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The Scale, Nature, and Timing of Agricultural Adaptations in Upland Kaʻū

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Abstract

Substantial changes in political and land organization occurred in Hawaiʻi in the last 200 years before European arrival. These changes are thought to have affected land access and management, with areas nearer centres of power being more heavily influenced. Less is known about the effects of these changes on outlying areas and those areas with substantial environmental diversity. We investigate this scenario here by examining remnants of the Kaʻū Field System located in the Kahuku Unit of Hawaiʻi Volcanoes National Park. We find evidence for local-scale agricultural management and the persistent use of houses through time. We also identify evidence of continued access to forest resources, even after formal agricultural infrastructure replaced a low-intensity agroforestry system. Our results speak to a high degree of autonomy in this section of the Kaʻū Field System, which contrasts with some parts of the Kona Field System and the centre of the Leeward Kohala Field System.

Keywords: Agriculture; land tenure; land management; agroecosystems; Hawaiʻi

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1. Introduction

Expansive agricultural landscapes were constructed across the Hawaiian archipelago. These landscapes and the techniques used therein broadly mapped onto a set of environmental characteristics, including slope, precipitation, geological substrate age, proximity to streams, and temperature (Ladefoged *et al.* 2009). It is well established that rainfed systems were associated with the gentle slopes of the leeward districts on the southern, younger islands of the archipelago, whereas wetland techniques were more frequent on the older, more dissected northern islands (Kirch 1984, 1994).

Variation within these broad categories is frequently recognized at finer spatial scales (see Allen 2004; Peck 2024; Tomonari-Tuggle 2006; Tuggle and Tomonari-Tuggle 1980), but the social implications of adaptation at these finer scales have only recently become the subject of interest. Analysis at these finer spatial scales can provide important information that cannot be gleaned from research at larger scales. It is at these finer spatial scales that the effects of practical management are most visible, and the scale of variation may be correlated with the scale of management or decision-making (Ladefoged *et al.* 2020). These finer spatial scales are also useful in elucidating how communities perceived their environments, especially the opportunities and constraints that organized the temporal relationships between techniques and strategies (see Allen 2004; Quintus *et al.* 2023).

The Kaʻū District on Hawaiʻi Island provides a useful case study to understand these finer scales of agricultural adaptation. The district is known for its environmental diversity, which may have given rise to significant agricultural diversity in the past. This is certainly the sense one gets from reading ethnographic descriptions of agricultural practices in the district (Handy *et al.* 1972). However, archaeological research on the district's past agricultural systems has been limited, especially relative to the better documented systems of Kohala and Kona. Here, we seek to address this deficiency and expand upon previously reported data and interpretations (Quintus and Lincoln 2020). To do so, we include additional morphological, spatial, and temporal data on agricultural infrastructure in the Kahuku Unit of Hawaiʻi Volcanoes National Park (HVNP). This case study in the uplands of Kaʻū provides an important spatial contrast and comparison with prior work in Kohala and Kona. The uplands of Kaʻū occupy a position outside the political centre of Hawaiian polities, which provides an opportunity to assess how distance from political centres affects the manifestation of resource management.

2. Land Tenure and Land Organization in Precontact Hawaiʻi

The basic unit of social organization across much of Polynesia was the house (Kirch and Green 2001). The house was a corporate land and material holding entity constituted by real or fictive kin. Decisions about land allocation and management were made at this level, though tribute demands were made by higher political tiers. Presumably, it was this form of social organization and land tenure that was introduced across Polynesia as communities established settlements.

Much attention has been placed on changes that occurred in Hawaiʻi that deviated from this introduced pattern. There, a breakdown of the widespread pattern of kinship land holdings is argued to have occurred at some point in the last few hundred years, with the absolute control of land falling to the paramount chief or king (Kirch 2010; Sahlins 1992). This structure of land organization and tenure is described at length ethnohistorically and ethnographically (e.g., Malo 1951), with few references to the corporate descent groups (see e.g., Sahlins 1992). Control of land is thought to have been a key driver of increased inequality and hierarchy as chiefs used the allocation of land to maintain loyalty (Jennings and Earle 2016). Chiefs, when coming to power, had the right to dispossess and reallocate land. This system is thought to have been legitimized by, among other things, the ritual role of chiefs and their relationship to the supernatural. This gave leaders authority to make demands of their adjacent lands as well as of outlying lands as they traveled (Hommon 2020).

This latter element of Hawaiian land organization is not unique in Polynesia. Indeed, across much of the region, chiefs and other leaders held theoretical control over land because they were ritually tied to the fertility of that land (Goldman 1970:509-514), and those leaders had the right to extract resources. Theoretical control of land is distinct from practical management of that land. This was noted by Hommon (2020:22-23), who argued that farmers had agency in a double-title system to modify the landscape and enhance production.

Institutionalized positions akin to land managers or decision makers are documented historically in the form of haku ʻāina and konohiki, with the former seemingly allocating land within families and the latter in charge, at times, of controlling the flow of produce and labor (Handy *et al.* 1972:53, 288, 321-322). Research in Kohala suggests that political influence on agricultural practices was spatially varied, with areas closer to ritual centres of authority affected more than outlying areas (Ladefoged *et al.* 2020). Indeed, viewsheds of temples have been argued to highlight growing authority over these lands (Phillips *et al.* 2015), with fewer and different kinds of ritual structures argued for less productive outlying areas (Hommon 2020:23-25). That cooperation was needed between social units is highlighted by the extension of some agricultural infrastructure across traditional boundaries, a situation that may have been aided by increased political control (Allen 2004:215, 217). Other strategies in Kona were truncated by political boundaries, implying political constraints on production decisions (Lincoln and Ladefoged 2014), though not outright management.

While some role for political interest and influence is clear in Hawaiian agricultural change, especially the demand for tribute, Dye (2021) recently argued that most practical management decisions were made by a persistent corporate descent group that has been largely ignored in archaeological research. To Dye, corporate ascent groups held long-term control of parcels of land termed ʻili ʻāina, which were transmitted between generations of that group. This view is consistent with ethnographic accounts that suggest long-term land tenure by nonleaders (Handy *et al.* 1972), even while leaders continued to have a right to dispossess those individuals. In this model, the haku ʻāina was a senior member of the corporate group who performed functions similar to senior members in descent groups across Polynesia. The konohiki, on the other hand, was not directly involved in everyday management. Rather, they were in charge of revenue generation while also commanding labor and resources for community and larger-scale projects driven by leaders.

The organization of agricultural land and the scale of decision-making have important implications for our understanding of social structure, more generally. Local-scale decision-making and long-term land tenure imply increased variation in agricultural practice with the use of more place-specific techniques. Secure land tenure also implies a more significant interest in infrastructure development, increasing the value of the land (Netting 1993). Local scales of control also correlate more strongly with agricultural strategies that seek to minimize yield variance and risks of subsistence shortfalls. More top-down, regional levels of management imply more homogenous or standardized styles of agricultural practice, a pattern that has been documented in the central areas of the leeward Kohala Field System (Ladefoged *et al.* 2020). Standardization highlights a lack of farmer autonomy, which may have limited innovation but increased the scale of production integration. This kind of integration can have important benefits for farmers, including enhanced access to goods in times of need (Allen 2004:218).

As highlighted by Ladefoged and colleagues (2020), the degree of practical influence on agricultural practices was likely spatially variable, with those areas closest to the centre of authority more subject to managerial influence. How common this influence was, and how far it extended across different parts of the polity, are less well understood. Furthermore, the temporal development of standardization or variation is not well established. The opportunity to evaluate these questions is offered by remnants of the Kaʻū Field System across three ahupuaʻa in the Kahuku Unit of HVNP.

3. The Kahuku Unit

The Kahuku Unit of HVNP is located in the Kaʻū District at the southern tip of Hawaiʻi Island, beginning at an elevation just over 600 meters (m) above sea level. Remnants of the agricultural infrastructure occur in at least two areas of the unit, in what the park refers to as Kaʻopapa Kīpuka (see Figures 1) and the pastures east of the park's administrative buildings (Figure 2). Kaʻopapa Kīpuka is a 10-hectare (ha) area defined by geological substrates that are roughly 2,000 years old, surrounded by lava flows that spread across the area in the late 1800s. The substrates of the eastern pasture are older, but still relatively young at around 5,000 years old. Agricultural infrastructure has been found covering at least 60 ha in this location. While these two project areas are located only 500 m apart, they are part of different ahupuaʻa. Kaʻopapa Kīpuka is located on the eastern edge of the large ahupuaʻa of Kahuku, while the eastern pastures form the northern upper elevation section of both Pākini Nui and Pākini Iki.

