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Early Inland Settlement Expansion and the Effect of Geomorphological Change on the Archaeological Record in Kāne‘ohe, O‘ahu

Scott S. Williams[1]

ABSTRACT

Construction of the Interstate H-3 Highway corridor on windward O‘ahu provided a 6.8 km transect of the inland portion of Kāne‘ohe *ahupua‘a* between 98 and 250 m above sea level. Intensive archaeological survey and excavation have shown that this inland area, previously thought to be marginal for permanent habitation because of the lack of surface archaeological remains, was actually an area of early growth and settlement. Annual frequency distributions are presented of 84 radiocarbon dates from 40 sites, most which were buried by sediment. The distributions suggest that the area underwent a period of rapid growth, beginning with an increase in irrigated and dryland agriculture around A.D. 950, followed by a rise in permanent settlements around A.D. 1150. Settlement accompanied by the rise of formal religious structures continued to increase until the period of Western contact.

Key Words: HAWAI‘I, O‘AHU, WINDWARD, RADIOCARBON DATING, SETTLEMENT PATTERN, GEOMORPHOLOGICAL CHANGE, LANDSCAPE ARCHAEOLOGY, CULTURAL RESOURCE MANAGEMENT.

INTRODUCTION

Recent archaeological research in inland Kāne‘ohe *ahupua‘a* (a traditional Hawaiian land unit) on the island of O‘ahu has revealed evidence of earlier use and occupation of this area during Hawaiian prehistory than was previously suspected. Geomorphological processes over the last 1500 years have buried archaeological deposits that may date to as early as the period between A.D. 400 and 700, and certainly to as early as A.D. 1000. By A.D. 1200, settlements in inland Kāne‘ohe were rapidly growing, with the expansion of irrigated and dryland field systems and the development of large temples and permanent house sites.

The research reported here was conducted by the Applied Research Group of the Bishop Museum, in the course of cultural resource studies along the route of the federally-funded Interstate H-3 Highway. Construction of this highway provided unique opportunities for Hawai‘i archaeologists: a 6.8-km-long transect through inland Kāne‘ohe was augmented by a heavily graded section known as the Windward Highway corridor, located approximately 4 km from the coast between 70 and 250 m above sea level (Fig. 1), which formed a 3-km-long, 100-m-wide stratigraphic trench through the area. Survey and excavation before construction, combined with intensive archaeological monitoring of construction activities

[1]Scott S. Williams, Pacific Archaeological Research Consultants, 826 Wanaao Street, Kailua, Hawaii 96734, USA

