 m², revealed a prehistoric cultural layer which in places was 40 to 50 cm thick, beginning 5 to 10 cm beneath the surface. This layer consists of a loamy sand which is dark gray in color in the top approximately 35 cm, and grades to light gray below. The soil contained charcoal; fish, bird and mammal bones; sea urchin remains; and quantities of shell representing numerous species of edible mollusks. In addition, a number of prehistoric types of artifacts were uncovered. These included slingstones, a double *leho* sinker (for octopus fishing), a hammerstone, adze flakes, numerous coral abraders, bone fishhook manufacturing debris, and a dog tooth pendant. Additionally, 11 volcanic glass flakes were recovered, and were dated in 1977 by Hawaii Marine Research. The dates were reported as follows: A.D. 1422, 1458, 1468, 1471, 1477, 1541, 1572, 1601, 1622, 1624, and 1629. While reliability of volcanic glass dating is presently in question (Olson 1983), radiocarbon dates from other areas of the park suggest that these dates may be within an appropriate range.

The features found in this site are of particular interest (Fig. 2 and 3). At the base of the back steps to the bathhouse, an *imu* measuring approximately 90 cm across, and consisting of firecracked basalt rocks and scattered concentrations of charcoal and ash was recorded. Approximately 45 cm to the west, the intact skeleton of a pig, lying in a narrow pit was discovered. The skeleton is that of a boar with limbs tightly flexed (suggesting that they may have been bound), lying on its right side, with its head pointed in the *mauka* direction. A dog femur was found just above the forelimbs. A pattern of post molds appear to be associated with the pig burial feature (and possibly the *imu* feature) suggesting that some kind of structure marked the location. Unfortunately, the records kept during these excavations are somewhat lacking, making interpretation of the relationships between various features difficult. Thus, it is unclear if the *imu* and pig burial are associated; or what their relationship may be to other post molds in the test

Fig. 2 Historic Stone Bathhouse

26 picas x 32 picas

Figure 2. Plan view of site area 1A–2 excavations.

pits just to the north—which indicate additional structural features. Figure 3, showing the *imu* and pig skeleton side by side following excavation, should not be taken as indicating that these features were necessarily associated in time.

Significantly, if one stands at the tail of this pig skeleton and looks *mauka* along its back and past its snout, one is sighting in a direct line along the edge of Mōliʻi Pond and up the ridgeline marking the Kualoa/Hakipuʻu boundary. It has therefore been proposed that the pig skeleton represents an offering intended as an *ahupuaʻa* boundary marker (Connolly 1977, Clark and Connolly 1978). As such, it would be the first of its kind found in an archaeological context.

The pig skeleton was left in place, and after being thoroughly recorded, it was reburied. The archaeological staff recommended permanent preservation of this feature for its very high interpretive value, with eventual re-excavation and display in place, as part of the park's educational and cultural programs.

Area Mauka of the Stone Bathhouse (Survey Area 1B) Discovered to be a continuation of the above site, the archaeological work described here has been done in the area bounded on the south and east by the south beach access road, on the west by Mōliʻi Pond, and on the north by an imaginary east-west line drawn from the corner where the access road turns south, to Mōliʻi Pond.

An area measuring approximately 45 x 65 m in the southeast corner of the larger area was bulldozed in the summer of 1977 to clear *koa haole* for temporary parking. At that time, 267 artifacts were surface collected, including 256 basalt flakes, polished adze fragments, scrapers, abraders, and a basalt awl. The archaeologists advised the program staff against allowing any additional disturbance to the area without archaeological clearance. Unfortunately, no written report was made concerning the finds or the archaeological recommendation.

In the spring of 1983 a 15 to 20 m wide swath was bulldozed ("grubbed") from the northeastern

Fig 3 Pig Skeleton photo

26 picas x 17 picas

Figure 3. Pig skeleton believed to mark *ahupua'a* boundary (Site 1A–2).

corner of the larger area to the center of its southern boundary, prior to the excavation of trenches for the installation of new water and electric lines. Unfortunately, the City and County did not go through the proper permit application process prior to this work, and the archaeologist was not informed about it, and did not discover it, until the bulldozing had been completed. The soil found turned up in the area was nearly black from the very high charcoal and organic content, and it was full of shell and bone midden remains. Hundreds of artifacts including basalt flakes, hammerstones and adze fragments, coral abraders, basalt awls, quantities of volcanic glass, and a *niho palaoa* were surface-collected when the work was discovered.

Archaeological test excavations, and monitoring of the trenching activities, resulted in the discovery and recording of 98 features. These included pits and post molds, fire pits and *imu,* a human and a dog burial, and a structural feature suspected at this time to be a small *heiau* or fishing shrine.

Although laboratory work is ongoing, the 2,639 presently recorded artifacts recovered in the area indicate adze manufacturing and use, as well as other stone and woodworking activities. Preliminary analysis (visual inspection and specific gravity measurements) of a small sample of the 589 pieces of volcanic glass recovered from this area suggest 3 sources for the glass. While most of it appears identical to that found in other areas of the park (which is believed to originate from a local source—Mokoliʻi Island is suspected), 1 piece appears to have been obtained from Puʻu Waʻawaʻa, on the Island of Hawaiʻi. If so, this may be the first archaeologically documented evidence of inter-island transport of what might be called a "high-status" consumer good. Dating of 3 volcanic glass flakes provide dates of A.D. 1643, A.D. 1693, and a date of A.D. 1643–1683 for the flake believed to be of Puʻu Waʻawaʻa origin.

The human burial has recently provided a conventional radiocarbon age of 260 ± 10 years (Matthew Spriggs, pers. com.). A Klein et al. (1980) calibration places this date between A.D. 1425–1625. Because the burial feature stratigraphically precedes the overlying layer from which volcanic glass dates were derived it is likely that the earlier half of the radiocarbon date range more accurately dates the burial.

Also during this project, the archaeologist conducted a walk-through survey of the areas west of the trenching, to the edge of Mōliʻi Pond. Approximately 40 prehistoric-type artifacts were surface-collected during the survey. They are of the same types as those found during the trenching project and are evidence that the archaeological materials extend beyond the bulldozed area.

Imu with Associated Postmolds (Site 1C–2)

Immediately southeast and across the access road from the above-described archaeological site area (and most certainly a continuation of that area), test excavations in 1985 uncovered a large *imu* surrounded by at least 13 post molds (Fig. 4). The overlying loamy sand, and the fill in the *imu* contained literally thousands of basalt flakes produced in the process of adze manufacturing. Additionally, a polished adze fragment was found in 1 post mold, and a small adze preform was found

Fig 4 Kualoa Rgional Park photo
(view of open pit/excavation site)

26 picas x 17 picas

Figure 4. *Imu* and associated post molds during excavation at Site 1C–2. Photo courtesy of Wendell Kam.

in another. Other artifacts recovered from these excavations include: 8 polished adze flakes, 4 basalt awls, a hammerstone, a whetstone fragment, and 13 volcanic glass flakes. A charcoal sample taken from the base of the *imu* has been radiocarbon dated by Beta Analytic Inc. as 90 ± 60 years B. P. ($\partial^{13}C$ –26.7 = 60 ± 60 years B. P.) A Klein et al. (1982) calibration places this date between A.D. 1670 and 1730.

At the time of this writing, salvage of these features is incomplete. The site was left in its partially excavated state with the intention that it would be incorporated into park interpretive programs.

Kamehameha Highway Area (Survey Area 3) Ten test pits and 37 test trenches were excavated in the park area bordering Kamehameha Highway before construction of the park maintenance building in 1976. These excavations provided insight into the geological development of the Kualoa peninsula, and produced evidence of prehistoric use of the immediate area. In the northwesternmost corner of the park area, the stone foundation of a structure was uncovered (Site 3–1) which may have been Niuolaa Heiau (Clark and Connolly 1978). Field work in the possible *heiau* area remains unfinished because of developmental priorities in other areas of the park.

East Beach Area The eastern beach of Kualoa Park has been undergoing extremely heavy erosion for at least the past 80 years. Here, wave action has exposed in the beach edge a cultural layer, ranging between 15 and 50 cm in thickness, of compact, black loamy sand, midden materials, and fire features which can be traced along the beach, sometimes intermittently, from the northern boundary of the park to within about 100 m of Kualoa Point. As of December 1985, an estimated 2,000 primarily worked stone artifacts (not counting unmodified basalt flakes) derived from this cultural layer had been surface-collected from along the beach and adjacent reef by the archaeological staff and many volunteers. These artifacts represent a range of activities including adze and other stone tool manufacture, wood working, fishing, food preparation, and game playing. In addition, a number of human burials have also been discovered as the beach recedes. Brief descriptions of actual work done in these areas follows.

1975 Test Excavations (Site 2B–1, 2B–2) During 4 weeks in the summer of 1975, 3 1 x 2 m test pits and 1 1 m^2 test pit were excavated in the central portion of the eastern beach, in and just north of a shallow depression running *mauka–makai* at the edge of the beach. These excavations revealed an ensilted water channel next to an area of intact cultural layer just to the north, and uncovered in this layer prehistoric-types of artifacts including bird bone picks or awls, polished adze flakes, and fishing equipment; and features including pits and fire places.

Fig 5 photo of club

26 picas x 15 picas

Figure 5. Tapa beater found in waterlogged site 2B–2.

Waterlogged Site (Site 2B–2) In December of 1977, erosion on the eastern beach in the area of the water channel mentioned above uncovered waterlogged and preserved organic materials including *kukui*, pandanus, gourd, numerous pieces of unidentified wood; and artifacts including a wooden tapa beater (Fig. 5), a net gauge, and pieces of canoe plank—some of which still retain their sennit lashings—and a 1.5 m long wooden pole which has adze markings over most of its surface. This area was designated as a single feature at the time of its discovery, and various plans were considered, but never implemented, to protect it from further erosion until adequate excavation and preservation could be undertaken.

University of Hawaii Field School Excavations (Site 2B–1) The Kualoa Regional Park East Beach Site was the location of the 1977 University of Hawaii archaeological field school. Excavations were done in conjunction with the ongoing Kualoa Archaeological Research Project and were conducted under the direction of Dr. Hallett H. Hammatt, then visiting professor at the University of Hawaii, and Stephan D. Clark and Robert D. Connolly III, co-directors of KARP. Fifteen students took part in the field school, which ran for 10 weeks during June, July, and August—6 weeks of field excavation and 4 weeks of laboratory analysis.

The goal of the field school was to excavate a 10 m^2 grid in the area around the northernmost test pits excavated in 1975, where an intact cultural layer containing features had been recorded. However, as excavation proceeded more slowly than expected, only a portion of the site was excavated: essentially removing the overlying Layers I and II (a plow zone and a sterile sand layer), and excavating *into* the targeted cultural layer in only 11 1 m^2 pits, and *through* the cultural layer to (what was believed to be) the underlying sterile sand in only 4 1 m^2 pits.

Two additional tasks were completed during the 1977 field season. A 10 x 1 m trench was shovel-excavated from the southern edge of the field school excavations into the adjacent ensilted water channel to correlate the stratigraphy in the 2 site areas; and, 1 day during an exceptionally low tide, the beach side of the channel mouth was swept clean of overlying beach sand and its extent and profile were recorded, both with drawings and photographs.

The 1983 University of Hawaii archaeological field school returned to Kualoa to continue excavation in site 2B–1. Under the direction of Dr. P. Bion Griffin, 16 archaeological field school students and 2 teaching assistants split their time between Kualoa Regional Park, supervised by the author, and Kahana Valley, supervised by Patricia Price-Beggerly. Fieldwork at Kualoa took place for 20 days between July 18 and August 12, and consisted of the excavation of 10 1 m^2 test pits. The test pitting procedure was chosen, rather than attempting to excavate 1 larger contiguous area, for several reasons. First, erosion on the *makai* side of the site had been so severe since 1977 that approximately 5 m of beach edge, and archaeological site, had been washed away. This made it imperative that the nature of remaining archaeological deposits nearest the beach edge be determined before they were lost. At the same time, testing in 1977 had indicated that different types of activity areas existed within the field school site, and further testing of this notion also seemed important for the overall interpretation of prehistoric activities in the east beach area. Thirdly, the labor force, being split and with personnel often shifted unexpectedly between the 2 field school sites, could not be depended on for the continuity needed to adequately excavate a single larger area.