Partially due to their history as pasture land, both areas are covered today by thick kikuyu grass (*Cenchrus clandestinus*) along with stands of Christmas berry (*Schinus terebinthifolia*) and ʻōhiʻa lehua (*Metrosideros polymorpha*). The former two plants are introduced and invasive, while the latter tree is assumed to have had a larger distribution in the past. Other plants are dispersed across both areas in lower densities. Much of each area is characterized by gentle slopes, though significant microtopographic variation occurs. Small swales are common across Kaʻopapa, defined by areas of higher bedrock. A small escarpment runs across the kīpuka around its midpoint, separating the area in half. Larger swales dominate the eastern pasture. A volcanic cone is positioned on the southwestern side of the pasture, surrounded on three sides by relatively steep slopes. Gullies or ravines are also present near the southeastern boundary of the Kahuku Unit, as well as running up slope into Kahuku ahupuaʻa from the northern boundary of Pākini Iki.

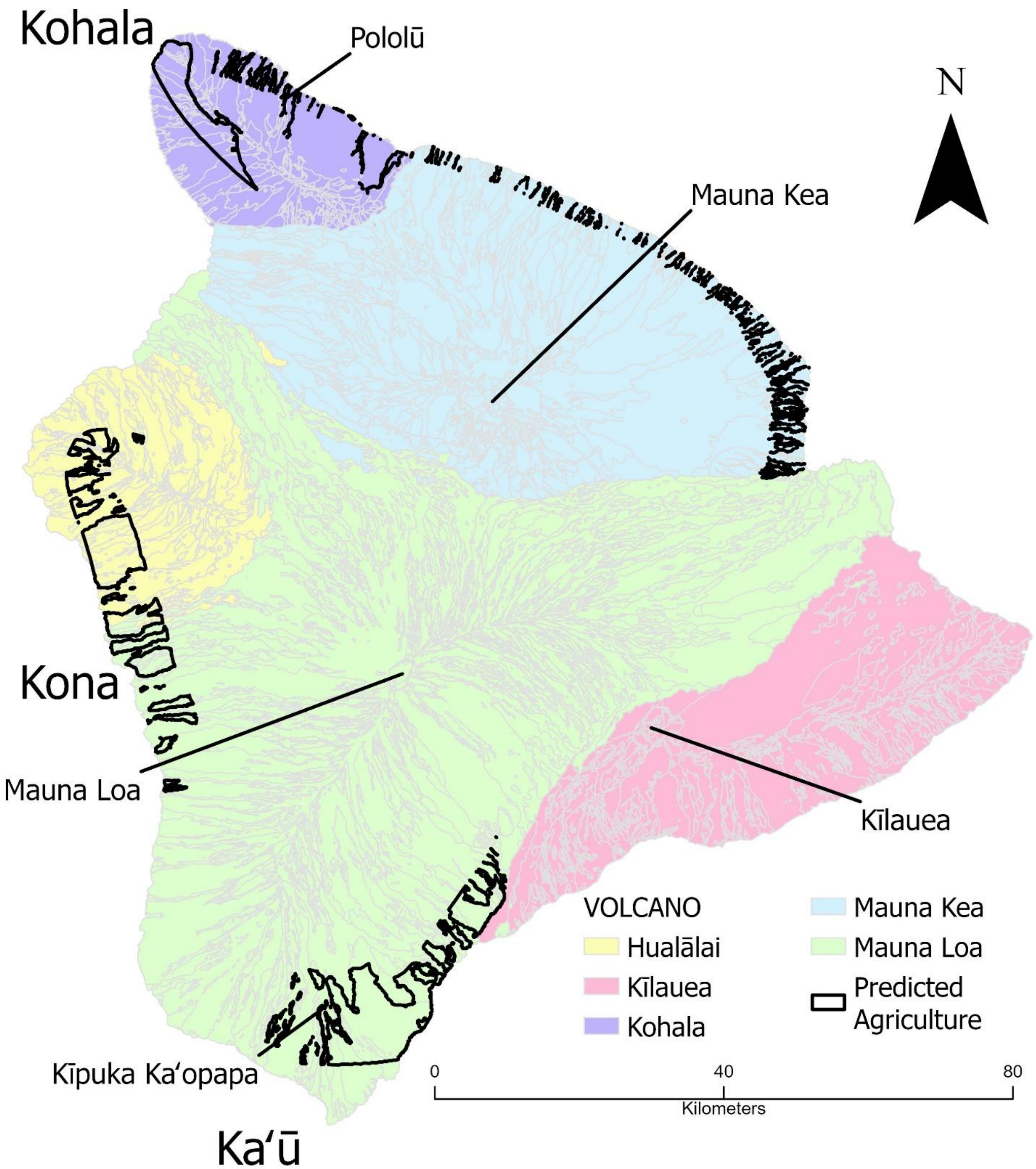


Figure 1: Kaʻopapa Kīpuka within the context of Hawaiʻi Island. Grey lines outline volcanic flows. Black lines outline predicted areas of intensive agriculture (wet and dry) as developed by Ladefoged *et al.* (2009).

Wind predominantly comes from east to west across the landscape. The project area, and much of the Kaʻū Field System, lies in an area of high wind speeds compared to areas to the east or west. However, wind speed increases with decreased elevation. Precipitation has an inverse pattern, with higher precipitation in higher elevations. The project area averages roughly 900-1000 millimeters (mm) of rain each year, though the kīpuka receives slightly less rain each year than the pasture (Giambelluca *et al.* 2013). Topographic variation modulated wind flow and water balance across the project area. Wetter environments, signified by denser vegetation, are found at the base of the volcanic cone and in the ravines. Swales likely also retained more moisture, given that they are less exposed to wind, though this is not well quantified.

4. Materials and Methods

Research in the Kahuku Unit of HVNP has been undertaken as part of four field schools run in partnership between the University of Hawaiʻi at Mānoa and the National Parks Service (NPS). During each field school, a combination of pedestrian survey and excavation were used to document the distribution of archaeological features and the nature of subsurface stratigraphy. A significant portion of surface architecture in Kaʻopapa was mapped by the Cultural Resource Management Division at HVNP prior to the start of the field schools. Our pedestrian surveys are built on these maps. No preexisting maps were available for the eastern pasture and dense grass cover prohibited traditional survey. In this case, feature mapping was accomplished by the examination of lidar-derived imagery along with targeted vegetation removal. When features were encountered, they were plotted on a GPS unit, photographed, measured, and described. A sample of these features was mapped using tape-and-compass, laser scanning, or a combination of the two methods. Spatial data derived from this survey were analyzed in ArcGIS Pro 3.6.1.

A sample of features was also excavated following feature identification. The methods of excavation were dependent on the interpreted function of the feature being excavated. For those features interpreted to have agronomic functions, including terracing and linear embankments (kuaiwi, mounded features of soil and stone that are longer than they are wide), excavation proceeded in 20-centimeter (cm) levels within natural layers. Twenty-five percent of the sediment from excavation was screened through 1/8” mesh until recovery of artifacts or faunal material, after which 100% of the sediment was screened. These features were dug to expose three faces within the feature itself, and the size of units varied depending on the size of the feature excavated. Excavation of all other features used 1 m^2 units dug in 10 cm levels within natural layers, with 100% of the sediment being screened through 1/8” mesh from the beginning of excavation. In each form of excavation, all artifacts and faunal material were collected, while a sample of nonmodified manuports (waterworn basalt cobbles) was also collected. In particular, methods of excavation in nonagricultural features were oriented toward the recovery of artifacts and other material that could provide information about the function of the feature. During all excavations, charcoal was collected from the screens. Charcoal was also collected and plotted *in situ* from contexts useful for dating stratigraphic contexts, particularly the construction of surface or buried architecture. Excavated units are described further in the online supplementary material. This includes images of excavation and a discussion of locations from which charcoal was sampled.

Charcoal was identified at the Wood Identification Laboratory at International Archaeological Research Institute, Inc. (IARII) by Darby Filimoehala and Carly Walker, under the supervision of Gail

Murakami. Freshly fractured transverse, tangential, and radial facets of charcoal specimens were identified using a dissecting microscope with magnifications up to 90X. These fragments were compared to reference collections housed at IARII. *Broussonetia papyrifera* charcoal can be difficult to discriminate from *Artocarpus altilis*. These identifications were placed under additional scrutiny during analysis. Specimens recorded as *Broussonetia papyrifera* most resemble that taxon and are interpreted as such here. All samples for radiocarbon dating were identified to the lowest taxonomic level to identify short-lived samples or Polynesian introductions, which were preferred when available. At times, such taxa were not available, and potentially longer-lived species were dated (see discussion below). Bulk samples, which were derived from screens, were identified for taxonomic redundancy.