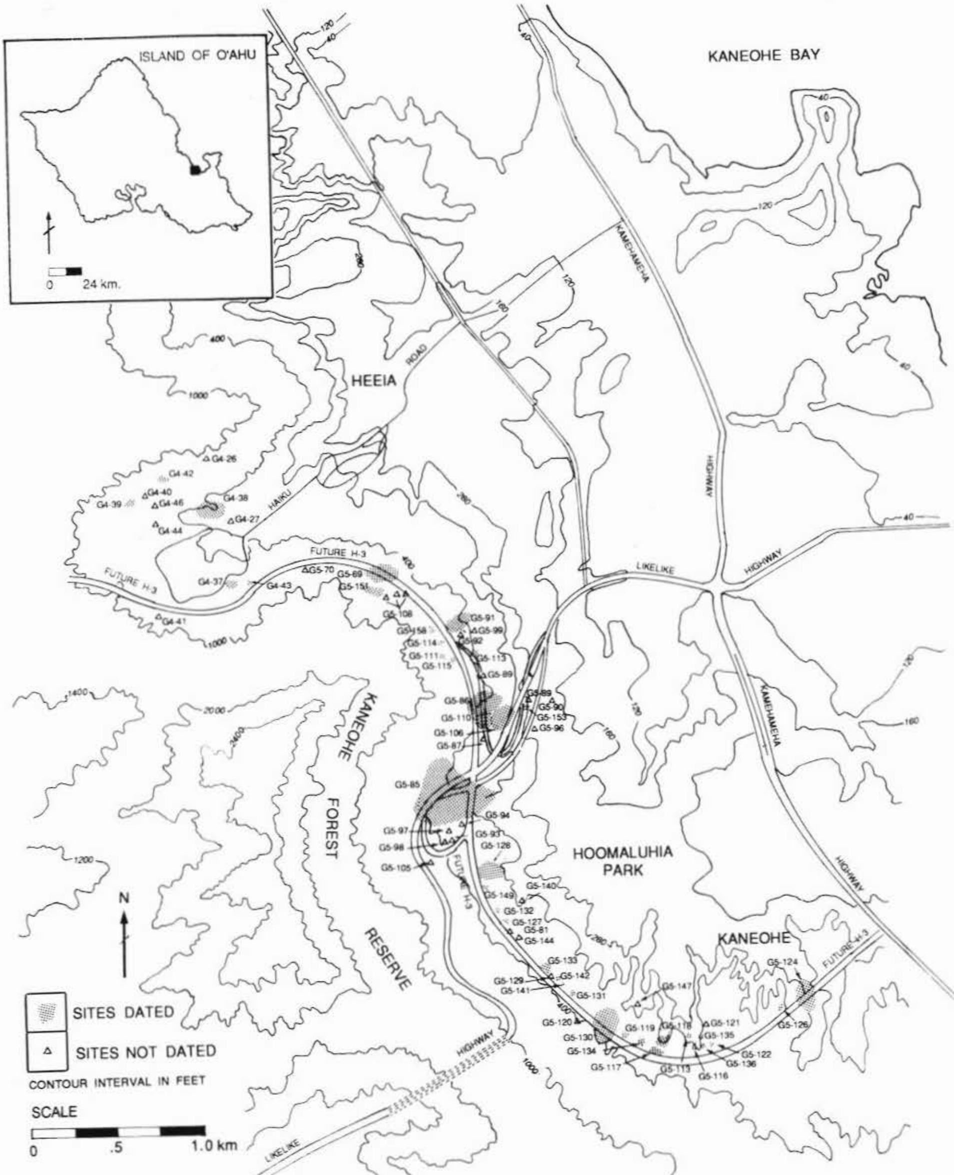

Figure 1: Map of the project area and site locations.

within the corridor, provided a component previous projects in the area lacked: both intensive and extensive subsurface testing, and excavations.

Several current models of the effects of geomorphological processes on the archaeological record of tropical high islands (Allen 1987; Spriggs 1991) predict that inland areas will generally be extensively eroded, by both pre-and post-Contact activities such as swidden agriculture and later grazing and farming. Much of inland Kāne'ohe was heavily grazed and farmed in historical times, and this would be expected to have destroyed whatever pre-Contact remains were present. Therefore, few archaeological sites other than pondfield terrace systems should be expected in steep areas of the inlands. Even fewer should be expected on ridge tops and sides, since these are the areas most affected by erosion.

This was the model that guided initial archaeological investigations along the highway, and this was the pattern seen during the surface survey. Twenty surface sites with 100 surface architectural features (primarily rock mounds, pondfield terraces, and alignments) were recorded along the Windward Highway corridor. Morphologically, only one feature, a rock platform with an associated grindstone, appeared to date to the pre-Contact period. By the time grading for road construction was complete, 17 subsurface sites with a total of 107 discrete features had been recorded. These were primarily earth ovens, hearths, and charcoal-stained occupation layers, but they also included buried pavements and terraces.

Evidence emerged that extensive archaeological deposits lay buried under accumulated sediments, even in steeply sloping areas of inland Kāne'ohe. Rather than being an area where deposits are being eroded away, it is primarily an area of deposition, with pre-Contact features buried anywhere from 10 to 150 cm below surface. Most importantly, such areas of deposition include not only the valley bottoms, where Allen (1987) found buried pondfield soils, but also ridge tops and sides. Accumulation of sediments, combined with post-Contact modification of architectural features by robbing them of rock and building new features, has effectively hidden the evidence of the substantial pre-Contact activities which took place on ridges and slopes of the inlands.

ARCHAEOLOGICAL DATA

Radiocarbon dates are seldom analysed as a discrete body of data by archaeologists. In the analysis presented here, the radiocarbon dates provide the data to generate frequency distributions through time, divorced for this purpose from the concept of "site". Obviously, the dates do not exist in a cultural vacuum or separate from the sites of which they are a part, but the analysis presented below is offered as one alternative way of looking at and interpreting the radiocarbon data.