Therefore, 6 1 m² test pits were excavated 1 m apart along the beach edge of what had been the eastern edge of the 1977 excavations. Four additional 1 m² test pits were randomly placed 4 to 10 m back from the beach.

During these excavations, 1 day was also spent facing the beach edge of the field school site so that the entire profile could be recorded. Unfortunately, only the southern ⅔ of the profile was completed before unusually high tides forced abandonment of this project. Two neonate burials were discovered and recorded during the profiling.

In addition to the above work, several field school students were assigned to test an apparent wall feature which had been discovered eroding from the beach edge toward the northern boundary of the park. This work is described under Site 2D–1.

In 1984, under the direction of Dr. Matthew Spriggs, and supervised by the author, 10 students and a teaching assistant again took part in excavations in the Kualoa field school site. The excavations were scheduled to take place between July 9th and August 16th. However, because of the nature of the finds made near the scheduled end of the summer session, work extended, on a voluntary basis, on weekends up until Thanksgiving of 1984.

Excavations took place in a 2 m wide strip along the entire length of the *makai* side of the [then] fenced field school site, ultimately excavating 37 m² into underlying sterile sand (Fig. 6). This was done to complete the cross-section of the site begun in previous field seasons, and to salvage as much information as possible before this area was entirely destroyed by the increasingly rapid erosion. The beach side of the site had to be sandbagged during the early part of the field season, and excavation was slowed during the summer and fall by the need to keep replacing the sand bags, which were displaced with every high tide. The excavation site was completely washed away during storm tides on November 21 and 22, 1984.

In addition to the above excavations, on July 30th and 31st when the tide was low enough, the adjacent waterlogged ditch site (Site 2B–2) was gridded off and 7 m² of the *makai* edge was salvage-excavated by shoveling the deposits into plastic bags. Analysis of this material is incomplete.

On September 22, during the continued excavation of the field school site, bones were discovered eroding from an area in the beach between 22 and 35 m north of the field school site. Students volunteering that day assisted in salvaging the remains of 17 human burials washed out of the beach by high tides.

While laboratory analysis for the excavations is unfinished, data presently available is summarized below.

Stratigraphy. Stratigraphy in Site 2B-1 generally conforms to the following:

Layer I: 0–20 cm bs. Historic plow zone. Black (10YR 2/1m) thoroughly churned loamy sand, containing mixed prehistoric, early historic, and post-World War II historic artifactual materials. This actually incorporates the upper portion of Layer IIIa in the western half of the site (see below).

Layer II: 0–20 cm thick. Light gray to white (10YR 7.5/2m) beach sand. Found only in the eastern half of the site, this layer lenses out approximately halfway across the site to the west. This sand contains a very few, small, prehistoric-type artifacts and scattered single bits of human bone, and teeth. This is believed to be a single-event storm deposit.

Layer IIIa: 30–50 cm thick. Black (10YR 2/1m) compact loamy sand with high carbon content. In the central portion of the site, from the beach edge west, this layer contains huge numbers of firepit features—often intruded one on top of another to the point where it is extremely difficult

Fig 6 photo of rectangular pit

26 picas x 18 picas

Figure 6. 1984 University of Hawaii Field School excavations (Site 2B–1).

to distinguish one from another. Early historic artifacts are found in the very top of this layer in the *mauka* portion of the site, while only prehistoric-types of artifacts are found beneath. The deposition of Layer II sealed in and protected the *makai* portion of this layer from later agricultural plowing activities, while the *mauka* portion has been plowed to a depth of nearly 20 cm (the plow zone now referred to as Layer I).

Layer IIIb: 0–10 cm thick. Gray (10YR 6/1m) moderately compact, very slightly loamy sand. This layer appears to be intermittent throughout the site, and was not recognized until 1979, after the designation of Layer IV had become firmly attached to the underlying sterile sand layer—thus the IIIa and IIIb division. This is, however, a separate layer. Layer IIIb appears to be the layer from which many human burials intrude into Layer IV. It also contains scattered small pits, and possible post molds, which also intrude into Layer IV. Few artifacts been recovered from Layer IIIB.

Layer IV: Culturally sterile yellow (10YR 3/1m) coral beach sand underlying Layers IIIa and IIIb to below the water table. The term sterile is used with caution because although no other cultural materials have been found in this layer, human burials are found around which no discernible pit fill can be recognized—suggesting that the burial originated from the upper portion of this layer.

Features. Roughly 300 features have been recorded during the excavations in Site 2B–1. The highest percentage of these are fire features including *imu* and smaller fire pits, and shallow charcoal and ash deposits, often in such concentrations as to be indistinguishable from one another during excavation. Other common features include miscellaneous small shallow pits, and post molds. Four human burials have also been recorded. Several features, which can be seen in Fig. 6, require some further discussion.

Possibly the most intriguing is a complex of features which can be seen in the foreground of Fig. 6. On the right (east) is a large pit containing a light gray sand fill, at the bottom of which we discovered the skeletal remains of an older middle-aged female. The body had been dismembered prior to burial. The skull and long bones were missing, and the remaining pieces had been placed (apparently) randomly in the bottom of the pit for a length of approximately 140 cm. A basalt prism with edge damage, and a mediumsized hammerstone were associated with this burial. Beta Analytic Inc. has provided a $^{13}C/^{14}C$ adjusted age of 420 ± 70 years B. P. for this burial (A.D. 1400–1525 using the Klein et al. calibration).

On the left (west) is another very large pit with light gray sand fill, near the bottom of which were discovered 2 parallel elongate "structures" of mud veneer, with impressions of what appear to have been rough planks in their tops. A large, deep *imu* intrudes into this pit, truncating the end of the westernmost mud feature (left foreground of Fig. 6). No explanation for the mud features had been forthcoming to date.

The 2 large pit feature/complexes were originally described as a single feature (Gunness 1987:133); however, subsequent re-examination of excavation records and photographs suggests otherwise. It is presently uncertain which pit cut into the other, but future completion of laboratory analysis of field school excavation materials may resolve this question.

What is believed to be a historically constructed section of a retaining wall (seen in the background of Fig. 6) was originally discovered eroding from the beach edge of the site. The excavated portion of the retaining wall, running roughly *mauka-makai*, is constructed of basalt rocks and 1 large upright coral head. A large postmold fills a gap adjacent to the western side of the coral upright. A number of smaller postmolds were recorded along the upper (northern) side of the wall. A roughly 1 m wide ditch feature was recorded along the southern side of the wall. The ditch fill, of heavily lensed black and gray loamy sand, contained a rusted and corroded metal object, and appears to have originated at a later date than the wall.

Artifacts. Artifacts recovered during the field school site excavations include both historic and prehistoric types. Ceramic fragments, beads, buttons, a fragment of a clay pipe stem, and flint flakes and fragments attest to the early historic nature of the upper proveniences. A Spanish coin dated 1773 was found in a clearly historic context. Prehistoric occupation of the area is indicated by objects including: basalt and *Conus* shell adzes and adze fragments, hammerstones, volcanic glass, coral abraders, bone and shell fishhooks and fishhook manufacturing debris, stone sinkers, and an *'ulu maika*.

Northern Extension of Picnic Area (Survey Area 2C) During the winter of 1977–1978, the previously undeveloped section of the east beach surrounding the field school site, and north for approximately 150 m, was bulldozed and planted in grass as a scheduled phase of the park development. Monitoring during the bulldozing and trenching activities related to installation of a sprinkler system provided information concerning the distribution and number of features and artifacts in the area. Twenty-seven features discovered during the trenching operations were recorded by the archaeologists. These included 3 human burials, several *imu*, other fire features, 2 stone alignments, a water channel, and several areas defined simply as activity areas on the basis of artifact concentrations. A total of 605 prehistoric-type artifacts was collected, including polished adzes and fragments, adze blanks and preforms, grindstones and whetstones, hammerstones, coral abraders, basalt awls, sinkers and cowry lures, slingstones and *'ulu maika*, a quoit, a muller, ground hematite, and many basalt flakes.

Coral Structure (Site 2D–1) In May of 1983, in the central portion of the northern, then undeveloped section of the eastern beach, a 17 m long alignment of large coral heads and a few small basalt boulders was discovered to be eroding from the wave-cut bank. During the 1983 field school, 11 1 m^2 test pits were shovel-excavated to test this alignment. Although excavation was not completed because the tide washed into several of the pits, some kind of cultural deposit seemed to be present on the *mauka* side of the wall. One broken segment of a boar's tusk bracelet was found during the testing.

A plan map was made of the *makai* edge of this feature in September 1983, after erosion had exposed what appeared to be its complete length. Sandbags were placed in front of the feature during the 1984 field school season, but by summer of 1985 erosion had cut back behind the alignment and was threatening to completely destroy it. Therefore, as part of the subsurface reconnaissance survey then underway for scheduled park improvements, several days were spent sweeping the beach sand off of the feature, remapping it, and taking a number of photographs. Two adjacent 1 m^2 test pits were excavated into the wave-cut bank at the feature's northern end where a cultural deposit still seemed to be present. A test trench was also later excavated (using a backhoe) from the beach, west, to determine if the feature extended any farther into the bank, and to further test for intact cultural deposits.

Exceptionally high tides and erosion again cut the field recording process short, and the feature is now nearly completely destroyed.

Based on the 1983 and 1985 archaeological work this feature appears to have been a retaining wall or narrow terrace of some type, measuring 17 m long, 50 to 60 cm high, and roughly 2 m wide. It was constructed on culturally sterile-appearing sand using the large (50 to 75 cm diameter) coral

Fig. 7 Beach site photo

26 picas x 16 picas

Figure 7. Basalt stone foundation of possible *hale mua* (Site 2D–2).

heads for the foundation, with smaller coral and basalt rocks placed on top. Smaller coral rubble was used as fill behind the facing rocks.

Functional interpretation of this structure is made difficult to impossible by the lack of associated intact cultural deposits. However, between 1975 and 1983 a significant concentration of artifactual materials (with an apparent emphasis on adze manufacturing debris) was surface-collected in the area on the *makai* side of this feature. It is possible that this may have been the lanai of a pre- or proto-historic period house. There are historic records of houses having been located along the beach in 1850, but none were recorded at that time in this location.

Stone Foundation (Site 2D–2) Early in 1981 an alignment of basalt boulders was observed eroding out of the northernmost portion of the east beach. Within a few months, a rectangular structural foundation measuring approximately 8.25 x 5.25 m had been uncovered (Fig. 7), with large numbers of stone artifacts both inside, and immediately outside of the walls. In late December 1981, waterlogged organic materials were found preserved in a thin layer of dark gray to black sediment within the structure. Remains salvaged at that time include gourd, pandanus, *kukui* nuts, unidentified worked wood, and a well-preserved *melomelo*, or bait stick. Stone artifacts presently believed to be directly associated with this feature include a *poi* pounder fragment, 2 fishing sinkers, 8 basalt awls, 15 hammerstones, 13 whetstones and/or grindstones, quantities of adze manufacturing debris including blanks and preforms, and fragments of polished adzes. Examination of the polished adze fragments indicates that one activity the occupants were engaged in was the conservation of adze quality basalt, by reworking large broken adze fragments into smaller adzes. Because all of the objects recovered here are thought to be from male-related activities, it has been suggested that this feature may be the remains of a *hale mua*, or men's house (P. McCoy, pers. com.).

On June 14, 1982, the author excavated an approximately 1 x 2 m test trench across the western wall of this feature, near the north end. This was done in an effort to learn more about the nature of construction of the feature, and to discover the boundaries of the sediment in which the waterlogged organic materials had been discovered.

The excavation showed that the dark sediment was confined to the interior of the feature, with only sterile beach sand being found on the western side. It appears that the foundation stones of this structure were placed either directly on top of the flat algal reef material, or on only a very thin layer of sand overlying the reef. The floor of the structure was covered with a layer of sand, and possibly pandanus matting (suggested by the salvaged waterlogged pandanus). It seems likely that this feature was destroyed and buried in a relatively short period of time, and that the rapid burial, coupled with freshwater springs in the area, produced the conditions necessary to preserve the organic materials. Radiocarbon dating of some of the wood from this site has recently provided a $^{13}C/^{14}C$ adjusted age of 70 ± 60 years B. P. (A.D. 1675–1775 or 1790–1840 using the Klein et al. calibration) (Matthew Spriggs, pers. com.).