Radiocarbon date determinations were measured on charcoal fragments at the Center for Applied Isotope Studies (CAIS) at the University of Georgia. These dates were calibrated using IntCal 20 (Reimer *et al.* 2020), and chronological models were produced in OxCal 4.4 (Ramsey 2009). The general model included a sequence for each excavated location. Sequences of infrastructure construction included at least two phases, one before (TPQ) and one after (TAQ) the construction of the infrastructure. The age of feature construction was estimated as a boundary between these phases. In stratified cultural deposits, each deposit was a separate phase with boundaries separating those phases. The full code and full descriptions of these models are provided in the online supplementary information.

5. The Spatial Distribution of Infrastructural Forms

Three basic forms of agricultural infrastructure are found in the project area: linear embankments (kuaiwi), mounds, and terraces. Scattered amongst this agricultural infrastructure are other feature forms, such as enclosures and platforms, used as houses or for other nonagricultural functions. The distribution of these features is best documented for Kaʻopapa Kīpuka. Feature documentation is spatially more sporadic in the eastern pastures.

The patterning of infrastructure in Kaʻopapa is briefly described in Quintus and Lincoln (2020). The system is structured by a combination of linear embankments running along and across the slope (Figure 2). Those kuaiwi that run parallel to the slope, which is perpendicular to the dominant wind, are the longest. These are spaced roughly 20-40 m apart, though their angles vary across the kīpuka. In the south, most of the dominant embankments are between 336-345 degrees, while in the north, they run from 350-358 degrees. Cross-slope embankments segment these areas, spaced roughly 10-50 m apart. These embankments are markedly larger on the downslope side of the kīpuka, where they are over a meter high, with those nearer the upslope boundary a meter or less high. Most embankments were constructed of large cobbles to small boulders of angular to subangular shape (Figure 3), though one embankment on the western side of the kīpuka was constructed of smaller cobbles. At least one of these embankments was constructed in multiple stages (Quintus and Lincoln 2020:59), evidenced by a charcoal lens in the middle of the feature that postdated the original construction of the feature. The lens was interpreted as a second burning event that occurred on top of the first two courses of stone, which characterized the original feature.

Figure 2. The distribution of notable features and kuaiwi across the kīpuka (left) and eastern pasture (right). Note that the gully is located near the southeastern boundary of the Kahuku unit.

The combination of these kuaiwi produced enclosed plots, which range in size from 200 m^2 to just over 1500 m^2, though a high density of Christmas berry makes identification of some features difficult. Within several of these plots are earthen and stone mounds (Figure 4). These mounds are variable in size and shape, but the majority are under 4 m in diameter. Similar to those found elsewhere, best documented in Kona (Allen 2004:209, 212; Major and Allen 2001:97), these mounds are hypothesized to have reduced evaporation, either by covering soils used for cropping or by protecting those crops from wind. Enclosures, platforms, and other habitation features are scattered amongst the agricultural infrastructure. Three features are of particular note. T4 is a rectangular enclosure on the western side of the kīpuka, T33 is an oval enclosure located on the downslope eastern side, and T25 is a terrace and enclosure complex located on the upslope eastern side. Artifacts were especially dense in T4 and T33, contrasting with agricultural features across the project area. A residential function is suggested for T33 and T25, while T4 is tentatively interpreted as a hale mua given the presence of pig, dog, chicken, other bird, and fish bone, as well as fishhook blanks, coral abraders, and a variety of lithic artifacts (see interpretation of hale mua in Ladefoged *et* *al.* 2020:16-17). Faunal remains were extremely rare in T33 and T25, as were artifacts other than volcanic glass.

Agricultural infrastructure in the eastern pasture is more variable. Still, the overall structure of much of the area is provided by linear embankments, kuaiwi, that run up and down the slope roughly 20-30 m apart. While the spatial distribution of these features is not as well attested as in the kīpuka, recorded examples are shorter, averaging less than half a meter and 2-3 courses high (see Figure 3). Initially, it was thought that this was caused by post-depositional changes, especially trampling by cattle, but excavation indicates that features were intact (Figure 3d). The kuaiwi that have been documented occur within and on the boundaries of natural swales in the landscape, similar to that described from Kahikinui on Maui (Kirch 2014). This is also the case for the volcanic cone, wherein three kuaiwi stretch from the cone cliffs out to the south. These microtopographies influenced the direction of the kuaiwi, with those in the northwest running 4-12 degrees and those in the volcanic cone running variable from 309 degrees to 347 degrees. Mounds, which are numerous across the kīpuka, have not been found in the eastern pasture. This does not mean they are absent, given the lack of systematic survey, but it does suggest they are not as dense or widespread in the eastern pasture. Additionally, documented cross-slope embankments are rarer than in the kīpuka, producing larger enclosed plots, apart from an area of higher slope leading down to a gully. Even in this location, the cross-slope infrastructure may have been meant to terrace rather than merely mark. In this sense, this infrastructure may have captured sediments moving downslope (see Allen 2004 for discussion of similar terraces in Kona). Only one habitation enclosure has been documented so far in the western half of the pasture (Figure 5), located on a high point in the landscape overlooking swales in which kuaiwi were built. This enclosure is small, with an internal space roughly 3 m across, and well-constructed.

Terraces are found at a higher frequency in the pasture owing to the presence of gullies on the eastern side of the survey area (Figure 6), with features concentrated on the slopes leading down to the gully bottoms. This infrastructure is reminiscent of that found in colluvial slope environments across windward valleys throughout the archipelago (Kirch 1977; Kurashima and Kirch 2012; Morrison *et al.* 2022). We hypothesize that it functioned similar to dryland infrastructure in Pololū Valley (Tuggle and Tomonari-Tuggle 1980), wherein infrastructure captured sediment and moisture moving downslope, slowing it down and allowing better infiltration. In addition to terracing in this area, planting rings or pits were found as well as potential stone-lined trails that may also have facilitated drainage (Figure 7). Two larger habitation enclosure complexes are situated on either side of the gully, which possess more formal and larger retaining walls relative to the agricultural infrastructure. This gully system is a small component of the general field system, but one that utilizes the unique topography and hydrology of this area.

Figure. 3: The internal structure of kuaiwi across the Kahuku unit. This includes: A) the completed XU-39 in T4, B) the completed XU-47 in T34, C) the completed XU-3 in EP2, and D) the top of XU-5 in EP4.

Figure 4: Circular mounds in the kīpuka bounded by kuaiwi. The kuaiwi in the image is the southern section of T1, and the picture is taken looking toward the southwest.

Figure 5: The surface of EP1 after vegetation was cleared. This feature is the only residential enclosure so far documented in the western half of the eastern pasture.

Figure 6: Examples of infrastructure in the gully system. A) is a circular planting pit bounded by 1-2 courses of stone, B) is a small terrace, and C) is a larger terrace. In all cases, infrastructure is roughly stacked and relatively expedient.