Eighty-four radiocarbon dates from both surface and subsurface features in 34 sites were divided into five categories, based on presumed functional association. The 84 samples were selected from a wide range of feature types and provenances in order to minimise sampling biases. All but two of the samples were wood charcoal, and all were processed by Beta Analytic Inc., a commercial radiocarbon laboratory in the United States. Two dates were from unburnt *Aleurites moluccana (kukui)* nuts found in pondfield soils. Corrections for fractionation were made using ^{12}C and ^{13}C ratios, but plant species represented by the samples were not identified before dating. The five functional categories are:

1) *Habitation*, which includes charcoal from earth ovens, hearths, or occupation layers within formal domestic features such as platforms, pavements, or terraces (30 dates from 12 sites).

2) *Irrigated agriculture*, from charcoal flecking within pondfield soils (14 dates from 3 sites).

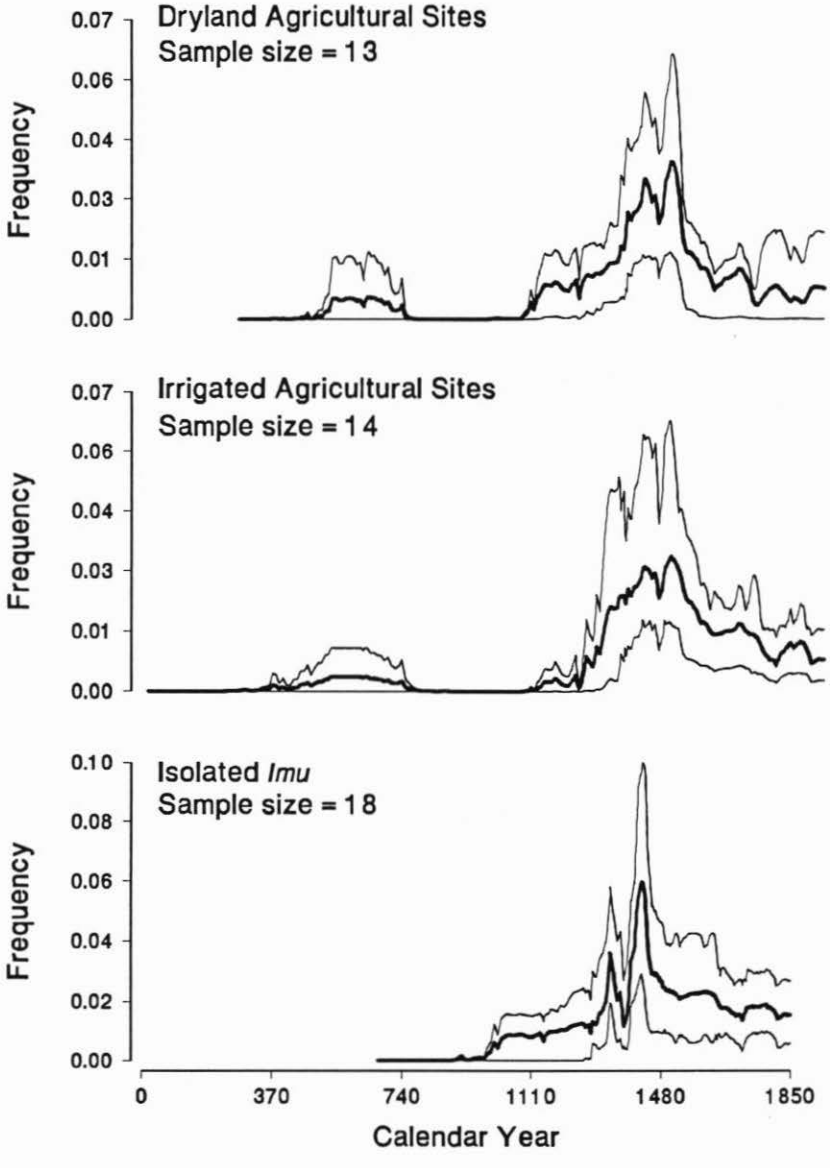

Figure 2: Annual frequency distributions for irrigated agriculture, dryland agriculture, and isolated oven samples.

3) *Non-irrigated agriculture*, from dryland agricultural features or charcoal dispersed within colluvial sediments (13 dates from 9 sites).