Summary and Conclusions

While a great deal of archaeological work remains to be done at Kualoa Park, we now have a tentative time sequence, and insight into the area's place in pre- and protohistoric Hawaiian social and economic spheres.

Kualoa Sequence While dates are presently not available for the very earliest portion of the Kualoa sequence, I have applied an arbitrary starting date of A.D. 1100, based on what is presently known about the physical development of the Kualoa coastline, and on what seems to have been happening in other areas of the islands at the same time. The clearly defined Hawaiian cultural sequence in the Kualoa Park area presently spans a period of time between roughly A.D. 1400 and 1850. This Kualoa sequence fits remarkably well with the later phases of a proposed Hawaiian cultural sequence by Kirch (1985: 298–308), which has recently been refined by Spriggs (1986:2–9).

Kirch proposed a 4 phase sequence: Colonization Period (A.D. 300–600), Developmental Period (A.D. 600–1100), Expansion Period (A.D. 1100–1650), and Protohistoric Period (A.D. 1650–1795). While drawing heavily on Kirch's sequence, Spriggs chose to divide the Hawaiian sequence into 5 phases: Phase I—A.D. 0–600 (Colonization Period), Phase II—A.D. 600–1100 (Developmental Period), Phase III—A.D. 1100–1400 (Early Expansion Period), Phase IV—A.D. 1400–1600 (Late Expansion Period), and Phase V—A.D. 1600–1795 (Classic Period). It is Spriggs' Early and Late Expansion and Classic Periods into which the Kualoa sequence falls.

A.D. 1100–1400. During this period the Kualoa coastline/beach consisted of a widening sand spit developing at the base of the ridgeline that now separates Kualoa from Hakipu'u, forming a small embayment on the Hakipu'u side. The colluvial slopes and back-beach area may have been used for non-intensive agriculture. Fishpond construction may have commenced by late in this period, with a fishpond wall constructed across the growing embayment on the western side of the sand spit. This may have been Mōli'i Pond. Such construction would impede the natural flow of offshore and longshore currents and thus alter the rate and shape of development of the sand spit, forming successive "lobes" on the southeastern portion of the sand spit with corresponding additional areas of embayment to the west or southwest. Through time additional ponds were constructed as the increasingly larger size of these "lobes" on the point/peninsula allowed incorporation of larger areas of embayment.

A large mammal bone—tentatively identified as whale bone—was recovered from (culturally sterile) sand deposits inland of the beach sites, indicating that from this period the beach may have been a source of scavenged whale ivory washed ashore as part of the depositional process. Such whale ivory was a resource for which the area was later famous.

A.D. 1400–1600. It is from A.D. 1400 that archaeological data begins to provide a clearer picture of prehistoric use of the Kualoa Park area. It seems likely that Mōli'i Fishpond, in its present configuration, was constructed in the beginning years of this period. Such an undertaking would have required extensive manpower and resources, suggesting that O'ahu was at that time under the control of a paramount chief capable of controlling extensive corvée labor. Spriggs, in discussion of his proposed Late Expansion Period, states that the first paramount chief of O'ahu was said to be Kapaealakone, who should date to about A.D. 1400 (1986:7).

Additional evidence of this time period at Kualoa is found in a thin, and sometimes intermittent, light gray loamy sand layer in the eastern and southern beach areas. The layer contains human burials, and a few scattered fireplaces and pits, and fishing gear—attesting to recurring temporary occupation of the beach and reef area for fishing and food collecting, and as a convenient place for burial of the dead.

The eastern beach seems to have been used as a burial ground, perhaps primarily for women and children throughout this period. Evidence from some of these burials also points to grave disturbance occurring, possibly to supply bone for fishhook manufacture.

Preliminary finds from excavations in the northwest corner of the park—where hillside erosion is indicated—suggest that agricultural use of the lower colluvial slopes and backbeach area (the portion of the beach abutting the colluvial slopes) may also have intensified.

Based on stratigraphic associations, the embayment forming ʻApua Pond was walled off no later than A.D. 1600.

A.D. 1600–1795. The period A.D. 1600–1795 is marked at Kualoa by a 20 to 50 cm thick stratigraphic layer of black loamy sand found early throughout the park area (labelled Layer IIIa in the Site 2B–1 excavations). This layer contains large numbers of features including *imu*, fire pits and fire places, the pig burial in Site 1A–2, post molds, and miscellaneous pits; and an extraordinary large numbers of Mōliʻi Pond and the *mauka* side of ʻApua Pond, to the eastern beach edge and reef including Mokoliʻi Island. Interestingly, no human burials have been directly associated with this period and it appears that use of the sandy peninsula for burial was not allowed during this period.

Construction of the fishpond off Kualoa Point at some time during this period marked the easternmost development of, and probably temporary stabilization of the beach, roughly 250 m seaward of the present eastern beach edge.[5]

The general picture of the Kualoa Park area that emerges from roughly A.D. 1600 is that of a chiefly "playground," and a kind of early "industrial park;" with a community of resident craft specialists living in pole and thatch houses, cooking in earth ovens (*imu*), and carrying on activities related to their particular skills, including woodworking, adze and other stone tool manufacturing, processing of *wauke* (*Broussonetia papyrifera*) for tapa and pandanus for plaiting and/or mat making, and fishing. These specialists were probably overseen by a resident chief or *konohiki* who reported to the paramount chief.

To date, no structural remains in the park area have been specifically identified as "chiefly residence," but based on other archaeological evidence it seems safe to assume the at least occasional residence of *aliʻi* here. Perhaps the most persuasive argument for their presence is made using the ornaments that have been recovered from the park area. *Lei niho palaoa*, and *lei ʻōpuʻu*, in particular, have been recorded as being for the exclusive use of chiefs (Cox 1967:421). Possession and use of such items as boar tusk bracelets was probably also generally confined to the *aliʻi* (Kirch 1985:306). Such may also have been the case of the drilled dog teeth, which were strung together to make necklaces and bracelets, and were fastened in large numbers to leggings worn by male dancers of the hula (Buck 1967: 553). (Hula,performed by both male and female dancers was an entertainment much appreciated by the *aliʻi*.)

A further argument for the presence of *aliʻi* has to do with the 88 *ʻulu maika*, 2 quoits, and 44 slingstones that have been recorded to date from the park area—most of them recovered (prior to 1983) from along the eroding eastern beach, and the reef paralleling the beach. The presence of such large numbers of *ʻulu maika* and slingstones here is best explained by the existence during this period of a recognized and bounded playing field,[6] and the presence of a chiefly "leisure" class, who are ethnohistorically recorded as having devoted much of their energies to games and sports.

Ritual practices discussed in the traditional literature also suggest the presence of a priesthood class here during this period. As mentioned earlier, Malo recorded that Kualoa was the seat of the Lono priesthood "*Moʻo-kuauhau-o-Lono*, or genealogical-line-of-Lono. . . . Also said to be of the order of Paliku" (1951:159). While archaeological evidence for this claim is presently on unsure ground, there is at least a basis for speculation concerning such a presence during this period.

Oral traditions tell us that Kualoa was a very sacred place; and 2 *heiau* are recorded to have been located here. One of these *heiau*, "Niuolaʻa," was located just to the east of the northeastern corner of Mōliʻi Fishpond—the eastern side of which forms part of the Kualoa/Hakipuʻu boundary—and in this location would have been adjacent to the path leading into and out of the *ahupuaʻa*. Neither of the recorded *heiau* are reported to have been of exceptional size which suggests that they were of the Lono class, or Hale-o-Lono.

Lono was the ancient Hawaiian god of agriculture, rain and storms, and medicine. Pigs played a significant role as ritual offerings and sacrifices in the ownership of Lono (unlike the worship of Kū, the god of war, who required human sacrifice).

Pig skeletons have been found in 2 separate excavations in Kualoa Park which have every indication of being sacrificial offerings. Both, significantly, are also located on, or just adjacent to, the Kualoa/Hakipuʻu boundary. In the case of the first, the intact pig skeleton found in Site 1A-2, post molds recorded around the feature indicate a structural "marking off" of the site. The second, located in Site 1B, Feature 29, just across the park road from the first, consists of the partial skeletal remains of a pig (this one cooked), deposited in a pit in what is presently believed to be a low platform constructed with a basalt rock face and coral rubble fill.

While the above facts hardly provide firm evidence for claiming the presence of Lono priests, they do provide a stepping stone for further research on the subject.

A.D. 1795–Historic Period. Although 1778 was the year of Cook's discovery of the Hawaiian Islands, I have used the year 1795 to mark the beginning of the historic period. This follows Kirch, who chose to end his Proto-Historic Period at 1795 because it

marks Kamehameha's conquest of Oʻahu Island and the end of the old political order with its competing independent chiefdoms; and… it was not until the final years of the eighteenth century that European ships began to call with regular frequency in the Islands, and that foreign goods and ideas began to make serious inroads in the native culture (1985:306).

While some of the activities described in the previous period may have continued at Kualoa for a short time after 1795, this date marks an ethnohistorically recorded additional use of the area.

Kamakau (1964:19–20) records that the boundary between Kualoa and Kaʻaʻawa was the ending point for the *makahiki* processions around Oʻahu, which Kamehameha I commenced after conquering the island in 1795. The following quotation provides significant insight concerning this period at Kualoa:

When the Makahiki was ended, the akua pāʻani, the god of play, came forth. His work was to promote the strengthening of the body. A place had been made ready before the akua pāʻani came, and the maika sites and level places (puʻuhonua) were full of people in readiness for competitive sports (hakakā leʻaleʻa) (Ibid.:20).

It would seem that the Kualoa park area, particularly the eastern beach was such a place for the few years that the *makahiki* circuit actually occurred. The use of this area for the *makahiki* games was a natural extension of its use as a chiefly "playground" in the previous period. Additionally, if Kualoa had been the historic seat of the Lono priesthood, this would provide an explanation for its choice as the end point of the *makahiki* circuit, and the location of the *makahiki* festivities which were dedicated to Lono.

Archaeological research indicates that the storm deposit recorded as Layer II in Site 2B–1, occurring *circa* A.D. 1800, probably marks the time that the fishpond wall off Kualoa Point was destroyed. This in turn destabilized the beach, and began the continuing and increasingly rapid rate of erosion at the point and along the eastern beach that we see today. By chance, this event also marks the end of pre-Western-influenced Hawaiian culture in the Kualoa area.

The upper proveniences of the field school site (post-dating the storm deposit) provide material evidence of the early historic period in the Kualoa Park area in the form of hand-made bone buttons, gunflints, glass beads, a Spanish coin, ceramic fragments, and a fragment of a clay pipe stem. Nearly all of these items indicate the presence of the house sites recorded in the Land Commission Survey of 1850.

Comparing archaeological records of certain features discovered in the field school site with descriptions from the land surveyor's notes, we may now even be able to pinpoint some named individual's house sites.

Kualoa was sold by Kamehameha III to G. P. Judd in 1850, setting the stage for the subsequent historic changes described earlier in this paper. Soon after 1850, Kualoa began to find its way into written versions of oral tradition, telling of its importance in pre-European Society.

Oral Traditions and Archaeological Findings

An interesting outcome of the work at Kualoa Park has been the apparent discovery that a connection can be shown between some of the oral traditions relating to the Kualoa area, and the archaeological data recovered to date. It seems likely that legends of early gods and goddesses relating to Kualoa reflect in part the early Hawaiian recognition of the ongoing geomorphological development of Kualoa, and various "acts of god" which are recorded in the archaeological record. It is interesting that the earliest story of the area tells of Haumea and Wākea living on the cliffs of "Palikū." It was not until the next generation that Hiʻiaka created the foothills and lowlands of Kualoa.

Occasional tsunami or very large storm surf seems also to have made enough of an impression to be incorporated into oral traditions. Haumea and Wākea were washed out to sea by a huge wave. And the story of the shark demi-god and the pond at Kualoa Point which was destroyed by "a great tidal wave" both reflect this fact. This last story is also almost certainly a Hawaiian explanation for the archaeologically recorded pond wall ruins off the point.

Oral tradition tells us that Kualoa was important for the whale ivory that washed onto its shores. What is tentatively identified as a whale bone was discovered in prehistoric beach deposits, in what is believed to be a naturally deposited context. While firm identification of the bone has not yet been made, there seems to be little reason why whale bone should not have washed ashore on what was a prograding sand spit.