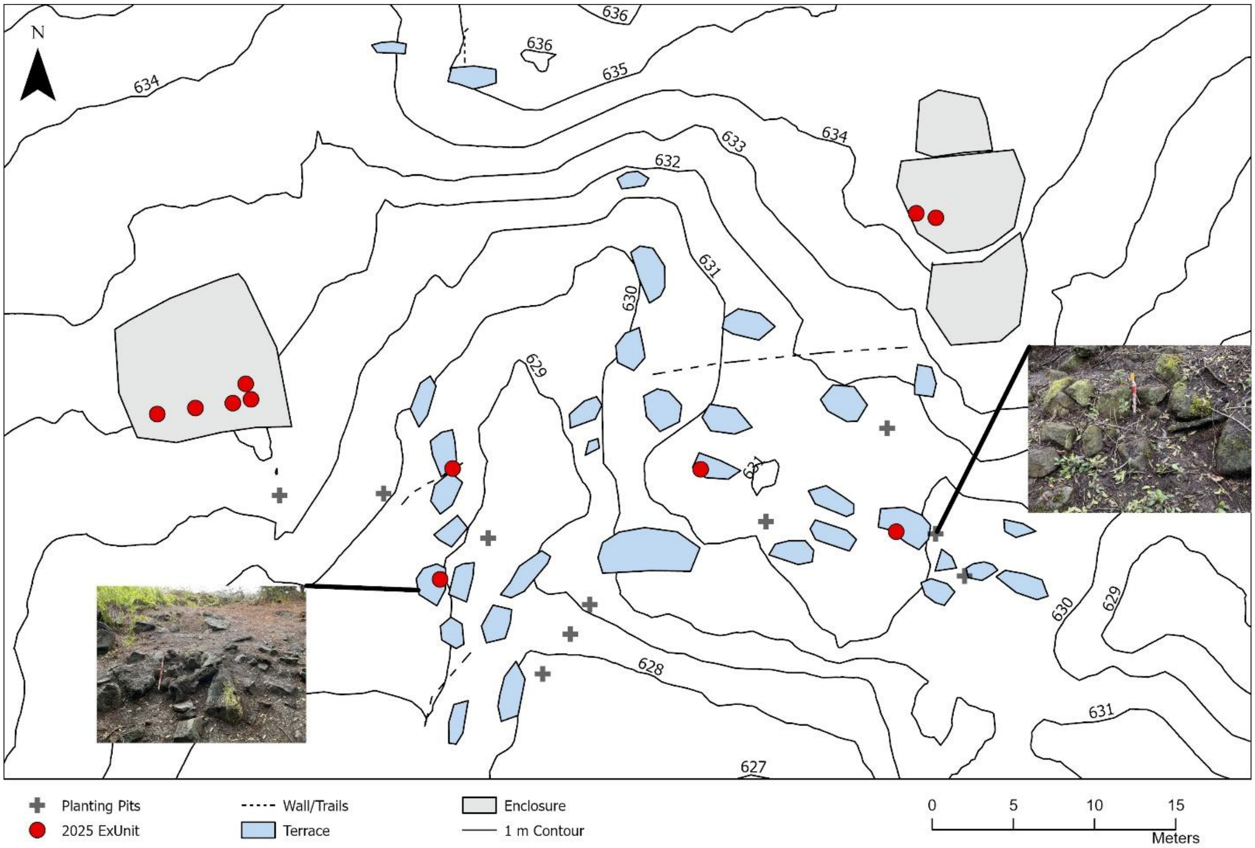


Figure 7: The distribution of archaeological features in the gully. Note the position of two enclosure complexes, one on each side of the gully, interpreted as houses.

6. The Temporal Development of Infrastructure

Forty radiocarbon dates (Table 1) are available from Kahuku stemming from a series of excavations undertaken by NPS staff (n = 6) and University of Hawaiʻi at Mānoa (UHM) field schools (n = 34). These dates include 27 from the kīpuka and 13 from the pasture (see Table 1). Of these dates, 13 are from T4 and eight are from other habitation contexts (T33, T35, EP1, EP6, and EP13). The rest are from stratigraphic contexts that allow estimation of the initial construction of agricultural infrastructure. Increased attention is placed on those dates from UHM field schools, as samples from these field schools were consistently acquired with explicit contextual information. However, mention is made of additional dates when context is clear.

These dates were used to estimate the chronology of events using Bayesian models, with events being either the construction of infrastructure or the deposition of a stratigraphic layers. In most cases, these models were simple, often including a single radiocarbon determination that was found stratigraphically inferior (*terminus post quem*, TPQ) to the infrastructure of interest. More complex models were built for contexts that included multiple determinations. All events of interest were

Table 1. Radiocarbon dates from the Kahuku Unit related to the Kaʻū Field System.

NPS BETA NUMBER	UNIT	FEATURE	FEATURE TYPE	DEPTH (CMBD)	MATERIAL	CRA	δ13C	CALIBRATED AGE (95.4%)	COMMENT
370509	TU-1	T4	Enclosure	61-71	cf. *Pteridophyta* sp.*	Modern	-10		Context unclear; not included in model
370510	TU-1	T4	Enclosure	84-94	cf. *Pittosporum* sp.*	10±30	-25.8	AD 1695-1725 (29.2%), 1811-1854 (29.6%), 1876-1917 (36.7%)	Context unclear; not included in model
370511	TU-1	T4	Enclosure	94-104	cf. *Euphorbia* sp.*	40±30	-9.5	AD 1694-1725 (27.8%), 1811-1917 (67.6%)	Context unclear; not included in model
370512	TU-3	T3	Linear Embankment	61-71	cf. *Euphorbia* sp.*	210±30	-10.5	AD 1642-1690 (30.8%), 1728-1809 (53.6%), 1923- (11.1%)	
370513	TU-4	Rock mound	Rock mound	55-66	cf. *Pittosporum* sp.*	340±30	-22.8	AD 1474-1638	
370514	TU-4	Rock mound	Rock mound	76-86	*Chenopodium* oahuense*	220±30	-25	AD 1639-1687 (37.3%), 1731-1807 (50.2%), 1926- (7.0%)	
BETA NUMBER									
471144	TP 6	T2	Linear Embankment	114	*Nothocestrum* sp.*	340 ± 30	-22.2	AD 1474-1638	Quintus and Lincoln (2020)
471145	TP 13	T6	Linear Embankment	42	*Wikstroemia* sp.*	370 ± 30	-25.9	AD 1450-1528 (52.3%), 1551-1634 (43.1%)	Quintus and Lincoln (2020)
471146	TP 12	T15	Linear Embankment	82	*Pittosporum* sp.*	330 ± 30	-28.2	AD 1480-1640	Quintus and Lincoln (2020)
471147	TP 11	T1	Linear Embankment	55	*Euphorbi*a sp.*	370 ± 30	-10.6	AD 1450-1528 (52.3%), 1551-1634 (43.1%)	Quintus and Lincoln (2020)
471148	TP 12	T15	Linear Embankment	63	*Myoporum sandwicense*	350 ± 30	-26.3	AD 1461-1530 (39.7%), AD 1539-1636 (55.7%)	Quintus and Lincoln (2020)
471151	TP 14	T25	Modified Outcrop	29	*Psychotria* sp.*	320 ± 30	-25.4	AD 1484-1644	Quintus and Lincoln (2020)
471149	TP 10	T20	Linear Embankment	121	Indeterminate Hardwood (twig)*	190 ± 30	-25.4	AD 1649-1695 (22.2%), AD 1725-1813 (53%), 1839-1878 (3.7%), AD 1918- (16.6%)	Quintus and Lincoln (2020)
471150	TP 7	T 33	Enclosure	31	*Myoporum sandwicense*	100 ± 30	-27.3	AD 1683-1735 (26.1%), AD 1803-1930 (69.3%)	Quintus and Lincoln (2020)
UGAMS NUMBER									
65616	XU 20	T4	Enclosure wall	124	*Euphorbia* sp.*	210±20	-9.74	AD 1648-1684 (32.8), 1736-1803 (57.4), 1936- (5.3)	Presumed intrusive; not included in model
65613	XU20	T4	Enclosure wall	108	*Wikstroemia* sp.*	360±20	-25.52	AD 1469-1525 (48.5), 1559-1632 (46.9)	
65612	XU20	T4	Enclosure wall	73	Possible bark*	180±20	-25.71	AD 1661-1693 (19.5), 1726-1810 (56.6), 1919- (19.3)	
65615	XU33	T9	Linear Embankment	84	*Wikstroemia* sp.*	370±20	-25.07	AD 1455-1524 (57.9%), 1572-1630 (37.6%)	
65614	XU30	T35	Enclosure wall	103	*Euphorbia* sp.*	350±20	-10.67	AD 1470-1529 (39.8%), 1545-1635 (55.7%)	
66205	XU20	T4	Enclosure	98	*Wikstroemia* sp.*	350±20	-26.75	AD 1470-1529 (39.8%), 1545-1635 (55.7%)	
66206	XU23	T33	Enclosure	43	*Wikstroemia* sp.*	320±20	-25.06	AD 1496-1602 (76.2%), 1612-1642 (19.2%)	
66207	XU29	T4	Enclosure	88	*Myoporum sandwicense*	270±20	-27.17	AD 1523-1572 (30.8%), 1630-1665 (61.6%)	
66208	XU34	T4	Enclosure	79	*cf. Euphorbia* sp.*	340±20	-27.15	AD 1479-1530 (32.6%), 1540-1635 (62.8%)	
71329	XU35	T4	Linear Embankment	45	*Wikstroemia sp.**	220±20	-25.95	AD 1644-1680 (42.3%), 1740-1753 (4.7%), 1762-1800 (46.2%)	
71330	XU2	EP1	Enclosure	32	*Artocarpus altilis*	350±20	-24.65	AD 1470-1529 (39.8%), 1545-1635 (55.7%)	
71331	XU39	T4	Deposit	92	*Artocarpus altilis*	260±20	-27.59	AD 1527-1552 (12.1%), 1633-1666 (74.3%), 1783-1795 (9%)	
71332	XU3	EP2	Linear Embankment	43	*Indeterminate Hardwood*	290±20	-24.86	AD 1517-1589 (63.5%), 1621-1657 (31.9%)	
71333	XU6	EP5	Linear Embankment	63	*Myoporum sandwicense*	250±20	-27.62	AD 1529-1540 (2.6%), 1634-1670 (73.5%), 1780-1799 (19.3%)	
71334	XU39	T4	Linear Embankment	57	*Metrosideros sp.*	290±20	-25.75	AD 1517-1589 (63.5%), 1621-1657 (31.9%)	
71335	XU5	EP4	Linear Embankment	62	*Artocarpus altilis*	330±20	-26.41	AD 1490-1639	
71336	XU5	EP4	Linear Embankment	57	*Euphorbia* sp.*	300±20	-25.34	AD 1510-1594 (71.3%), 1618-1650 (24.1%)	
77368	XU11	EP6	Hearth	59	*Cocos nucifera* endocarp*	150±20	-23.1	AD 1669-1702 (15.2%), 1721-1781 (28.0%), 1796-1817 (10%), 1833-1890 (21.5%)	
77369	XU11	EP6	Stone-Lined Hearth	52	*Pittosporum sp.**	260±20	-25.02	AD 1527-1552 (12.1%), 1633-1666 (74.3%), 1783-1795 (9%)	
77370	XU17	EP17	Terrace	43	*Metrosideros* sp.	160±20	-26.26	AD 1666-1699 (16.6%), 1722-1784 (36.4%), 1795-1814 (9.9%), 1835-1884 (11.3%)	
77371	XU7	EP6	Enclosure	29	*Pittosporum* sp.*	100±20	-27.09	AD 1692-1727 (25.7%), AD 1810-1919 (69.7%)	
77372	XU48	T4	Enclosure	32	*Euphorbia* sp.*	320±20	-10.83	AD 1496-1602 (76.2%), 1612-1642 (19.2%)	
77373	XU13	EP13	Enclosure	52	*Broussonetia papyrifera*	120±20	-27.54	AD 1683-1735 (24.8%), 1803-1930 (70.7%)	
77374	XU18	EP27	Terrace	45	Unidentified tuber*	290±20	-24.39	AD 1517-1589 (63.5%), 1621-1657 (31.9%)	
77375	XU47	T34	Linear Embankment	40	*Broussonetia papyrifera*	320±20	-24.91	AD 1496-1602 (76.2%), 1612-1642 (19.2%)	
77376	XU15	EP16	Terrace	89	*Broussonetia papyrifera*	290±20	-26.58	AD 1517-1589 (63.5%), 1621-1657 (31.9%)	