4) *Isolated cooking*, from earth ovens not directly associated with habitation sites (18 dates from 15 sites).

5) *Religious structure*, from features of probable religious function within the Kukuiokāne Complex, a large multi-function complex which includes an agricultural *heiau* (9 dates from one site).

RESULTS

Radiocarbon annual frequency distributions were produced for each category (Figs 2–3), using the technique described by Dye and Komori (this volume). These diagrams suggest three trends in the activities presumed to be represented by the radiocarbon data. Note that it is assumed the relative intensity of certain prehistoric activities can be correlated with the amount of charcoal produced by those activities, at least in a relative way. Charcoal, as an artefact of human activities, occurs in patterned ways and in contexts that allow the activities that produced those patterns and contexts to be inferred. Obviously, such relationships are not always direct, and factors such as secondary deposition, later disturbances, and the problem of inbuilt age can influence the results.

The first two factors can be minimised by careful selection of samples in the field, but the problem of inbuilt age and the time-widths of samples are more difficult to control. Species identification of charcoal samples is a relatively new procedure in Hawai'i, and little is known of the lifespan of many of the native woody species; *koa (Acacia koa)*, for example, may live to be several hundred years old. None of the samples reported here were identified to genus or species before being dated, so they certainly could be affected if they represent long-lived species.

The three trends suggested by the annual frequency distributions are as follows.

1) Increased use of the area for agriculture and cooking at isolated earth ovens began around A.D. 1000. There are radiocarbon data for agricultural activity as early as A.D. 300, and habitation by A.D. 700, but these should be treated with caution until more data are found to fill in the gaps, and because of the potential problem of inbuilt age.

2) The increases in agricultural and isolated cooking activities were followed 150 to 200 years later (around A.D. 1200) by the establishment of habitation sites.

3) Evidence of charcoal produced by agricultural and isolated cooking activities declines steadily after A.D. 1450, but evidence of charcoal produced by habitation activities continues to grow throughout this period.