Kualoa is also said to have been a residence of chiefs and training ground for the children of chiefs. Archaeological evidence has shown that Kualoa was indeed at least the part-time residence and "playground" of chiefs. As such it would naturally have been a training ground for the children of chiefs. However, 2 questions that deserve consideration here are that of the rank of skilled artisans such as stone and woodworkers and tapa makers, and the possibility that such artisans might have been teaching their skills at Kualoa. It is possible that laboratory analysis of lithic materials could resolve some of the second question, as it did in relation to Mauna Kea (Cleghorn 1982).

Kualoa is described by Kamakau as being "a sacred land and a true *puʻuhonua*, where persons marked for death were saved if they entered it" (1964:18). He also said that the *ahupuaʻa* of Kualoa had been such a place since "ancient times" (Ibid). Kamakau explains a *puʻuhonua*, or place of refuge, as

a place to which one could escape and be saved from being taken captive or from being put to death.... The king was called a puʻuhonua because a person about to die could run to him and be saved; so also were called his queen (ka Moʻiwahine) and his god. They were sacrosanct, and therefore their lands were sacrosanct, and were ʻaina puʻuhonua, lands of refuge (1964:17).

Kualoa was certainly a special place. It was obviously set apart for, and dedicated to, specific people and purposes. And the uses to which the area was put were nearly all, in one way or another, subject to prohibitions. These include: the traditional highly *kapu* or sacred nature of chiefs and chiefly residences; the *kapu* associated with fishponds, and those undoubtedly associated with specialized craftwork; the appearance on the beach of highly prized whale ivory—said to be for the exclusive use of *ali'i*; and the likelihood that the area was the seat of the Lono priesthood, with all the attendant *kapu* that such a possibility implies. Taken together it is easy to see how Kualoa would be considered "very sacred," and thus, usually forbidden to the general populace. There would, then, have had to be an exception to this rule for persons seeking refuge here if Kualoa was a true *pu'uhonua*. Evidence for this being the case seems convincing. Using Kamakau's explanation of a *pu'uhonua*, Kualoa would have been a *pu'uhonua* by reason of a king's [paramount chief's], or his dedication to the god Lono; even if not by some other official designation.

Final Comments

When archaeological work was started at Kualoa Regional Park, it was fairly well assumed that little worthwhile archaeological information could be gained from the area. It was believed that the intensive historic modifications that had been made to the area, some of which were described above, would have destroyed any very useful archaeological record of aboriginal occupation. The results to date have shown that such thinking should be used with a certain amount of caution. The archaeological work conducted at Kualoa Park and briefly described above has provided important information bearing on Hawaiian prehistory. However, I must point out that the above-described tour of Kualoa archaeology has underemphasized what may prove to be some of the most important information left to us by the area's early occupants. That is an extraordinarily large collection of artifacts (see Gunness 1987:205–234). Much of this collection lacks the precise provenience information that good archaeologists should demand, because the artifacts have been recovered either as a result of beach erosion, or from plowed or bulldozed areas. Through the years Park developers, and some local archaeologists alike have questioned the usefulness of collecting these unprovenienced items. It turns out, however, that the collection is so large (4,000+ "real artifacts," and roughly 14,000 basalt flakes, mostly produced in the process of adze manufacturing/finishing) that future analyses of these artifacts, including materials sourcing, production and manufacturing studies, typological studies, will provide considerably more social and economic information about the prehistoric occupants of the Kualoa area than otherwise has been gained to date. There may be a lesson to be learned here.

Finally, I would remind readers that Kualoa Regional Park encompasses only ¼ of the entire *ahupua'a* of Kualoa, of which oral traditions speak. The fact and nature of my employment by the Department of Parks and Recreation has of necessity forced me to confine archaeological work within the park boundaries. However, results of that work would seem to suggest the possibilities to be gained for Hawaiian prehistory if those horizons could be expanded.

Notes

1. *Ahupua'a*—"Land division usually extending from the uplands to the sea, so called because the boundary was marked by a heap (*ahu*) of stone surmounted by an image of a pig (*pua'a*), or because a pig or other tribute was laid on the alter as tax to the chief" (Pukui and Elbert 1968).

2. I am indebted to the editors for allowing me to make fairly major revisions and additions to the original version of this paper, which was written in 1983–1984. Field and laboratory work between 1984 and 1986 added so significantly to the archaeological knowledge of the Kualoa Park area that the original paper, if published, would have provided a woefully inadequate picture of the archaeological findings at publication date. While containing a few minor additions and corrections, this paper is now substantially a condensed version of my M.A. Thesis (Gunness 1987).

3. *Makahiki*—"Ancient festival beginning about the middle of October and lasting about 4 months, with sports and religious festivities and taboo on war" (Pukui and Elbert 1986). An integral part of this season was the collection of taxes in the form of tapa cloth, feathers, pigs, etc., at the boundaries of each *ahupua'a*.

4. In 1980, Kualoa was removed from the State Register of Historic Places by the Historic Sites Review Board along

with approximately 500 other sites in the state, as the result of a legal technicality involving notification of some of the sites' landowners. It is hoped that the proper paperwork can eventually be processed to put Kualoa Park back onto the State Register. In the meantime, Kualoa's listing on the National Register is supposed to provide it protection under Federal and State laws.

5. This figure is derived from a tentative reconstruction of the beach edge using the northern end of the pond wall off Kualoa Point as a base point, and from the general distribution of artifacts found on the reef.

6. Since about 1983, few of these artifacts have been recovered from the beach, suggesting that erosion cut into, and has now washed away, the playing field boundaries.

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Aboriginal Sweet Potato Farming in the Hawaiian Dry Forest[1]

Joseph Kennedy and Mark David Merlin

Physical Setting

Geography and Geology The Waiʻanae Mountain Range forms the western part of Oʻahu Island. It is the deeply eroded, subaerial portion of a typical mid-Pacific oceanic shield volcano. Keaʻau is an older, headward eroded amphitheater-like valley located southeast of Kaʻena Point at 21° 30'N latitude and 158° 15'W longitude on the leeward side of the Waiʻanae Range. The valley has a maximum length of about 4 km (E-W), is a little more than 3.2 km wide along the coastal portion (N-S), and covers an area of approximately 775 ha.

A wide marine bench or coastal outcrop extends along most of the seaward end of the valley. Behind this coastal bench lies a broad, low lying, relatively flat area in the front of the valley. This lower area eventually gives way to a high gravel terrace that leads up to the alluvium-filled head of the valley. In the back of Keaʻau, talus and landslide debris form a great apron that extends upwards over the lower portions of the steep, corrugated rear walls of the valley. These walls rise to a serrated summit ridge with peaks as high as 884 m above sea level.

Like many of the older amphitheater-like valleys on the leeward side of the Waiʻanae Range, Keaʻau has passed from a mature to an old-age stage of erosion. Furthermore, the geological and climatological history of the Waiʻanae Volcano has been significantly affected by the growth and development of the Koʻolau Volcano. For example, the entire Waiʻanae Moun-

Table 1 Annual Rainfall Data from Six Leeward Coastal Sites in Hawai'i[a]

Rainfall gage name	Elev. (m)	Period of Record	No. of years	Max.	Med. (mm/year)	Min.
Mâkaha Kai	9	1921–1958	37	1079	505	168
Wai'anae Mill	6	1891–1957	62	1140	521	165
Mākaha Ditch	122	1936–1958	20	1326	864	305
Wai'anae Powerhouse	107	1932–1958	26	1339	660	152
Wai'anae Mauka	480	1905–1958	53	2979	1722	1092
Kolekole Pass	512	1934–1953	18	1829	1082	533

[a] Source: Taliaferro (1959).

tain Range, including Kea'au Valley, has experienced an apparent decrease in rainfall since Ko'olau Volcano reached heights above the lifting condensation level and consequently placed the Wai'anae Range in its rain-shadow.

In valleys such as Kea'au where stream erosion lessened due to a large drop in rainfall in the rain-shadow of the Ko'olau Volcano, chemical weathering has increased greatly. Evidence of this can be seen in the "thoroughly rotten condition of most of the older alluvium in the rainbelt" (Sterns and Vaksvic 1935:26). This long-term, intense chemical weathering and the associated leaching of the originally rich transported soils on the floor of Kea'au Valley may have reduced soil fertility and had a significant impact on the distribution, techniques, and yields of prehistoric Hawaiian agriculture.

Climate While the geomorphology and climatology of the Wai'anae Mountain Range has certainly been affected by the geological history of Ko'olau Volcano, the present climatic conditions (including the spatial and temporal distribution of available moisture) in Kea'au Valley are probably quite similar to those experienced by the prehistoric human residents of the area. Modern rain-fall data show that the distribution of rainfall throughout the leeward portion of the Wai'anae Mountain Range varies seasonally with a greater percentage of precipitation occurring during the winter (*ho'oilo*) months (mid-October to mid-April) when the islands are affected by frontal storms that usually come in from northwesterly or southerly directions. Within the major valleys in this part of O'ahu, such as Kea'au, climatic conditions vary spatially from the hot, arid lowland sections near the coast, to the cooler, moderately humid upper regions in the rear areas of the valley.

Table 1 presents rainfall data collected at a number of sites near the study site. These sites are located at different elevations and should give us an idea of what the actual precipitation patterns are in Kea'au Valley itself.

Temperature regimes for the valleys in the leeward portion of the Wai'anae Range are exemplified by the data from a station near sea level in Wai'anae Valley. These data are included in Table 2 below.

Another climatic variable of significant importance for Kea'au Valley is cloud cover which is

Table 2 Temperature Data from Three Leeward Coastal Sites in Hawai‘i[a]

	January			August				
Station	mean	max.	min.	mean	max.	min.	Max.	Min.
Kaua‘i								
Mānā	21.3	26.1	16.3	25.6	31.1	20.0	35.0	8.9
O‘ahu								
Wai‘anae	22.2	27.7	16.9	26.8	31.9	21.1	35.6	10.0
Maui								
Lahaina	21.8	27.1	16.6	25.4	30.8	20.1	33.9	11.1

[a] Source: Blumenstock and Price (1967).

normally produced orographically from either tradewind or sea breeze sources. Cloud cover is generally greater in the backs of amphitheater-like valleys of the Hawaiian Islands.

In the rear of a valley such as Kea‘au, the greater cloud cover keeps the ambient air temperature lower than that in the sun-drenched lowlands near the coast. Increased cloud cover in the back of the valley also probably reduces evapotranspiration in the rear portions of Kea‘au and most likely contributes a fair amount of available moisture through the mechanism of fog drip, especially in higher ridge and summit regions.

Pristine Conditions in the Valley

When early settlers first settled Kea‘au, they probably encountered a pristine dry forest ecosystem covering most of the valley except for the cooler, cloudier, high gulch and ridge areas in the back of the valley where mesic forest plant associations could survive. *‘Ōhi‘a lehua* (*Metrosideros collina*) was observed on a remote ridge at about 400 m during this survey.

Although the lower portion of the valley is today largely covered by exotics such as *koa haole* (*Leucaena leucocephala*) and some *kiawe* (*Prosopis pallida*) near the coast, it was originally dominated by native shrubs and small trees adapted to the very dry conditions throughout most of the year. Based on observations of the presence and relative abundance of native species still found in the study area, we may assume that the original dry forest of Kea‘au Valley included the following trees: *wiliwili* (*Erythrina sandwicensis*), ‘*ohe* (*Reynoldsia sandwicensis*), *lama* (*Diospyros sp*.), sandalwood (*Santalum ellipticum*) *‘iliahialo‘e* and *māmane* (*Sophora chrysophylla*). Other, smaller woody native species still found in the more exposed areas of Kea‘au include ‘*ūlei* (*Osteomoles anthyllidifolia*), *ko‘oko‘olau* (*Bidens waianaeensis)*, and ‘*akoko* (*Euphorbia sp*.). In some of the shady areas in the back of Kea‘au, native ferns such as *pala‘ā* (*Sphenomeris chinensis*), *Pteris sp*. and *Nephrolepis sp*. can be found. On the higher ridges and on the upper portion of the steep, cloudy cliffs, the pristine vegetation included the ‘*ōhi‘a lehua* tree, *moa* (*Psilotum nudum*) and other native plants requiring moderately humid conditions. The pattern is the same as reported for similar environments in Hawai‘i, and allows more informed study of prehistoric land use patterns.