*** Short or moderate-lived species (estimated less than 50 years, building on Rieth and Athens 2013)**

estimated using the boundary command in Oxcal, with constraining radiocarbon determinations organized in phases around boundaries and a universal *terminus ante quem* (TAQ).

The posterior probabilities created from these models were used to produce joint posterior estimates of the occurrence of events using ArchaeoPhases (Philippe *et al.* 2017). ArchaeoPhases provides a means to statistically analyze groups of estimates, rather than individual ones, derived from Bayesian analysis. Occurrence plots analyze the MCMC output of Bayesian models to calculate the number of occurrences of an event, such as the construction of infrastructure, before a specified time period. In simpler terms, the occurrence plot will estimate a time by which *n* events have occurred, beginning with 1. The time period is calculated as a range at a desired level of confidence. In this case, the confidence level was set to 95%. As such, the occurrence plot provides a means by which to visually demonstrate rates of change, with a higher slope indicating a higher rate of change.

Potentially long-lived species were dated from several contexts (Table 1). This was done because either no other samples were available for a useful context or because we wished to acquire direct dates on Polynesian introductions. This can complicate chronology building. The structure of the Bayesian model is used to address this issue in most cases. The structure of the model assumes that these determinations are already older than the event of interest, which is the construction of the feature in most cases. The model does not specify how much older the TPQ is relative to the target date. As such, the structure of this model, in its use of TPQ phases rather than taking individual dates as related directly to the target events, considers the possibility of inbuilt age.

To further address issues of inbuilt age, especially in cases where potentially long-lived species were used to estimate boundaries in a sequence, we applied an outlier model after Christen (1994) and used in Quintus *et al.* (2023) with a prior outlier probability of 0.10 for each charcoal date. This model identified UGAMS-66207 and UGAMS-71331 as potential outliers, with posterior outlier probabilities of 0.30 or more. The output of this iteration of the Bayesian model, however, was very similar to the one without an outlier model applied, with individual estimates usually varying by 20 years or less (see Online Supplements for direct comparison). The results highlight the robust nature of the model output.

All conventional radiocarbon ages (CRAs) are less than 400 bp, and no calibrated date extends earlier than the mid-15th century AD, with ranges of all the earliest dates extending into the 17th century AD. Available dates relate stratigraphically to 31 events, including 24 events of infrastructure construction. These include activities associated with five enclosures or habitation terraces, 18 linear embankments, and one rock mound. Estimated construction events are unequally distributed, with eight in the eastern pasture and 16 in the kīpuka.

Jointly, the results indicate the use of the area initially in the late 15th century AD or early 16th century AD (see Figure 8). This activity occurred in the area now bounded by T4, but linear embankments may also have been built at this time. The level of activity in the project area was constant from the 16th century AD through the 17th century AD. The rate of construction may have declined slightly in the 18th century AD, though this is the time when habitation structures EP6 and EP13 may have been built. Other habitation structures, such as T33 and EP1, were contemporaneous with the early phase of agricultural infrastructure construction.

Chronologies of the eastern pasture, the gully, and the kīpuka are similar (Figure 9). While the estimated construction age of the first occurrence of construction extends further into the 15th century AD in the kīpuka, there is substantial overlap with the first occurrence of construction in the eastern pasture. There is also no evidence that the chronologies of functionally different infrastructure were different. Instead, habitation, dryland agricultural, and colluvial slope features were built at a similar time, based on current evidence.

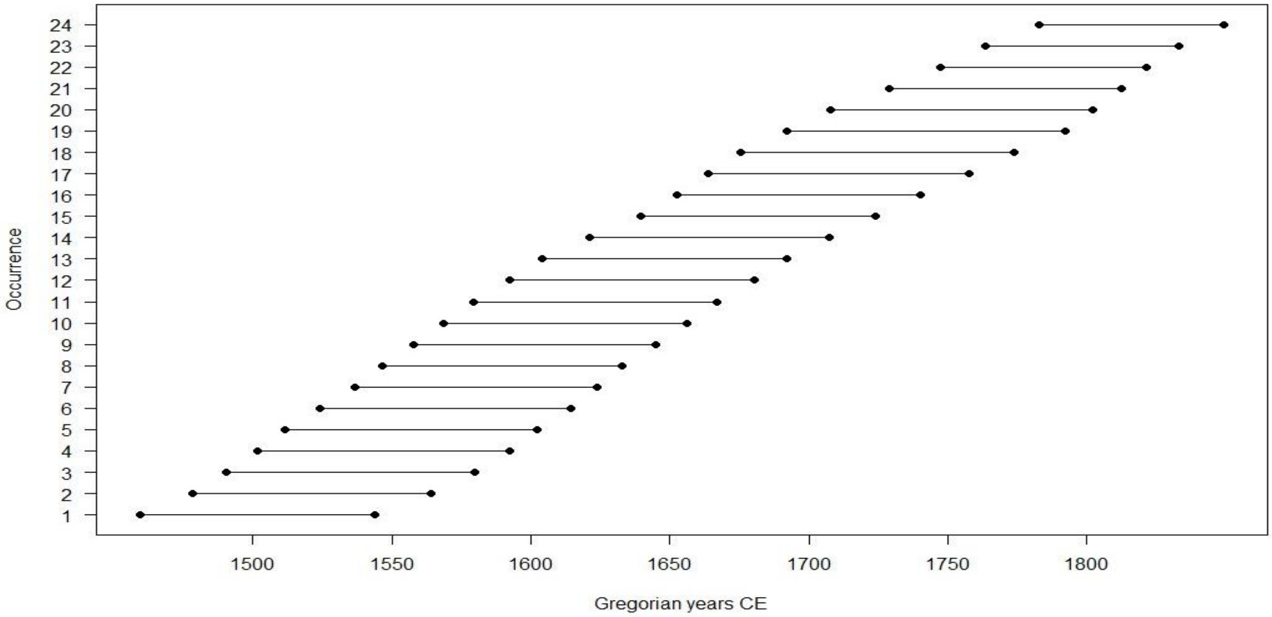
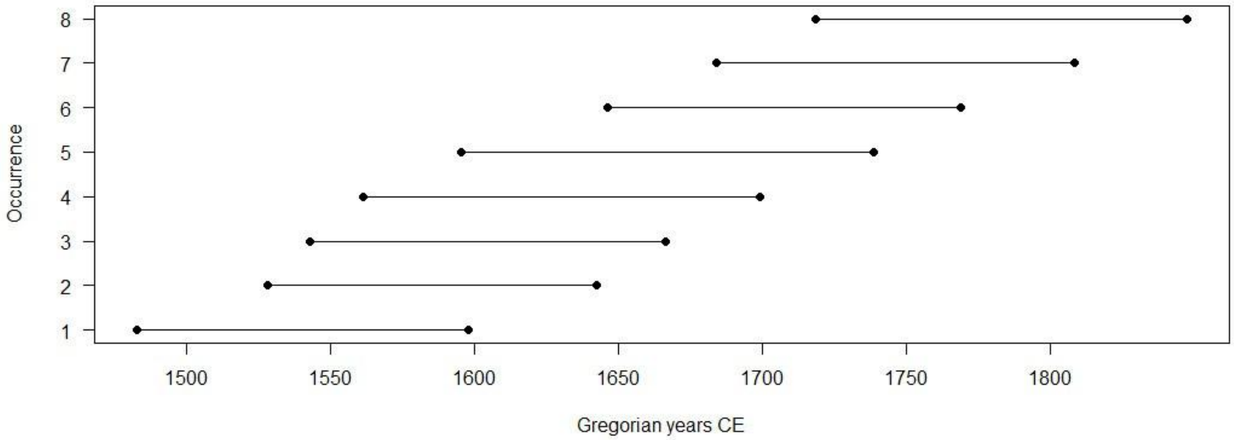


Figure 8: Joint probability distributions for the occurrence of events of feature construction across the entire project area.