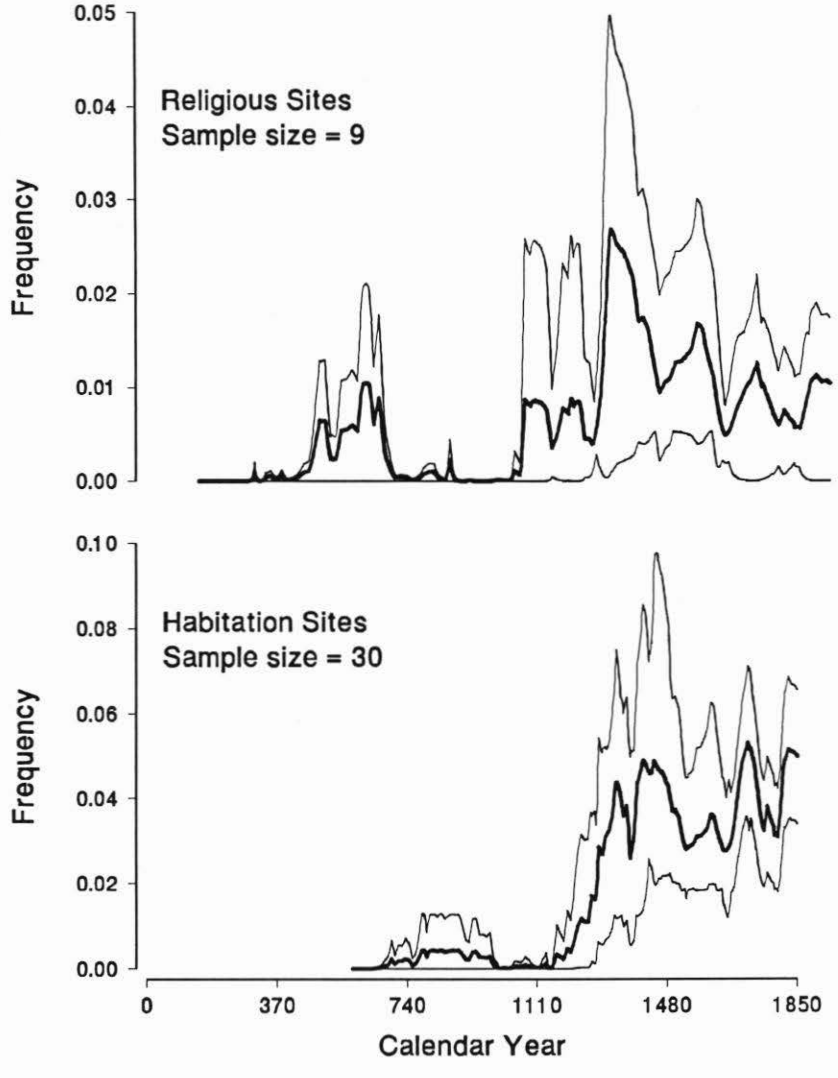

Figure 3: Annual frequency distributions for habitation and religious structure samples.

DISCUSSION

This analysis of the radiocarbon data suggests that exploitation of inland Kāne'ohe began early in the Hawaiian cultural sequence, possibly even as early as what Kirch (1985) has termed the Colonization Period (A.D. 300–600), although the data supporting this proposition are not particularly convincing. Certainly, however, by the start of what Kirch refers to as the Expansion Period (A.D. 1100–1650), the inlands were being used for a variety of activities.

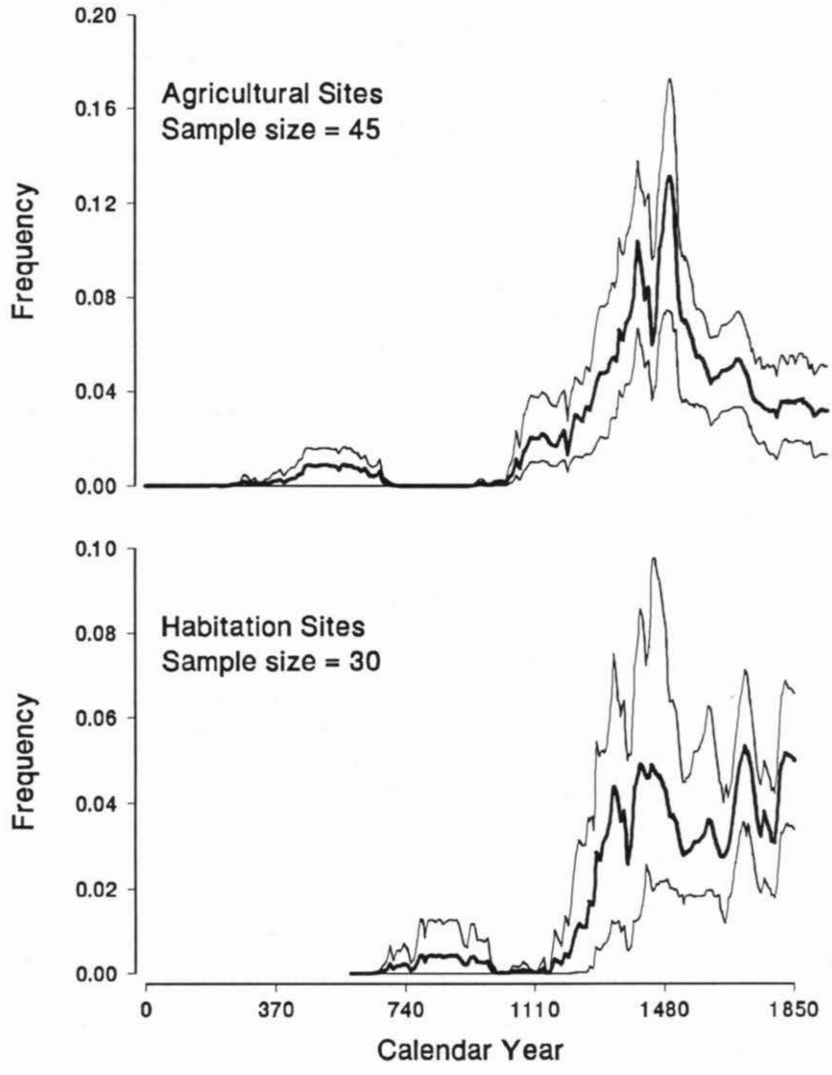

Figure 4: Annual frequency distributions for radiocarbon dates from agricultural and habitation sites.