Polynesian Impact on the Ecosystem

As they seem to have done throughout much of Hawai‘i's dry forest ecosystems, prehistoric Polynesians most likely made some significant environmental changes after early colonization in Kea‘au Valley. In addition to bird hunting which may have caused the reduction or extinction of some species (Olsen and James 1983), the early settlers in the valley may have set fires consciously (or even accidentally let them get out of control) and consequently cleared much of the dry forest. This would have encouraged the growth of pioneer species, thus increasing the population of native *pili* grass (*Heteropogon contortus*). This grass was important since it was widely used to thatch houses and could be used as a mulching agent to "grow dry taro in areas with less than 1,270 mm of rainfall a year" (Yen in Green 1980:27). *Pili* grass therefore may have played a role in the ancient farming of Kea‘au.

The earliest historic drawings we have of Hawai‘i include the sketches of Waimea, Kaua‘i by Webber, who was an artist with Cook's third expedition. Webber's drawing of the village at Waimea and the environment behind it show the hills and ridges surrounding the village as largely devoid of woody vegetation and almost entirely covered with grass. The geographical position (and consequently the ecological situation) of Waimea, Kaua‘i is similar to that of Kea‘au. Both are extreme leeward positions on the west coasts of the 2 oldest high Hawaiian Islands.

Regarding the importance and impact of fire, we have some evidence that burning probably played a role in the alteration of the dry forest environment on the steep slopes in Mākaha (see Ladd and Yen 1972 or Ladd 1973). Concerning Waimea, Kaua‘i, its relationship to Kea‘au, and the general question of fire as a direct or indirect agent of ecological change in prehistoric Hawai‘i, one may refer to 2 articles by Kirch (1982a,b) who notes that burning for agricultural purposes was only one application of fire. Kirch quotes Menzies who in 1792 "observed a large fire kindled a few miles to the eastward of Waimea, [Kaua‘i] spreading over the face of that plain country, which was mostly covered with dry, rank grass … that burnt with great rapidity." According to Menzies, the purpose for doing this was so "the next crop of grass grew up clear and free of stumps, and was therefore better adapted for thatching their houses" (Menzies 1920).

Green mentions the importance of hydrological resources in his evaluation of prehistoric land use in Mākaha.

Any discussion of the prehistoric use of Mākaha Valley requires an appraisal of the freshwater resources available to its Hawaiian inhabitants before the major changes wrought by European intervention. These resources took 4 forms: rainfall, surface runoff, permanent streams and springs. (1980:27)

As already noted, because of the frequency of cloud cover in the rear of Kea‘au (which often intercepts the surface), it is likely the contribution of fog drip in some parts of the uplands should also be considered here as important in terms of providing more available moisture for forest vegetation, groundwater recharge, surface stream and spring flow—as well as for human use for drinking water and irrigation.

As suggested earlier, the record of rainfall at stations near the study area indicate that precipitation varies significantly from the front of the valley to the rear as well as from year to year. Green (1980:27) comments on this kind of rainfall distribution in relation to the prehistoric agricultural activities in the Leeward District, noting that rainfall determined where taro could be cultivated without irrigation, and that when taro production was impossible, sweet potato was important. He argues that most of the leeward dry valleys were planted with sweet potato.

Hommon (1976:264) argues from the available agronomic, ethnohistoric and archaeological evidence that at least 1,270 mm per year of rainfall is required for dry taro. Like sweet potato, it requires from 3 to 6 months to mature, in contrast to much longer periods for wet taro. Droughts and dry months, which are almost non-existent in the wetter zones, grow increasingly common when rainfall drops below 1,524 mm per year. This means that in Mākaha, which was subject to marked seasonality in rainfall, with most of it falling between mid-October and March or April, dry taro cultivation was, in general, limited to the wetter upper valley.

Table 3 Checklist of Flowering Plants Collected in Kea'au Valley

FAMILY Names	Origin
ANACARDIACEAE	
Schinus terebinthifolius Christmas Berry (*Wilelaiki*)	Recent intro.
APOCYNACEAE	
Rauwolfia sandwicensis (Hao)	Endemic
ARALIACEAE	
Reynoldsia sandwicensis ('Ohe)	Endemic
CACTACEAE	
Opuntia megacantha Prickly Pear (*Pānini*)	Recent intro.
CASUARINACEAE	
Casuarina equisetifolia Ironwood (*Paina*)	Recent intro.
COMPOSITAE	
Artemisia sp. *(Hinahina kuahiwa)*	Endemic
Bidens waianaeensis (Ko'oko'olau)	Endemic
Conyza sp. *(Ilioha)*	Recent intro.
Eupatorium riparium (Pāmakani)	Recent intro.
Pluchea indica Indian Pluchea	Recent intro.
CRASSULACEAE	
Bryophyllum pinnatum Airplant (*'Oliwa ku kahakai*)	Recent intro.
CUCURBITACEA	
Sicyos sp. (*Kūpala)*	Endemic
EBENACEAE	
Diospyros ferrea (Lama)	Endemic
EUPHORBIACEAE	
Aleurites moluccana (Kukui)	Poly. intro.
Euphorbia sp. *('Akoko)*	Endemic
GRAMINACEAE	
Oplismenus hirtellus Basket grass (*Honohono kukui*)	Recent intro.
Panicum maximum Guinea grass	Recent intro.
Melinis minutefolium Molasses grass	Recent intro.
LABITAE	
Salvia coccinea (Līlīlehua)	Recent intro.
LEGUMINOSAE	
Acacia confusa Sm. Phil. koa	Recent intro.
Acacia farnesiana Klu	Recent intro.
Leucaena leucocephala (Koa haole)	Recent intro.
Cassia glauca (Kalamona)	Recent intro.
Erythrina sandwicensis (Wiliwili)	Endemic
Indigofera suffruticosa Indigo (*'Inikō*)	Recent intro.
Sophora chrysophylla (Māmane)	Endemic
LILIACEAE	
Cordyline terminalis Ti (*Kī*)	Poly. intro.
MALVACEAE	
Sida cordifolia ('Ilimakukula)	Endemic
MELIACEAE	
Melia azedarach Pride of India (*'Inia*)	Recent intro.
MYRSINACEAE	
Eucalyptus sp. Eucalyptus trees (*'Eukalikia*)	Recent intro.
Metrosideros collina 'Ōhi'a lehua	Indigenous
Psidium guajava Guava (*Kuawa*)	Recent intro.
Syzygium cuminii Java plum	Recent intro.
PASSIFLORACEAE	
Passiflora edulis (Liliko'i)	Recent intro.
Passiflora suberosa (Huehue Haole)	Recent intro.
PLUMAGINACEAE	
Plumbago zeylanica ('Ilie'e)	Indigenous
PROTEACEAE	
Grevillea robusta silky oak (*'Oka kilika*)	Recent intro.
ROSACEAE	
Osteomeles anthyllidifolia ('Ūlei)	Endemic
RUBIACEAE	
Canthium odoratum (Alahe'e)	Endemic
Coffea arabica Coffee (*Kope*)	Recent intro.
RUTACEAE	
Citrus aurantifolia Lime (*Lemi*)	Recent intro.
SANTALACEAE	
Santalum ellipticum ('Iliahialo'e)	Endemic
STERCULIACEAE	
Waltheria indica (Hi'aloa)	Indigenous
THYMELAECEAE	
Wikstroemia sp. ('Ākia)	Endemic
VERBENACEAE	
Lantana camara Lantana (*Lākana*)	Recent intro.
URTICACEAE	
Pipturus sp. (*Māmaki)*	Endemic

Historic Human Impact in the Valley

Although fire probably removed much of the original vegetation in the front of Kea'au during the prehistoric period, much of the native dry forest in the back of the valley most likely survived into the historic period. The cutting of some trees for construction materials and agricultural clearing undoubtedly took their toll, but significant stands of native species persisted. This is supported by reports that the forced harvesting of sandalwood trees in the late 18th and early 19th centuries was an important activity in the dry forests of Wai'anae. By the time this selective exploitation ended the sandalwood trees were greatly reduced in number but not eliminated.

Even more devastating to the native forest in Kea'au, as well as in many other similar ecological regions of the Hawaiian Islands, has been the impact of domestic and feral mammals such as cattle and goats. These herbivores, without natural predators, devastated the native plant life that was ill-equipped to withstand the new type of grazing pressure. By the 20th century, the former dry forest and much of the mesic forest areas in Hawai'i, including Kea'au, had been reduced to a fraction of their pristine condition. As herds of hoofed animals trampled and/or consumed the relatively defenseless vegetation, the forest floor became exposed. Consequently, when heavy rains fell soils soon became compacted and much of the remaining soil was washed down slope.

The degraded soil conditions were soon invaded by a host of weedy species better adapted to dispersal by introduced animals and able to survive their grazing pressure in the pioneer ecological conditions. A preliminary botanical survey conducted within the archaeological study area (see checklist of flowering plants collected in Kea'au Valley) indicates that more than 60% of the naturalized flowering species observed there are of recent introduction. Furthermore, the percentage of plant cover in the study area is dominated by exotic species. In some heavily altered areas, we estimate that recently introduced plants now occupy as much as 90–95% of the vegetation in Kea'au Valley.

In addition to soil damage and severe erosion, the ecological impact of the uncontrolled herds of feral grazing mammals and the domesticated stock has had a great effect on groundwater recharge and consequent spring flow that now occurs in Kea'au Valley. Such changes in available water should be taken into consideration when attempts are made to reconstruct the prehistoric land use patterns in this area.

The checklist of flowering plants found at Kea'au (Table 3) reflects these environmental conditions and may allow an inferential basis for reconstructing the prehistoric and pre-Hawaiian flora and fauna.

Archaeological Methodology

Three major areas were studied through survey at Kea'au. The first area to be surveyed was the cliffs fronting Farrington Highway between Kapuhi Point and just past the Mākua end of Kea'au Beach Park. This area was selected because there is a high potential for cave burials in the many lava pockets that dot this geologic formation. In addition, there is some evidence that this area was used by a criminal element in the prehistoric and early historic period as a point from which raids would originate (Krauss 1973:11).

Malolokai, on the beach between at the foot of the ridge which divides Mākaha and Kea'au Valleys was named after a gang of robbers who preyed on travelers going by. A lookout on the ridge would call out 'Moanakai' (high tide) if the approaching party was too large to meddle with. But if only 1 person was on the path, the lookout called 'Malolokai' (low tide) and the robbers attacked. Some legends say the robbers were cannibals. The late Harry George Poe, born in Mākua Valley in 1882, wrote in his diary that the robbers threw their victims into a pit that led to the ocean.

The second area to be examined was the beach fronting these cliffs, again between Kapuhi Point and the Mākua end of Keaʻau Beach Park. Due to recent construction, tidal wave action and other developments, it was assumed that there would be little chance of cultural material on the surface. This area was investigated last with a minimal amount of time being accorded it.

The third area of investigation took place at selected locales at the back of the Keaʻau Valley, because this dry forest section was of particular interest in terms of aboriginal agricultural techniques. At this writing, this area has been relatively undisturbed by recent human hand and had not been previously surveyed by an archaeologist. The back of Keaʻau was therefore considered an excellent candidate for the discovery of some examples of prehistoric Hawaiian agricultural sites.

Beyond this, a presurvey conference that took place at the State of Hawaii Department of Land and Natural Resources, Historic Sites Section, helped underscore the practicability of preselecting potentially high areas of archaeological interest and potential, and then arranging the survey schedule in a way that would give these locations the lions' share of time and consideration.

The value in locating archaeological sites, placing them in their proper ecological setting and providing a foundation for future research in the Keaʻau area is clear in light of research that has already taken place in similar settings, e.g. Lapakahi, on the Island of Hawaiʻi, and Mākaha Valley on the Island of Oʻahu. In both regions, a considerable amount of archaeological work has preceded the present study and, therefore, presents a baseline for comparative study and hypothesis testing.

In survey area number 1 (the cliffs fronting Farrington Highway), survey team members climbed as close as they could to the top of the ridge and conducted long sweeps from the Kapuhi Point end of the ridge to the Mākua end. Seven sweeps were needed to complete this phase of the survey. The ridge was examined from very close to the top, down to the *mauka* private property boundary lines located along Farrington Highway.