Pasture



Ka‘opapa

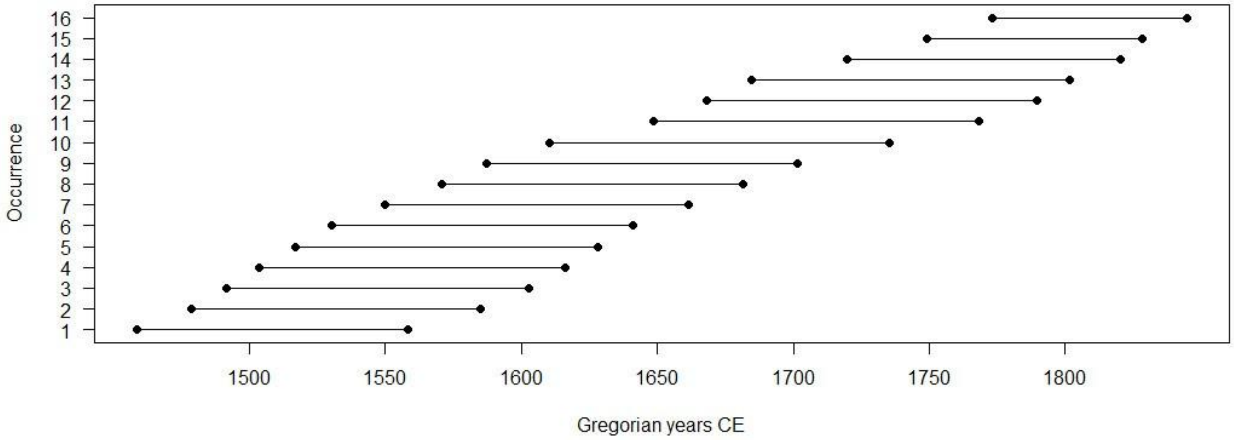


Figure 9: Joint probability distributions of events of feature construction in the pasture (top) and kīpuka (bottom). Note that time scales (x-axes) are slightly offset.

A distinct 2-3 cm thick cinder layer exists across much of the project area, best represented in three habitation structures, T4 (Figure 10), T33, and EP1, but also visible in EP6. In each case, the cinder layer marks the transition between Layer I and II. In the case of T33 and EP1, a cobble and slab basalt paving was built atop this cinder layer (Figure 11). We infer that this cinder layer relates to a period of volcanic activity in the vicinity of the site, estimated to have been deposited between the late 17th century AD and the middle 18th century AD based on radiocarbon dates from above and below the layer (Figure 12). The presence of paving on top of the cinder highlights that people maintained the same residences after cinder deposition, either renovating or rebuilding these structures.

Foreign goods (imported non-Hawaiian goods) are rare in the Kahuku assemblage, limited to a bullet. The lack of identifiable foreign goods, which became more substantial components of the archaeological record in the mid-19th century AD (Kirch 1992), suggests that the features investigated here were largely abandoned by that time. Ranching is well documented in the project area over the last 150 years, but we found little evidence of the reuse of archaeological features for that purpose. Instead, new infrastructure, including more vertically stacked walls, was constructed and used in the kīpuka, while evidence of heavy machinery is present in the eastern pasture.

Figure 10: The location of the cinder layer in XU-44 in T4.

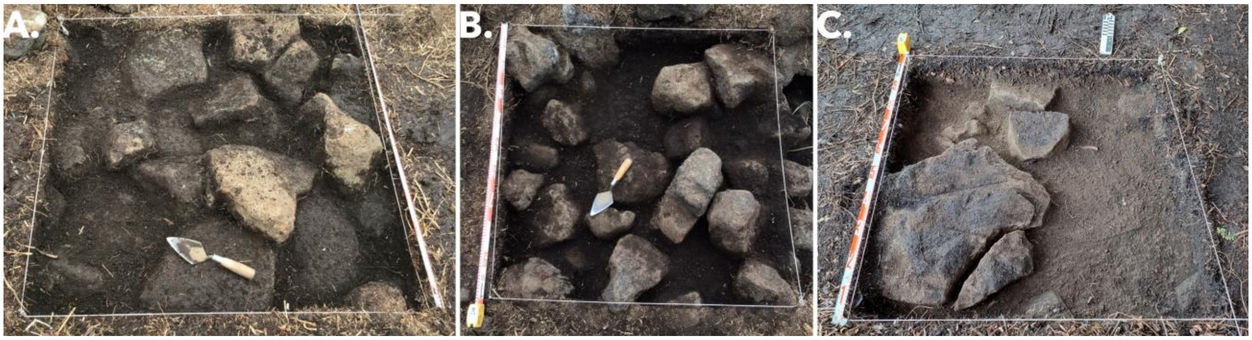


Figure 11: Interpreted pavings positioned above cinder layers in: A) EP1, B) T33, and C) EP6. All examples extend beyond the boundaries of these individual units.

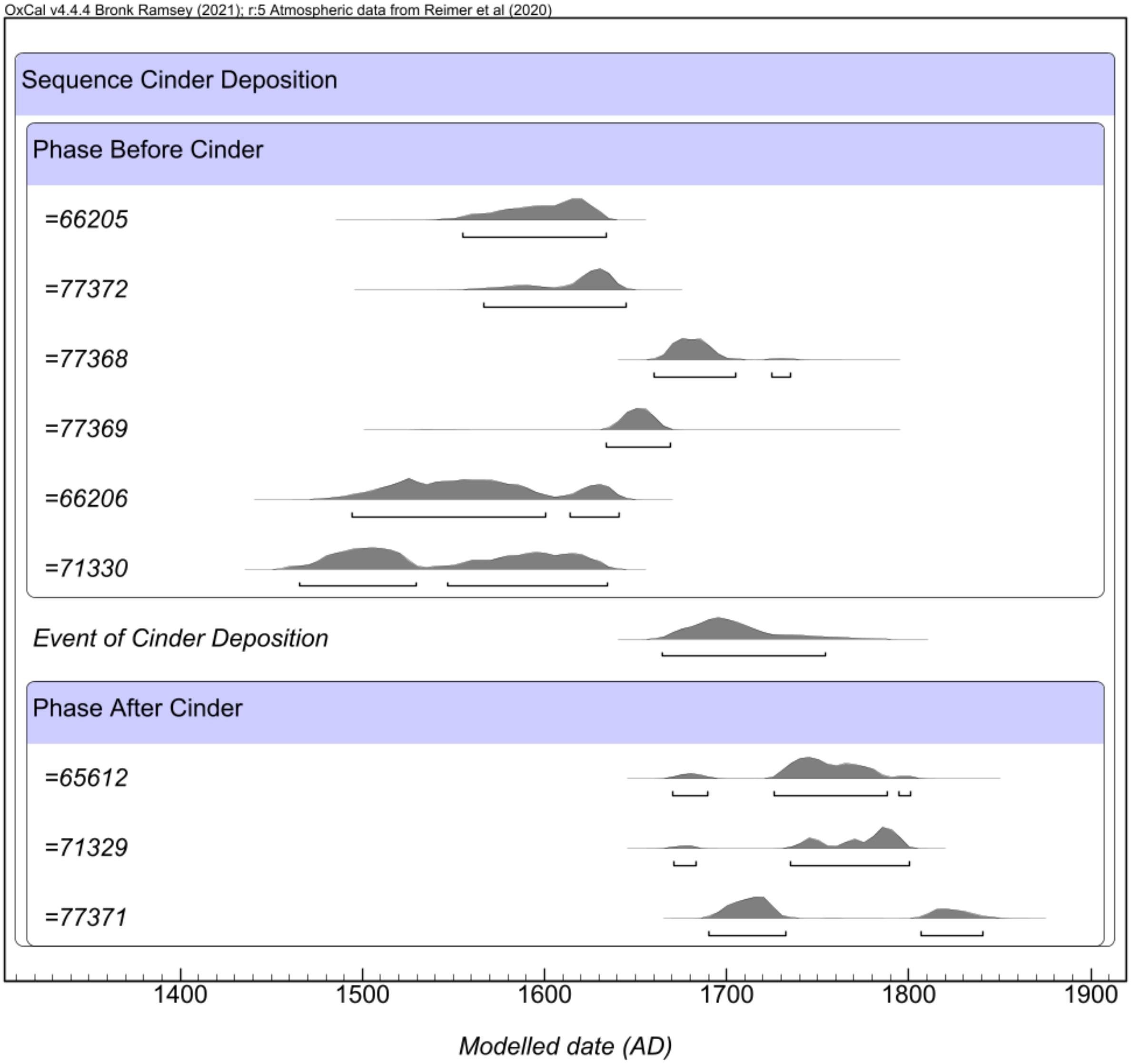


Figure 12: Modelled estimate of cinder deposition across the project area (methodology described in Supplementary Information).