The 150 to 200 year lag between the start of rapidly increasing frequencies in the agricultural and habitation data is especially interesting, and suggests a diachronic settlement pattern (Fig. 4). When the inlands were first cultivated, people were living closer to the coast and walking to the inland gardens. The presence at this time of isolated ovens suggests that cultivators stayed long enough to cook and eat a substantial meal or to process local resources. Later, people began living in the area permanently, probably as population grew and agriculture was both expanded and intensified to meet increasing local and supra-local demands.

Various hypotheses can be offered to explain the differing shapes of the distribution diagrams. Although production of charcoal in agricultural activities appears to decline after peaking around A.D. 1450, it seems unlikely that agricultural activities actually decreased during this period. Other factors must be responsible for the decline seen in the diagrams. One probable cause is that once slopes had been initially cleared of forest cover, charcoal production would decrease because of the decrease in biomass present on grass- or shrub-covered slopes compared to forest-covered slopes. Although erosion certainly occurred, the survey data suggest that more material was deposited than was generally transported away, burying archaeological deposits even on the tops and sides of ridges. Therefore, the decline in the diagrams is probably not the result of erosion washing away later deposits. This suggests that Hawaiian agricultural practices may have been more effective in preventing soil erosion than current models give them credit for.

Post-Contact land-use is also a possible cause of the apparent decline in production of agricultural-related charcoal, because of its potential to disturb deposits. Much of inland Kāne'ohe was heavily grazed, farmed, or under pineapple cultivation, and these activities could have disturbed upper deposits to such an extent that they are no longer visible in the archaeological record. This is almost certainly the reason for the decline seen in the diagram for the data from Kukuiokāne *heiau*, since Kukuiokāne was badly disturbed during the twentieth century, particularly by pineapple cultivation. Certainly, religious activity was not decreasing during the latter portion of prehistory, as this was the time the ruling elite solidified their power through the *kapu* system.

The apparent decline in use of the isolated cooking ovens after A.D. 1500 is potentially the most interesting pattern in the radiocarbon data. Isolated cooking features, represented primarily by earth ovens often dug to a metre below surface, are by the nature of their construction protected from later surface disturbances, so the decline must be due to cultural factors. Because these ovens are not associated with habitation features, I interpret them as representing primarily garden ovens, although some probably represent ovens used for processing forest products (such as *imu kī*) or specialised oven features for various ritual sacrifices (cf. Kamakau 1976; Malo 1951). The decline in the use of isolated cooking features coincides with the establishment and spread of habitations, which suggests that when permanent house sites were constructed in the inlands, garden ovens were no longer necessary since cooking activities could then take place in habitation areas or, if the features represent ovens for processing forest products, then they were no longer used as the forests disappeared under expanding agriculture and habitation.

CONCLUSIONS

Through a combination of natural and culturally induced sediment deposition and land alteration, many sites in inland Kāne'ohe became buried and/or surface features were destroyed. Surface survey alone presents a view of inland use that is severely biased towards the last 200 years. The combination of extensive subsurface testing and radiocarbon dating extends our view back over a thousand years of changing settlement patterns. Rather than marginal areas used only for temporary exploitation of inland resources or for irrigated field systems, even steep parts of inland Kāne'ohe were areas of relatively early and rapid growth, with permanent habitation, extensive irrigated field systems, and large religious structures all in place by the fourteenth century.

The analysis of ^{14}C dates provides data to create one possible model of the growth of these activities in relation to each other. On the basis of this preliminary analysis of the data, I suggest the following as a model for inland Kāne'ohe, which can be refined when the full range of data from stratigraphy, artefact analysis, and charcoal species identification becomes available. First, low levels of agriculture beginning at an as yet unknown date were followed by agricultural expansion beginning around A.D. 1000. This was followed 150 to 200 years later by the rise of permanent house sites, which in turn was followed by the development of Kukuiokāne *heiau* nearly 100 years later. This large religious structure suggests increasing political organisation and social control.