The beach portion of the survey (survey area number 2) took very little time, as it was quite clear that little or no cultural materials would be forthcoming from the surface. Again, sweep teams consisting of 3 members methodically covered the property *makai* of Farrington Highway from Kapuhi Point to the Mākua end of Keaʻau Beach Park by making long sweeps. Three sweeps were needed to complete this phase of the survey.

Survey area number 3 is located in the most *mauka* portion of Keaʻau Valley. As mentioned earlier, it was thought that the rear portion of the valley would be the most likely to contain intact cultural resources. At the end of the jeep road, survey team members set off on foot to systematically investigate the gulches, ridges, and infrequent flat lands that comprise the back of the valley. Team members spaced themselves roughly 10 m apart and set off on transects established with the aid of a handheld bearing monocular. Survey team members used compasses to maintain the correct bearing.

When sites were discovered in this survey area, it was not difficult to fix their location on a standard USGS quad map because 4 of the 5 sites that were discovered in this area were situated on ridgetops easily discernible by merit of contour lines. It should be noted that obtaining exact location using a transit and stadia rod would have been very costly in terms of energy expended and amount of ground covered. Had transit and stadia locations of all sites been a requirement on this job, it is estimated that the total survey area would have been reduced to roughly 25% of its present size. The locations of the sites that were discovered in survey area number 3, while not exact, are nevertheless more than adequate for purposes of relocation. Individual sites were mapped using the chain and compass method.

Previous Archaeological Work in the Area

To the best of our knowledge, there has been no previous archaeological work done on any portion of the subject parcel. However, there has been a considerable amount of work done in nearby Mākaha Valley (Green 1970, 1980, Ladd and Yen 1972, Ladd 1973) that has a significant bearing on some of the suppositions and findings presented in this report. As may be seen in the "Physical Setting" section of this report, the Mākaha information is called on several times, especially regarding the conditions for agricultural growth relating to specific crops.

In addition to the Mākaha information, data collected in the *ahupua'a* of Lapakahi on the Island of Hawai'i is called for comparative purposes. The reason for this is that ecological conditions, site type and, most likely, site function data is similar in both areas.

The Sites

A total of 5 archaeological sites were discovered in the course of this survey; all sites were located in the back of Kea'au Valley. The following discussion overviews the environmental setting, the archaeological remains and their contexts and establishes a basis for further comparative analyses.

Site 1 This structure is located in the section of Kea'au known as Kaulu Gulch. This gulch is located at an elevation of 350 m and has soil belonging to the rSY, or Stony Steep Land. Foote, et al. (1972) report that this soil "consists of a mass of boulders and stones deposited by water or gravity on side slopes of drain ways.... The slope ranges from 40 to 70 percent. Elevations range from 100 to 1500 feet. The annual rainfall ranges from 20 to 80 inches."

Site 1 is exceptionally large, measuring more than 200 m long and 25 m wide. A small rock wall borders the entire site and there are many rocks scattered within the interior. In addition to the random scattering of rock, there are a number of very crude terraces, some mounding (also made of rock), some massive boulders (one over 6 m long and more than 3.5 m high) and a well–formed wall featuring a conspicuous upright stone that is incorporated in the wall.

On the Mākua side of this site is an intermittent stream that runs the entire distance of the site. It should be noted that the stream bed is, in some places, as much as 3 m below the archaeological site and so could not provide direct irrigation.

An important part of the survey of Site 1 was the discovery of an *'ō'ō*, or digging stick, that had been placed in a hollow under the massive boulder mentioned earlier. The *'ō'ō* was submitted to the State of Hawaii, Department of Forestry for examination and was identified as being made of *kauila* a native Hawaiian wood that was often used for tools of this nature.

Site 2 This feature was located on a ridge top at an elevation of 381 m. The soil classification for this location has been identified by Foote, et al. (1972) as rRK or rock land, and has been described in the following terms:

Rock land (rRK) is made up of areas where exposed rock covers 25% to 90% of the surface. It occurs on all 5 islands. The rock outcrops and very shallow soils are the main characteristics. The rock outcrops are mainly basalt and andesite. This land type is nearly level to very steep. Elevations range from nearly sea level to more than 1800 m. The annual rainfall amounts to 40 to 150 cm.

Rock land is used for pasture, wildlife habitat, and water supply. The natural vegetation at the lower elevations consist of mostly kiawe, klu, pili grass, Japanese tea, and koa haole. Lantana, guava, Natal redtop and molasses grass are dominant at the higher elevations. This land is typically used for urban development. In many areas, especially on the Island of O'ahu, the soil material associated with rock outcrops is very sticky and very plastic. It also has a high shrink-swell potential. Buildings on the steep slopes are susceptible to sliding when the soil is saturated. Foundations and retaining walls are susceptible to cracking.

Site 2 covers roughly 1,579 m² of this ridgetop and is comprised of a number of different features. The most important of these is a series of crude terraces that follow a gradual slope towards a gully on the Mākua side of the site. Like Site 1, there is an abundance of scattered rock throughout the site and several large boulders, although none as large as those reported in Site 1. In addition, there is a well-defined house site at the *mauka* end of this feature and a series of well-constructed terrace walls associated with it. As was also seen in site 1, rock mounding was present.

Site 3 This site, like the one just described, is located on a ridgetop but at a slightly higher elevation, 410 m. Again, like Site 2, this feature rests on soil classified as rRK, or rock land. Site 3 is the smallest of the archaeological features discovered in the back of Kea‘au Valley, being just 6 m wide and 12 m long. The site itself is comprised of 2 distinct enclosed areas, bordered by a small rock wall on all sides. In addition, a small rock mound is associated with the enclosures. However, it is located outside the wall and off to one side. There is a scattering of rock within the boundaries of these 2 small enclosures.

Site 4 This feature is comprised of 3 distinct terrace levels located at the top, and most *makai* portion, of one of the many ridges in the back of the valley. The elevation at this location is 396 m and the soil upon which it rests has been classified as rRK, or rock land.

Site 4 is bounded on all sides by a low rock wall and each separate terrace is clearly demarcated by an additional well-constructed wall that separates each level. Like all other features examined in this survey in the *mauka* portion of Kea‘au, a significant stone scatter is present in each of the 3 terrace levels.

Site 5 This site is also on a ridgetop on rRK, or rock land type soil. The elevation at this location is 350 m. Like all previous sites recorded, Site 5 is bordered on all sides by a low rock wall. The interior section is divided near the rear quarter marked by an additional low rock wall that runs across the width of the site. Beyond this, there are 2 single lines of rock, each 3 m long, which create internal modifications.

Conclusions

There are some general comments concerning the 5 sites discovered in the back of Kea‘au Valley that should be addressed at this point. A case can be made that all 5 sites reported in this survey were the loci of sweet potato cultivation. First, let us consider the alternatives and the ecological conditions for each. To begin with, it is altogether impossible for these sites ever to have been the location of wet land taro production because the necessary hydraulic accessories are missing. The remaining cultigen possibilities are dry land taro and sweet potato.

It is known that dry land taro requires an average of 12 months of growth for maturation, and during this period enough rain must fall to ensure continued growth, and obviously, prevent a state of hydro-starvation. Given the evidence previously presented in this report, it is unlikely that the back of Kea‘au could have sustained a growing period suitable for dry land taro.

On the other hand, the sweet potato will mature in a period from 3 to 6 months and can effectively be produced with as little as 75–100 cm of rain a year. This time table would be much better suited to the 6 month rainy period that is the norm for the back of Kea‘au Valley. In support of these findings, we note that Hommon (1969:48) argued that sweet potato and not taro was the staple for Mākaha Valley.

There are functional considerations that also may support these findings. Handy (1940:118) tells us that agricultural features were often enclosed to protect crops from cattle; although we also hear from Cook on this matter (1967:521,592) who references a socio-political function for rock enclosures of this sort to show ownership. We have some hard evidence that bordered areas such as these were used to grow crops.

In a somewhat similar environmental setting on the Island of Hawai‘i *ahupua‘a* of Lapakahi, a report of a sweet potato site by Choy (1973) offers some comparative data that is hard to ignore in terms of the sites in the back of Kea'au. The overall map of her site, 5110, is remarkably similar to Site 1 in Kea'au, and in concept, is in concert with the others as well. Choy's map shows a large, oblong shaped enclosure that is bordered by a low, single line rock wall on all sides. It follows the land contour, has informal, crude terraces, rock outcrop and boulder areas, rock mounds and internal modifications in the form of roughly shaped C-shaped structures and an abundance of rock scatter.

Near Choy's site 5110, a sweet potato was recovered in an archaeological context (Arlas 1972). When one considers this evidence and couples it with the short *kauila* digging stick (*'ō'ō*) found in Site 1 at Kea'au, a good functional interpretation of the sites at Kea'au is sweet potato farming at about the 300 m level in the Hawaiian dry forest.

Some of the questions that might be asked by a future researcher are:

a) How many people could be supported by the agricultural activities that took place here?

b) Where did these people live?

c) When did they live there?

d) Was there a seasonal occupation of the area?

e) How did the activities that took place here fit into the development and evolution of the Hawaiian political unit (*ahupua'a*, *'ili,* and even district)?

There has been much archaeological debate concerning the many stages or "phases" of Hawaiian cultural development. The answers to many questions relating to the formation of the Hawaiian chiefly state may be contained in agricultural data and many Hawaiian scholars have been attracted by the notion that major societal changes are perhaps best reflected by divergent agricultural practices.

Note

1. In April 1984 the authors conducted an archaeological and ethnobotanical examination of selected parts of Kea'au Valley, Wai'anae, Island of O'ahu. Mr. Kennedy conducted the search for archaeological sites and reviewed the archaeological literature. Dr. Merlin compiled the geographical and botanical sections of this report and accompanied the survey teams in the field. Funding for this project was provided by the State of Hawaii, Department of Land and Natural Resources and Archaeological Consultants of Hawaii, Inc. The authors are indebted to Dr. Don Hibbard, Mr. Earl Neller, Mr. Jason Ota, Mr. Wendell Kam, and Ms. Martha Yent for their input on the Kea'au survey.

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Pathways in Hawaiian History

Robert J. Hommon

Nearly all that we know of Hawai'i's precontact chronology is based on several hundred radiocarbon age determinations of samples collected during the past 30 years. Essential to the use and refinement of this chronology is the translation of the chronometric raw material, expressed as mean radiocarbon years before present (B.P.) with a standard deviation, into calendrical years. One translation method, the calibration of radiocarbon data according to recently published tables representing a consensus of decades of calibration research, has already been accepted by most archaeologists in Hawai'i (cf. Clark and Kirch 1983; Hommon 1983; Schilt 1984).

The adjustment of radiocarbon data according to the ratio of the stable isotopes of carbon, ^{13}C and ^{12}C, in an analyzed sample has not yet been so widely adopted, though it has special relevance to the construction of Hawaiian chronologies. Since the overwhelming majority of radiocarbon age determinations have come from woody charcoal found in fireplaces the following discussion deals with plants. However, it should be noted that analysis of the stable carbon isotope ratio in samples of human and non-human bone have contributed significantly not only to chronometry (Arundale et al. 1981), but also to human diet studies (Bender et al. 1981).

In the past 2 decades botanists have discovered that plants exhibit 3 different complex photosynthetic pathways.

These pathways, termed the Calvin-Benson or C_3 pathway, which characterizes most plants, the Slack-Hatch or C_4 pathway and the Crassulacean Acid Metabolism or CAM pathway, differ in part in the extent to which they are capable of discriminating among the isotopes of carbon during chemical reactions.

The ratios of ^{14}C, ^{13}C and ^{12}C in all plants vary from that of atmospheric CO_2, a factor that may affect the radiocarbon age of a sample, which is based on the abundance of ^{14}C relative to ^{12}C. The range of stable carbon isotope ratios characteristic of C_3 plants has long been known and compensated for in radiocarbon age determinations, so that analysis of stable carbon isotopes commonly results in little or no adjustment in reported radiocarbon years for samples from such plants (Browman 1981:249, 268–272). Radiocarbon samples from plants that follow the C_4 and CAM pathways, however, may present a very different picture.

The C_4 sequence is partly a closed system. It is thus not able to discriminate as completely against the heavier isotopes, but must use available carbon, which in such a partly closed system will include the more energy-expensive heavier isotopes. Therefore C_4 plants have an isotopic composition "enriched" with respect to the heavier isotopes when compared to the C_3 pathway. They will have more ^{14}C per unit ^{12}C than C_3 plants, and when compared to wood samples from the same provenience will appear to be too young. The CAM pathway is a very interesting one. At times it operates as a closed system, at other times as an open system.