7. Macrobotanical Remains

Individual pieces and bulk samples of charcoal were recovered across excavated contexts. These samples allow for an examination of vegetation use and change across the project area. Given that we did not employ flotation as a method of recovery, identification was biased toward larger pieces that were visible in and collected from 1/8” screen. Identified charcoal is available from 21 contexts across the project areas. In most of these contexts, individual pieces of charcoal were identified for potential radiocarbon data. However, identified bulk samples of charcoal are available from seven contexts, three of which are associated with T4. As such, we discuss charcoal in two ways. First, we explore what has been identified across the project areas using both the identification of individual specimens and the results of bulk charcoal analysis. We then explore vegetation quantitatively by considering bulk charcoal analysis alone.

At least twenty-nine taxa were recorded across the project area (Table 2). This is a conservative estimate, as indeterminate and unknown taxa were also identified. These taxa were identified to different levels, though the majority were identified to the species level. Seventeen taxa were identified in only one context each, including *Cocos nucifera* (niu, coconut) and *Cordia subcordata* (kou). These two taxa are more abundant near the coastline, and their presence in the Kahuku unit may relate to transport as resources or tools. The most ubiquitous taxon was *Myoporum sandwicense* (naio), a dryland forest species, with other common dryland species also represented across the project area (*Metrosideros polymorpha* [ʻōhiʻa lehua], *Euphorbia* spp. [ʻakoko], and *Pittosporum* spp. [hōʻawa]). Other dryland species known from the area today (Vance 2015) were rarely recorded, including *Diospyros sandwicensis* (lama) and *Dodonea viscosa* (ʻaʻaliʻi). Several economic trees and shrubs were also recorded in the project area, including *Cordyline fruticosa* (kī), *Broussonettia papyrifera* (wauke, paper mulberry), *Artocarpus altilis* (ʻulu, breadfruit), and *Aleurites moluccana* (kukui, candlenut). Of these, *B. papyrifera* was the most ubiquitous, followed by *A. altilis* and *C. fruticosa*. Importantly, all of these taxa were found beneath infrastructure, highlighting their presence before the construction of that infrastructure. *B. papyrifera* is more common in the eastern pasture than in the kīpuka, though uneven sampling could cause this. This taxon was stated as having grown feral in "old forest plantings…in Kaʻū" by Handy *et al.* (1972:209).

For the bulk samples, the number of taxa, including an indeterminate category, ranged from seven to 12, a pattern that was not related to sample size (Coefficient = -1.89; r^2 = 0.15; F = 0.87; p = 0.39) (Table 3). Indeterminate charcoal ranged from 6-14% of each assemblage. As measured by weight, *M. sandwicense* was the most common taxon, constituting between 24-68% of assemblages, across all samples. *M. sandwicense* constituted more than half of the assemblage in four of the seven bulk samples. The two assemblages with the lowest proportion of *M. sandwicense* were also the smallest samples. The second-ranked taxon across all but one sample was either *Euphorbia* spp. or *M. polymorpha*. This was not affected by assemblage function; these taxa were highly ranked in both general layers and features. *Euphorbia* spp. was the third-ranked taxon in the remaining assemblage, with *Pittosporum* spp. the second-ranked taxa. Where Polynesian introductions were identified in bulk samples, they were minor components, with individual taxa never more than 7% and largely less than 5%.

An analysis of change is complicated by the inclusion of both layer (general) and feature (specific) charcoal. However, these contexts provide a set of hypotheses that can be evaluated. Early assemblages are from the base of Layer III in XU-34 (Feature) and XU-39 (Layer) in T4. A middle period assemblage is available from the interface of Layer II and III in XU-31 (Layer) of T4. A later period assemblage is provided by XU-11 of EP6 (Feature). Assemblages are markedly similar. The XU-39 assemblage is the richest, as is expected given it is early and from the general layer. *M. sandwicense* is dominant in all assemblages, while *M. polymorpha* and *Euphorbia* spp. are well represented. *Pittosporum* spp. is most common in the assemblage from EP6; it is unclear if this is a temporal or environmental pattern since EP6 lies adjacent to a gully. Both *A. altilis* and *C. fruticosa* are present in both early and later deposits, though never at high levels relative to other taxa.

The analysis of large, comparable charcoal assemblages from other agricultural contexts would be an additional and much-needed line of evidence to explore agronomic adaptations to

Table 2. Plant Taxa Identified in the Kaʻū Field System Archaeobotanical Collection (Green Shading Denotes a Presence).

Taxon	Hawaiian/ Common Name	T2	T33	T25	T1	T15	T20	T6	T4	T35	T9	T34	EP1	EP4	EP5	EP6	EP13	EP16	EP17	EP27
Aleurites moluccana	kukui								X											
Alphitonia ponderosa	kauila															X				
Antidesma sp.	hame				X															
Artocarpus altilis	ʻulu, breadfruit								X				X	X						
Asparagaceae	Asparagus family			X																
Bidens sp.	koʻokoʻolau, beggartick					X	X													
Broussonetia papyrifera	wauke											X		X		X	X	X		
Cheirodendron trigynum	ōlapa								X			X				X				
Chenopodium oahuense	ʻāheahea								X											
Cocos nucifera	niu, coconut															X				
Coprosma sp.	pilo			X					X					X						
Cordia subcordata	kou								X											
Cordyline fruticosa	kī, ti								X					X		X				
Diospyros sandwicensis	lama			X																
Dodonea viscosa	ʻaʻaliʻi													X						
Euphorbia spp.	ʻakoko, spurge			X	X	X			X	X				X		X				
Indeterminate corm or tuber	-																			X
Metrosideros polymorpha	ʻōhiʻa lehua			X		X			X					X		X	X		X	
Myoporum sandwicense	naio		X	X		X		X	X				X	X	X	X				
Nestegis sandwicensis	olopua					X														
Nothocestrum sp.	ʻaiea	X				X														
Perrottetia sandwicensis	olomea								X											
Pisonia sp.	pāpala kēpau				X															
Pittosporum spp.	hōʻawa			X		X			X					X		X				
Psychotria sp.	kōpiko			X		X			X					X						
Psydrax odorata	alaheʻe															X				
Pteridophyte	fern			X		X														
Polyscias sp.	ʻohe, ʻoheʻohe								X											
Wikstroemia sp.	ʻākia			X				X	X		X									
Xylosma hawaiiense	maua					X														

Table 3. Taxa Identified in Bulk Sample Analyses Arranged by Context and Sorted by Weight (g) (Most to Least Abundant).

Taxon	EP4, XU-5, Layer II	EP6, XU-11, Feature 1	T4, XU-31, Layer III	T4, XU-34, Feature 1	T4, XU-39, Layer III	T15, XU-12, Layer Ib	T25, XU-14, Feat. 1	Total
Myoporum sandwicense	10.68	16.92	8.42	15.41	2.05	10.86	2.64	66.98
Indeterminate	3.08	2.82	1.04	3.43	1.23	0.96	0.98	13.54
Euphorbia spp.	2.42	2.85	0.7	4.57	0.27	1.26	0.58	12.65
Metrosideros polymorpha	1.23	1.84	1.69	2.83	1.57	0.51	1.92	11.59
Pittosporum spp.	1.41	4.35			0.18		0.13	6.07
Artocarpus altilis	0.82			0.63	0.62			2.07
Cordyline fruticosa	1.04	0.43	0.49	0.11				2.07
Broussonetia papyrifera	0.76	0.7						1.46
Nestegis sandwicensis						1.09		1.09
Wikstroemia sp.					0.99		0.07	1.06
Polyscias sp.					0.70			0.70
Psychotria sp.	0.19				0.5			0.69
Nothocestrum sp.						0.67		0.67
Xylosma hawaiiense						0.60		0.60
Psydrax odorata		0.59						0.59
Coprosma sp.	0.19				0.22		0.1	0.51
Perrottetia sandwicensis			0.07	0.34				0.41
Dodonea viscosa	0.37							0.37
Chenopodium oahuense				0.35				0.35
Diospyros sandwicensis							0.31	0.31
Asparagaceae							0.27	0.27
Cordia subcordata					0.26			0.26
Aleurites moluccana			0.15					0.15
Cheirodendron trigynum					0.10			0.10
Pteridophyte						0.03	0.02	0.05
Total	**22.19**	**30.5**	**12.56**	**27.67**	**8.69**	**15.98**	**7.02**	**124.61**

microenvironments on Hawaiʻi Island. For example, we note that *B. papyrifera* was documented during radiocarbon taxa identification in Kona (McCoy *et al.* 2017), which is not surprising given ethnohistoric documentation of the tree there (see Handy *et al.* 1972:209). The tree was absent from Waimea-Kawaihae assemblages systematically analyzed by Murakami (1983). Additional evidence may be useful in addressing whether that absence spreads across the northern part of the island or if it is restricted to small areas suggestive of place-based adaptations. The discussion by Handy *et al.* (1972:209-210) hints at a level of such place-based adaptations, though the tree was widely planted.