On the basis of the present data, the process of inland settlement began nearly 400 years earlier in Kāne'ohe than in the leeward area studied by Hommon (1976, 1986). This supports and greatly expands upon Allen's (1987) findings in the Kāne'ohe Interchange portion of H-3, and provides chronometric data which support hypotheses Hommon originally proposed in 1986 (Hommon 1986). Inland Kāne'ohe had already experienced rapid growth in a variety of activities, and that growth had peaked and stabilised by the time rapid growth began in leeward areas. This has some implications for the development of the *ahupua'a* system and the rise of social complexity (Hommon 1986; Allen 1987, 1990). It suggests that the basis for these events may have been laid earlier in Hawaiian history than is generally supposed and implies that the development of political complexity was not necessarily a rapid process confined to the latter part of Hawaiian history, but may instead have had long antecedents, at least in certain areas.

This pattern of extensive subsurface deposits is now being seen all along the Interstate H-3 corridor on the windward side of O'ahu, and preliminary evidence suggests it will be true for the leeward portion in North Hālawa Valley as well. It is also being seen in Maunawili Valley, adjacent to Kāne'ohe on windward O'ahu. These extensive archaeological deposits buried in inland areas hold the potential to increase considerably our knowledge of the early exploitation of these areas and the development of social complexity in the Hawaiian Islands. Long thought by archaeologists to be marginal areas, because of the paucity of surface remains and the presumed highly eroded nature of the topography, at least some of these areas are not eroded but contain primary archaeological deposits spanning at least 1000 years, and perhaps more. Although highway construction is a rather specialised case, because of its potential to strip large areas of land, and the bulldozing of dozens of acres of land is not recommended as a site location technique, large projects such as these can be used to formulate predictive models of site location and to develop diachronic settlement patterns.

ACKNOWLEDGEMENTS

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APPENDIX 1
RADIOCARBON DATES

Note: ¶ = AMS date, no $\delta^{13}C$ value given

BPBM #	Lab #	Site Number	CRA	SD	$\delta^{13}C$
DRYLAND AGRICULTURE					
HRC-0719	BETA-12561	50-80-10-1887	640	80	-26.26
HRC-0743	BETA-13476	50-80-10-1888	880	90	-25.78
HRC-1034	BETA-28927	50-80-10-1887	330	50	-27.8
HRC-1085	BETA-30509	50-80-10-2078	650	100	-24.9
HRC-1090	BETA-30514	50-80-10-1903	700	100	-30.1
HRC-1092	BETA-30516	50-80-10-1893	50	70	-28.4
HRC-1180	BETA-33377	50-80-10-2038	1530	60	-27.6
HRC-1184	BETA-33678	50-80-10-1888	490	80	-31.4

HRC-1185	BETA-33679	50-80-10-1888	160	60	-27.9
HRC-1186	BETA-33680	50-80-10-1888	880	70	-26.8
HRC-1187	BETA-33599	50-80-10-1888	390	70	-30.3
HRC-1212	BETA-34011	50-80-10-2208	530	60	-27.0
HRC-1222	BETA-34021	50-80-10-2158	530	70	-27.4
HABITATION					
HRC-1078	BETA-30502	50-80-10-2076	330	60	-26.9
HRC-1079	BETA-30503	50-80-10-2076	290	60	-28.0
HRC-1086	BETA-30510	50-80-10-2078	110	50	-26.6
HRC-1089	BETA-30513	50-80-10-2086	70	70	-26.2
HRC-1093	BETA-30517	50-80-10-2092	370	60	-27.9
HRC-1133	BETA-32305	50-80-10-2160	550	70	-27.7
HRC-1134	BETA-32306	50-80-10-2160	210	50	-27.3
HRC-1135	BETA-32307	50-80-10-2162	550	80	-28.6
HRC-1138	BETA-32310	50-80-10-2164	50	80	-25.8
HRC-1176	BETA-33373	50-80-10-2076	410	50	-27.6
HRC-1177	BETA-33374	50-80-10-2038	150	60	-29.0
HRC-1178	BETA-33375	50-80-10-2038	110	60	-27.0
HRC-1179	BETA-33376	50-80-10-2038	600	70	-17.7
HRC-1181	BETA-33675	50-80-10-2076	80	50	-26.2
HRC-1210	BETA-34009	50-80-10-2004	1180	60	-26.7
HRC-1215	BETA-34014	50-80-10-2157	640	80	-26.7
HRC-1220	BETA-34019	50-80-10-2204	120	50	-26.1
HRC-1224	BETA-34023	50-80-10-2157	570	70	-26.8
HRC-1225	BETA-34024	50-80-10-2201	130	60	-27.2
HRC-1226	BETA-34025	50-80-10-2201	160	70	-23.5
HRC-1227	BETA-34026	50-80-10-2201	220	60	-26.6
HRC-1236	BETA-34801	50-80-10-2204	110	60	-26.3
HRC-1238	BETA-35351	50-80-10-2204	520	50	-27.3
HRC-1256	BETA-36452	50-80-10-2204	400	60	-21.1
HRC-1257	BETA-36453	50-80-10-2204	770	60	-24.2
HRC-1274	BETA-37007	50-80-10-2204	300	50	-26.1
HRC-1300	BETA-37646	50-80-10-2204	140	50	-26.3
HRC-1301	BETA-37647	50-80-10-2204	60	50	-25.7
HRC-1302	BETA-37648	50-80-10-2204	270	50	-27.4
HRC-1303	BETA-37649	50-80-10-2204	370	60	-27.5
IRRIGATED AGRICULTURE					
HRC-0717	BETA-12559	50-80-10-1887	590	110	-26.56
HRC-0718	BETA-12560	50-80-10-1887	620	70	-12.1
HRC-0720	BETA-12562	50-80-10-1887	540	60	-32.59
HRC-0721	BETA-12563	50-80-10-1887	780	90	-17.14
HRC-0744	BETA-13477	50-80-10-1887	1560	100	-25.92
HRC-0745	BETA-13478	50-80-10-1887	430	100	-26.29
HRC-0746	BETA-13479	50-80-10-1887	610	90	-26.36
HRC-0893	I-14558	50-80-10-1887	310	140	-24.2
HRC-0913	BETA-16267	50-80-10-1887	190	80	¶
HRC-1025	BETA-28498	50-80-10-2042	410	60	¶
HRC-1080	BETA-30504	50-80-10-2077	250	60	-25.8