Environmental conditions determine which mode will pertain. Hence correction factors for CAM plants vary with respect to environmental variables. In some cases, no correction factors are required, while in other cases the dated plant material may be enriched with sufficient ^{14}C to yield determinations that are about 200 years too recent (Browman 1981:272).

The abundance of ^{13}C relative to ^{12}C is expressed as the deviation from the PDB (Peedee belemnite) standard in parts per thousand (per mil). This value is known as $\partial^{13}C$. Values of $\partial^{13}C$ for C_3 plants average about –27 per mil and range from –21 to –29 per mil; those for C_4 plants average –11 per mil and vary from –8 to –20 per mil. Values for some CAM plants resemble those for C_4 plants while others resemble those for C_3 plants.

Adjustment of radiocarbon age based on analysis of $\partial^{13}C$ value is of particular importance in Hawai'i for 2 reasons. First, corrections of a few decades, much less 200 years, can be significant in a sequence as short and as late as that of pre-contact Hawai'i. Second, the literature on the 3 photosynthetic pathways and the results of recent excavations on the island of Kaho'olawe indicate that major adjustments to radiocarbon ages based on stable carbon isotope analyses can be expected in some Hawaiian samples.

Most of the plant species in the world and all plants living exclusively in regions above 40° north or south latitude are C_3 plants, which are especially suited to moist mesophytic environments. All 3 types of plants are found in the broad region between 40° north and 40° south.

The C_4 plants evolved in habitats that were light intensive, had high temperatures, and where water supply was in some cases a limiting factor. They represent a specific evolutionary adaptation for heat stress. Crassulacean acid metabolism or CAM pathway plants appear to be a specific evolutionary adaptation to water-stressed environments (Browman 1981:273).

Given these distributional and adaptational data, it is reasonable to expect that some of the radiocarbon samples from Hawaiian archaeological sites, especially those in arid regions, might be from C_3 or CAM plants whose unadjusted radiocarbon ages could be decades to centuries too young.

Radiocarbon analyses of samples from Kaho'olawe sites in 1981 support this assessment. All 10 radiocarbon samples excavated from 8 inland Kaho'olawe fireplaces submitted to Beta Analytic, Inc. and Teledyne Isotopes, Inc. were subjected to stable carbon isotope analysis. Seven of the samples yielded $\partial^{13}C$ values from –22.88 per mil to –24.9 per mil, which are within the range for C_3 plants. The other 3 samples (including SA.056.1 and SA.056.2, 2 portions of a split sample analyzed by different laboratories, and SA.202.1) yielded values of –12.08 per mil, –11.8 per mil and –12.42 per mil, respectively, results within the range of C_4 (and some CAM) plants.

The unadjusted age of one of the latter samples, SA.056.2 (I–12,615) from fireplace 1, feature B, site 104, was reported as 190 ± 75 radiocarbon years B.P. On the basis of its $\partial^{13}C$ value (–11.8 per mil), this age was adjusted or "normalized" to 415 ± 75 radiocarbon years B.P., 225 years older than the original result. The calibrated A.D. alternate ranges of the unadjusted result would have been 1620–1890 or 1910–1950; the range of the adjusted result is 1400–1525. The radiocarbon age of sample SA.056.1 was reported as "Modern (less than 30 B.P.)" and that for SA.202.1 as "Modern (less than 150 B.P.)". As reported, neither result can be adjusted or calibrated.

While these results constitute an extremely small statistical sampling from a single island they are sufficient to demonstrate the importance of stable carbon isotope analysis to the interpretation of Hawai'i's archaeological record. If the split sample is counted as 1, 2 out of the 9 Kaho'olawe samples (about 22%) yielded results that would add roughly 200 years to a radiocarbon age given non-"modern" values. In the single non-"modern" example noted above, the site is centuries older than would have been indicated by the unadjusted result; it was clearly occupied well before Western contact, and the approximate age is known with considerably more precision than would have been the case without adjustment. Moreover (if we can accept certain broad inferences about Hawaiian prehistory that are ultimately derived from unadjusted radiocarbon data), the adjusted result noted above allows the placement of the dated site in an entirely different cultural phase.

Recent data from Kaho'olawe (Paul Rosendahl, pers. com.) and O'ahu (Alan Haun, pers. com.) support the observation that adjustment of radiocarbon ages based on $\partial^{13}C$ values can be expected to have a significant effect on the construction of chronologies in Hawai'i. Clearly, from now on this analytical procedure should be performed on all Hawaiian samples submitted for radiocarbon age determination.

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Through Volcanic Glass, Darkly

Robert J. Hommon

Few tools are available to us for the construction of the chronological frameworks that are vital to an understanding of the evolution and history of pre-contact Hawaiian culture. The presence, absence, and/or frequency of a few portable artifact types and of even fewer non-portable artifact types may indicate that a site or deposit (or simply the artifact itself) is relatively early or relatively late (e.g. Emory et al. 1959; Pearson et al. 1971; Kirch 1974). However, the Hawaiian archaeological record is devoid of time-sensitive evidence such as pottery or other artifactual material whose formal attributes or frequencies vary through time sufficiently to make possible the construction of detailed inter-site relative chronologies.

The generally-accepted Hawaiian pre-contact chronological framework is based almost exclusively on the results of radiocarbon age determinations. Radiocarbon dating in Hawai‘i has proven very useful, not only in determining the ages of individual sites and features, but also in assigning approximate dates to significant events and processes such as the first settlement by Polynesian pioneers and the expansion of settlement into the inland zone (Hommon 1986). The construction of a radiocarbon-based chronology for Hawai‘i has benefitted recently from the adoption of a method of assigning calendrical ranges to radiocarbon age determinations based on calibration tables representing a consensus of numerous attempts to correct for long-term variations in the radiocarbon content of atmospheric carbon dioxide (Klein et al. 1982).

The drawbacks of radiocarbon chronometry in a sequence as short and recent as that of Hawai'i, however, are clear. First, a single radiocarbon derived calendrical range often spans so great a fraction of the entire sequence that it makes difficult the construction of detailed chronology. Calibrated calendrical ranges of the late pre-contact period usually extend well into the 20th century. An ancillary problem at present is that late (post-1600) radiocarbon age determination ranges that have been reported as "Modern, less than [n] years B. P." cannot be calibrated with the Klein et al. (1982) tables.

For a time in the 1970s another method of absolute dating, based on the measurement of hydration rinds of worked volcanic glass, appeared to many to be an excellent chronometric compliment to and perhaps even the successor to radiocarbon chronometry. Both the presence of numerous datable tools and debitage of volcanic glass in many archaeological sites and the relatively inexpensive technique for their chronometric analysis often made possible multiple "dates" for each provenience. Moreover, the calendrical year ranges that corresponded to the measured thickness of the hydration rinds, commonly spanning less than 100 years, appeared more precise than most of those based on radiocarbon age determinations. Volcanic glass dating was enthusiastically accepted by archaeologists in Hawai'i, often to the near exclusion of radiocarbon analysis (Barrera and Kirch 1973; Cordy 1981; Hommon 1976; Kirch 1979; Morgenstein and Riley 1974; Morgenstein and Rosendahl 1976; Tuggle and Griffin 1973).

In recent years, factors that may affect the rate at which recognizable chemical changes occur at the surface of volcanic glass have been the subject of research both in Hawai'i and elsewhere. Among these factors are the chemical and petrographic nature of the glass itself and the effective temperature and other characteristics of the sample's archaeological context. It has also been suggested that the rate at which Hawaiian glass changes is better described by a quadratic than by a linear equation. The most readily accessible reference for studies of Hawaiian volcanic glass is Olson's paper in Clark and Kirch (1983). Olson (1983) indicates that the process that holds the most promise is not the formation of a hydration rind, as has been stated in earlier Hawaiian studies, but rather the chemical alteration of the glass. Since the 2 archaeological studies discussed below refer to "alteration," this term is adopted here as well.

As work progresses on the factors affecting alteration of Hawaiian volcanic glass, archaeologists have continued to report the measurements and tentative chronometric interpretations of alteration and/or hydration phenomena of samples that they retrieve. It seems, however, that the heady optimism originally generated by this chronometric technique has been replaced by an attitude compounded not only of healthy skepticism but also of a pessimism gloomier than is warranted by a careful consideration of the facts at hand. While this attitude is most often expressed verbally, we can find published examples in the 2 sources upon which we focus the present investigation: the Mudlane-Waimea-Kawaihae Road Corridor study (Clark and Kirch 1983; Olson 1983) and the Kuakini Highway realignment study (Schilt 1984).

Olson (1983:332–333) suggests that volcanic glass chronometry is best viewed at present as a relative rather than an absolute dating technique. In the archaeological literature, however, the term "absolute dating" refers not to a high degree of accuracy or precision but rather to the fact that a technique yields quantitative results expressed as years in the past. A relative dating technique, in contrast, indicates that observed phenomena occurred in a particular order in the past; e.g. artifact type "A" was in use before type "B" and type "B" before type "C".

While Olson's "relative" dating approach is based on a well-advised caution in interpreting the results of volcanic glass chronometric analysis, it results in misuse of the data. First, by beginning with rounded values of alteration thicknesses and predetermined cultural periods, it seems to suggest that not only has the rate of alteration varied substantially in the past, but also it has alternately accelerated and decelerated according to the succession of the 6 cultural periods (ranging from 200 to 350 years in length) that Olson suggests. The values that Olson's table indicates (quite unintentionally) for these periods are, from early to late: 1.2, 0.86, 1.0, 0.5 and 1.25 µ of alteration per 100 years. In fact, the overall sequence appears to have been based on a rate of 1.0 µ per 100 years for which the original µ values have been rounded to the nearest 0.5 µ. The rounding evident in the construction of the "relative" dating sequence was evidently intended to impress upon the reader the imprecision of the technique.

The error of this method is compounded when Olson (1983:333) suggests that if any 2 samples' alteration measurements fall into a single range (correlated with one of his cultural periods) then they should be treated as contemporaneous. For example, since the "Early Prehistoric Period" (A.D. 1000–1350) is correlated with an alteration measurement range of 6.0 to 9.0 µ, then samples with measurements of 6.1 and 8.9 µ are to be considered contemporaneous. This approach would indicate that the precision of the technique varies through time since the range of required contemporaneity (corresponding with the 200 to 350 year periods) vary from 1.0 to 3.0 µ. Moreover, if the contemporaneity determination is accepted, then the "splitting" function of the period boundaries must be accepted along with their "lumping" quality. For example, according to Olson's reckoning, while the sample with 6.1 µ of alteration is considered to be chronometrically indistinguishable from one with 8.9 µ, it cannot be considered contemporaneous with, and must be earlier than, one with a measurement of 5.9 µ. The mislabelling of what is clearly an absolute dating technique (however accurate, precise, or useful) results in the self-contradictory conclusions that alteration measurements allow chronometric resolution at the level of less than 0.2 µ and simultaneously at a level no finer than 3.0 µ (or 1.0 or 2.5 µ, depending on the cultural period).

Olson (1983) uses this "relative dating" approach in reporting the results of the analysis of volcanic glass samples from 1 of the 2 projects of interest here, the Mudlane-Waimea-Kawaihae Road Corridor study (Clark and Kirch 1983). By lumping the results of the volcanic glass analyses according to the predetermined "cultural periods" into which they are seen to fall rather than comparing calendrical ranges for volcanic glass and radiocarbon samples, Olson failed to observe the relationships between the 2 that are discussed in the present paper.

In contrast, Schilt (1984), in the report of the Kuakini Highway realignment study, compares the results of the 2 chronometric techniques both graphically and in tabular form. Yet it seems to me that in her discussion of these results she too neglects to emphasize features of the volcanic glass chronometry that suggest internal consistency and a striking degree of agreement with those of the radiocarbon method.

The 2 recently reported archaeological studies mentioned above have been chosen to explore the utility of volcanic glass-derived chronologies because they provided multiple single-context sets of radiocarbon and volcanic glass data. Both study areas are corridors of planned highways situated on the western (leeward) side of the island of Hawai'i. The 32.3 km (20 mi) long Mudlane-Waimea-Kawaihae (M-W-K) Road Corridor, in the district of South Kohala, leads eastward from Kawaihae at the coast to a point east of the town of Waimea at an elevation of about 853 m (2,800 ft). The average annual rainfall varies from less than 250 mm (9.8 in) at the coast to 1,500 mm (59.1 in) at the upper end.