HRC-1081	BETA-30505	50-80-10-2077	400	120	-25.2
HRC-1084	BETA-30508	50-80-10-2077	130	60	-25.5
HRC-1237	BETA-35350	50-80-10-2202	790	50	-26.9
ISOLATED IMU					
HRC-1087	BETA-30511	50-80-10-2081	90	70	-26.8
HRC-1088	BETA-30512	50-80-10-2081	190	50	-28.0
HRC-1111	BETA-31875	50-80-10-2076	100	40	-27.8
HRC-1112	BETA-31876	50-80-10-2077	320	50	-27.7
HRC-1113	BETA-31877	50-80-10-2085	490	50	-26.5
HRC-1114	BETA-31878	50-80-10-2086	160	50	-27.8
HRC-1115	BETA-31879	50-80-10-2156	200	50	-27.1
HRC-1137	BETA-32309	50-80-10-2163	330	50	-26.6
HRC-1139	BETA-32311	50-80-10-2165	560	50	-27.9
HRC-1140	BETA-32312	50-80-10-2165	400	60	-25.3
HRC-1211	BETA-34010	50-80-10-2159	390	140	-28.7
HRC-1213	BETA-34012	50-80-10-2209	940	80	-27.5
HRC-1214	BETA-34013	50-80-10-2210	460	70	-28.0
HRC-1216	BETA-34015	50-80-10-2200	280	50	-27.1
HRC-1217	BETA-34016	50-80-10-2207	890	80	-27.7
HRC-1218	BETA-34017	50-80-10-2205	610	50	-26.9
HRC-1221	BETA-34020	50-80-10-2165	770	70	-28.6
HRC-1228	BETA-34027	50-80-10-2206	490	50	-27.1
RELIGION					
HRC-1026	BETA-28497	50-80-10-2038	410	50	-26.2
HRC-1027	BETA-28500	50-80-10-2038	1050	50	-29.4
HRC-1028	BETA-28501	50-80-10-2038	630	50	-29.0
HRC-1029	BETA-28502	50-80-10-2038	420	50	-26.7
HRC-1030	BETA-28503	50-80-10-2038	350	70	-26.8
HRC-1110	BETA-31874	50-80-10-2038	130	60	-26.7
HRC-1157	BETA-32391	50-80-10-2038	160	50	-28.3
HRC-1158	BETA-32392	50-80-10-2038	10	60	-25.7
HRC-1182	BETA-33676	50-80-10-2076	310	50	?