The Kuakini Highway corridor in North Kona district parallels the coast from a point about 45.6 m (151 ft) in elevation in the vicinity of Kailua for a distance of 4.96 km (3.1 mi) southward to a point about 91.2 m (300 ft) in elevation. Rainfall varies from about 760 mm (30 in) at the northern end to 890 mm (35 in) along most of the corridor. For the most part, the pre-contact inhabitants of both study areas practiced fishing and dry-land farming.

In the present paper, calibrated radiocarbon results (cf. Klein et al. 1982) constitute the standard with which the results of volcanic glass analysis are compared. The rate for volcanic glass

Table 1 Mudlane-Waimea-Kawaihae Radiocarbon and Volcanic Glass Samples

Sample Label	Provenience	Sample Number	Radiocarbon Age	Calibrated A.D.Range	Alteration Thickness μ	A.D. Range
A	5947-G	HRC-379	<110	(after1840?)[a]		
B		HRC-380	90±50	1660–1945		
1	20–25cm	HHD-588			1.7-1.1	1810–1870
2		HHD-590			1.7-1.1	1810–1870
3		HHD-587			1.9-1.3	1790–1850
4		HHD-586			2.1-1.5	1770–1830
5		HHD-585			2.3-1.7	1750–1810
6		HHD-589			2.3-1.7	1750–1810
7	30–35cm	HHD-722			3.0-2.0	1680–1780
8		HHD-721			3.5-2.9	1630–1690
9		HHD-719			4.0-3.0	1580–1680
10		HHD-723			4.3-2.7	1550–1710
11		HHD-720			4.4-3.4	1540–1640
C	2727-A	HRC-494	<110	(after1840?)[a]		
D		HRC-383	150±60	1645–1950		
12		HHD-739			2.5-2.1	1730–1770
13		HHD-737			3.5-2.7	1630–1710
E	8803-A	HRC424	300±80	1415–1950		
14		HHD-731			2.2-1.6	1760–1820
15		HHD-670			4.1-2.3	1570–1750
16		HHD-732			5.8-5.2	1400–1460
F	8892-A	HRC-528	220±60	1510–1950		
G		HRC-501	320±80	1410–1800		
17		HHD-725			1.9-1.5	1790–1830
18		HHD-726			2.1-1.3	1770–1850
19		HHD-687			2.5-1.9	1730–1790
20		HHD-724			2.7-2.3	1710–1750

[a] Uncalibrated range of “Modern, less than [n] years” calibrated range assigned by Schilt (1984)

Table 2 Kuakini Radiocarbon and Volcanic Glass Samples

Sample Label	Provenience	Sample Number	Radiocarbon Age	Calibrated A.D.Range	Alteration Thickness μ	A.D. Range
H	D8-33	HRC-580	<70	1675–1930[b]		
				(after 1880?)[a]		
21		HHD-660			1.9-1.3	1791–1851
22		HHD-659			2.5-1.9	1731–1791
I	D6-21	HRC-418	<120	1660–1945[b]		
				(after 1830?)[a]		
23		HHD-707			3.1-2.3	1672–1752
24		HHD-705			3.3-2.3	1652–1752
25		HHD-704			3.5-1.9	1632–1792
26		HHD-706			4.1-2.9	1573–1693
J1	D7-66	HRC-517	120±60	1655–1950		
J2		HR-C414	270±70	1760–1795		
				1485–1665[e]		
27		HHD-827			4.6-3.2	1522–1662
28		HH-828			4.6-3.2	1522–1662
K	D7-27	HRC-415	200±60	1840–1885		
				1605–1850[d]		
				1525–1570[c]		
29		HHD-832			2.2-1.4	1762–1842
30		HHD-833			2.2-1.6	1762–1822
31		HHD-834			2.8-1.2	1702–1862
L	D8-33	HRC-391	<270	1550–1660[b]		
				(after 1680?)[a]		
32		HHD-667			3.1-2.5	1671–1731
33		HHD-665			3.5-2.7	1631–1711
34		HHD668			3.7-2.7	1611–1711
M	D7-66	HRC-514	350±60	1420–1650		
35		HHD-801			5.0-4.2	1482–1562
N	D7-27	HRC-521	390±70	1410–1630		
36		HHD-854			2.8-1.6	1702–1822
37		HHD-853			2.8-2.0	1702–1782
38		HHD-851			3.5-2.1	1632–1772
39		HHD-852			4.0-3.0	1582–1682
O	D8-20	HRC-338	570±60			1305–1420
(Layer II)						
40		HHD942			4.0-3.0	1580–1680
41		HHD-941			4.04-3.24	1576–1656
42		HHD-940			6.52-5.92	1328–1388

Table 2 (continued)

Sample Label	Provenience	Sample Number	Radiocarbon Age	Calibrated A.D.Range	Alteration Thickness µ	A.D. Range
P	(Layer III)	HRC-339	830±70	1055–1270		
43		HHD-709			3.2-1.8	1662–1802
44		HHD-710			4.3-2.9	1552–1692
45		HHD-708			4.5-2.5	1533–1733
46		HHD-946			6.5-5.7	1330–1410

[a] Uncalibrated range of "Modern, less than [n] years" radiocarbon sample

[b] "Modern, less than [n] years" calibrated range assigned by Schilt (1984)

[c] One of alternate possible calendrical ranges selected by Schilt (1984)

[d] One of alternate possible calendrical ranges selected by Hommon (present paper)

[e] One of alternate possible calendrical ranges selected by both Schilt (1984) and Hommon (present paper)

used here is the same as that noted by the authors of both studies: an alteration thickness of 1 µ per 100 years. The dated volcanic glass samples used are all those which are considered by the authors of the 2 studies to have been collected from the same stratigraphic context as 1 or more analyzed radiocarbon samples. The basic data for both types of samples are summarized in Tables 1 and 2 and presented graphically in Fig. 1. Each of 17 radiocarbon age determinations, lettered A through P (including J-1 and J-2, which are parts of a split sample analyzed at different laboratories) is compared with from 1 to 11 of 46 analyzed volcanic glass samples numbered 1 through 46. These samples are grouped as 13 sets of data, each consisting of at least 1 radiocarbon sample (appearing at the top of each set in both tables and figure), and at least 1 volcanic glass sample from the same provenience. Note that since the method of calibrating "modern, less than [x] years B. P." determinations is unclear at present, the calibration method applied to such results from Kuakini samples (Schilt 1984) is not accepted here, though associated data suggest that the resulting calendrical ranges are approximately correct.

Comparisons of the sets of data from both study areas yield the following observations, all of which support the view that volcanic glass-derived date ranges closely approximate radiocarbon-derived calendrical ranges:

1) The general distribution of volcanic glass-derived ranges is similar to that of radiocarbon-derived ranges, i.e. from the mid-14th century to the early 19th century. Apparent exceptions to this observation are the radiocarbon-based ranges with no apparent glass-based equivalents at the early and late ends of the sequence. Sample P, the early radiocarbon sample, is discussed in item 5, below. At the late end of the sequence it should be noted that the indigenous Hawaiian nature of most of the dated sites in both study areas indicates that they were abandoned before widespread adoption of non-Polynesian artifacts, i.e. by the early decades of the 19th century. Thus, portions of radiocarbon ranges spanning the middle to late 19th and early 20th centuries do not pertain to the sites under investigation.

2) The volcanic glass-derived ranges from most proveniences tend to cluster, a phenomenon that would be expected if 2 or more accurately dated samples were *in situ* within a stratum that was deposited within a relatively short period of time. On the other hand, non-clustered samples need indicate neither an inaccurate dating technique

Fig 1 Line graph

34 picas 6 pts x 26 picas 2 pts.

Figure 1. Radiocarbon and volcanic glass dates from the Mudlane-Waimea-Kawaihae road corridor and the Kuakini Highway realignment corridor.

nor varying rates of alteration. Instead, the 3 non-clustered samples numbered 14 through 16, for example, might represent repeated reuse of the site over a period of several centuries, apparently a relatively common occurrence in leeward region sites (See item 5, below).

3) The agreement between the volcanic glass ranges and radiocarbon ranges within a set is generally good. At least a portion of the ranges of 28 of 37 volcanic glass samples overlap the calibrated ranges of the radiocarbon samples with which they are associated. (The remaining 9 glass samples of the total of 46 are not associated with calibrated radiocarbon samples.) Such agreement does not suggest that each volcanic glass-derived range is "confirmed" by its associated radiocarbon-based range, since the latter usually "dates" a single event that may have occurred at any point within the range. Rather, the agreement with the radiocarbon data demonstrates that the glass-derived ranges in most cases refer to the same portion of the *circa* 1300-year Hawaiian pre-contact sequence as do the radiocarbon-derived ranges.

4) In several cases, volcanic glass-derived ranges resemble associated radiocarbon ranges to a marked degree. Ranges of volcanic glass samples in 3 of the 6 sets that include the shortest calibrated radiocarbon ranges (those that do not extend to the 20th century) are fully included within those calibrated ranges. (See the ranges of samples J-2, M and O and their associated glass-derived ranges.)

5) Successive clusters of glass-derived ranges in multi-stratum contexts are consistent with repeated site reuse at widely spaced intervals. Glass

samples 1 through 6, whose ranges indicate activities around A.D. 1800, were retrieved from a level in M-W-K feature 5947–G stratigraphically above samples 7 through 11, which generally appear to date from the mid-16th century to the late 17th century. The volcanic glass samples from Kuakini site D8–20 present a more complicated picture. Samples 40 and 41 from layer II and samples 43, 44, and 45 from layer III appear considerably younger than the radiocarbon samples in either layer and sample 42 seems in inverted position relative to 43, 44, and 45. Schilt (1984:63) has suggested that the apparent inversion of glass-derived ranges at the site may have resulted from post-depositional disturbance, possibly by roots or a late construction phase at the site. Additionally, the numerous cracks, pores, and voids in the rocky soil matrix present in most non-beach sites in Hawai'i are channels through which small items like volcanic glass samples can be introduced into older archaeological contexts. Apparent inversion of glass-derived ranges should not be an unexpected circumstance in such sites. Such problems aside, it should be noted that most of the 15 glass-derived ranges from D8-20 (of which only 7 were chosen by Schilt to compare with radiocarbon data) form 2 separate clusters: one in the 14th century, closely resembling the range of radiocarbon sample O; the other centered at about 1600. No radiocarbon sample from the site supports the latter cluster. The ranges of 3 of the glass samples from Layer III of the site not chosen by Schilt to compare with the radiocarbon data overlap that of radiocarbon sample P (Schilt 1984: Fig. 1.20, p. 63).

6) The site with the latest-appearing cluster of volcanic glass samples (1–6) is M-W-K 5947–G, the only site of the 12 discussed here that contained clear-cut evidence of early post-contact use, in the form of a "roseheaded" nail believed to date from the late 18th to early 19th century and a small flake of imported flint (Reeve 1983:227).

This brief consideration of calibrated radiocarbon ranges, stratigraphic relationships and artifactual evidence indicates that, at least in the case of these study areas, volcanic glass dating based on an alteration rate of 1 μ per 100 years is an extremely useful chronometric tool, even in the absence of correction for chemical composition of the glass and environmental variables such as temperature. Such results indicate that volcanic glass chronometry will be particularly valuable in the investigation of the last 2 centuries before Western contact, a crucial period in the evolution of complex society in Hawai'i. To ensure that volcanic glass analysis fulfills its great potential in the exploration of Hawai'i's past, research in the variables of material and effective environment that may affect rates of alteration and hydration, as well as refinement in analytical technique, should be of highest priority.

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In citing radiocarbon dates, Hawaiian Archaeology uses the following conventions: BP (before physics) indicates an uncalibrated radiocarbon age; CRA (conventional radiocarbon age) indicates a radiocarbon age that (i) uses 5568 as the ^{14}C half-life, (ii) was measured against the NBS oxalic acid standard, (iii) uses 1950 as the zero date for radiocarbon time, (iv) is normalized for $\partial^{13}C$, and (v) has not been corrected for reservoir effects; BC/AD indicates a measurement that has been calibrated to calendar years.