8. Discussion

Kaʻū has figured prominently in our understanding of Hawaiian agricultural practices (Handy *et al.* 1972). Still, our knowledge of the nature of agriculture in the region beyond that which was practiced or remembered in the 19th and 20th centuries is limited. This is unfortunate both because Kaʻū may be the largest contiguous agricultural landscape in the archipelago (Kagawa-Viviani *et al.* 2018) and because the varied environments of the landscape provide an opportunity to better understand the process of place-based adaptation and its links to larger-scale social relationships. This is especially the case for the last several centuries before European arrival on the islands. The results reported here provide one set of data by which to evaluate these questions.

We infer that the agricultural sequence in our project area began with the creation of novel forests (after Lincoln *et al.* 2024; Quintus *et al.* 2019). The presence of several tree crops beneath later infrastructure indicates the presence of these tree crops, namely *A. altilis* and *B. papyrifera*, before the construction of infrastructure at this elevation in the field system. That this was of low intensity is suggested by the low frequencies of these economic trees and the high density of typical dryland forest species in our charcoal assemblages. Furthermore, several shrubby species are also represented, suggesting that an understory was still relatively intact. Hawaiian communities had not remade forests as they would do in some parts of the island (Lincoln and Ladefoged 2014), and evidence of specific agroforestry techniques is currently lacking. When groups started to produce novel forests in the uplands of Kaʻū is not clear, though our evidence highlights they were in place by the 15th century AD.

Infrastructure was built by Hawaiian communities across the project area by the 16th century AD, potentially slightly earlier. This includes a variety of infrastructure types, including terracing associated with a gully colluvial slope system, house enclosures, and linear embankments that would come to structure the largest component of the agricultural landscape. Infrastructure was built initially across multiple microenvironments, including the shallow soils of the kīpuka, the swales of the eastern pasture, and the gully. There is no clear spatial patterning to the chronology of this construction besides increased segmentation and infilling of fields over time.

Even while the chronologies were similar, how communities in Kaʻū adapted to microenvironments was obviously different. While all linear embankments are roughly perpendicular to prevailing wind, slight deviations in the angle of dominant linear embankments took advantage of the direction of swales and subsoil bedrock formations. This is most visible in the kīpuka, where the angle of linear embankments is distinct in the south and north halves. While all houses were perched on high points in the landscape, these houses were directly on bedrock in the kīpuka, while those currently known from the eastern pasture were simply in areas exposed to wind. Mounds may be present in the eastern pasture, given the lack of survey coverage possible in the area, but they are at the very least at a lower density. It may be that the soils of the kīpuka are rockier than those of the eastern pasture, given its younger geological age. However, soils in the eastern pasture are also relatively shallow. These lines of evidence highlight how farmers in the area were operationalizing a similar set of tools and techniques, but were not attempting to replicate each other or produce an overarching system of plots. We hypothesize that connectivity between plots was emergent over time as segmentation and infilling continued.

Access to both economic and dryland forest trees continued through time, evidenced by charcoal assemblages. This was likely gained through proximity to upslope forests, given that agricultural infrastructure is not known from areas upslope of the kīpuka or eastern pasture. Still, it is possible that economic trees continued to be grown within or on the sides of the infrastructure-lined plots. This would be advantageous for generating better access to important resources, increasing production diversity, and enhancing moisture savings because the trees would act as a windbreak. If these were present in the project area, rather than transported in, we might expect their charcoal to be present under infrastructure constructed later in the sequence.

Construction activities and agricultural use of the area continued through the 18th century AD. This continuity seems to have occurred through at least one period of volcanic activity that may have deposited a layer of cinder across much of the project area toward the end of the 17th century AD or beginning of the 18th century AD. Following the deposition of this cinder, whether through volcanic activity or otherwise, renovations or reconstruction activity took place at two houses, and activity persisted at others. As such, the location of settlement remained stable – we have no clear evidence currently for house abandonment.

8.1. Thinking through Land Organization and Tenure in Upland Kaʻū

The sequence of agricultural change in the Kahuku Unit extends across a time of considerable change in Hawaiʻi, when populations were expanding across leeward districts and political power was centralizing (Kirch 2010). Evidence for increased field standardization and strategies that occur across political boundaries is documented for areas of Kona and Kohala (Allen 2004; Ladefoged *et al.* 2020). An apparent shift in the focus of the economy to better supplement the wealth and ambition of an elite class that grew in practical and religious authority is also interpreted for this time (Dye 2014; Field *et al.* 2011; McCoy *et al.* 2011).

Results reported here confirm that the initial development of infrastructure in the Kahuku region occurred at generally the same time as the initial development of other systems of rainfed agriculture, either across leeward slopes (Allen 2004; Ladefoged and Graves 2008; McCoy 2005) or the slopes of windward valleys (Morrison *et al.* 2022). This initial patterning is not consistent with a politically-motivated expansion of food production, though elites probably benefited. Instead, this has the hallmarks of shared population growth across the archipelago as well as the influence of the introduction of sweet potato (*Ipomoea batatas*), as has been argued by others (Kaschko and Allen 1978; McCoy 2005:350; Quintus *et al.* 2023). Returning to Kaʻū, the establishment of infrastructure occurred following a period of novel forest development, contrasting to some extent with the sequence of shifting cultivation documented for both Kona (Allen 2004) and Kohala (Ladefoged and Graves 2008). This difference likely relates to elevational variation between sites studied in each agricultural landscape, with the expectation that shifting cultivation was practiced downslope in Kaʻū.

If practical resource management and control by leaders were occurring, we may expect large religious architecture, occupational discontinuity in houses reflecting non-leader movement, and evidence of larger scales of agricultural decision-making that extends beyond individual microtopographic characteristics (see Kirch 1992; Ladefoged *et al.* 2020; McCoy *et al.* 2011). In contrast, variation in the Kahuku Unit was generated early in the agricultural sequence, as infrastructure was built in different microenvironments. While it is clear that farmers shared a suite of agricultural knowledge, variation speaks to decisions made at small spatial scales (< 1/2 km^2). The construction of houses within or overlooking fields is suggestive of local control and management, as opposed to control and management of konohiki. The interpreted religious architecture of the project area is small-scale, currently restricted to a single hale mua, reflecting local ritual practices that integrated the surrounding community. These patterns do not seem to have changed markedly through time. Instead, excavation indicates the continued occupation of houses, including after the deposition of cinder, which may reflect stability of land tenure.

The Kahuku Unit, then, shares much with the archaeological record of South Kohala (Ladefoged *et al.* 2020) and Kahikinui, Maui (Kirch 2014). In contrast to South Kohala, though, what drove local management was not limited production. Rather, it may have been caused by the increased environmental variability of the area, especially the microtopographic features, that is similar to Kahikinui. Distance also likely played a role. The Kahuku Unit, while not environmentally marginal, is on the margins of the predicted sweetspot of agricultural production in Kaʻū (see Ladefoged *et al.* 2009). As such, the gravity of social control may have been reduced because of distance, assuming that elite presence was more spatially centralized within the field system. This seems to be the case based on a limited survey to the south of the Kahuku Unit (Reeve and Cleghorn 2017). We expect that increased standardization occurred closer to these areas of political power, or at least the spatial scale of decision-making was larger, based on research in Kohala (Ladefoged *et al.* 2020). However, the considerable microenvironmental variation across Kaʻū may have made larger-scale management less feasible.

The lack of clear indications of top-down influence in the Kahuku Unit does not imply the absence of other elements of social integration. It is unclear, because of 19th century AD lava flows, whether the infrastructure of the Kahuku unit was linked to infrastructure further downslope. Given the nature of other agricultural systems (i.e., Allen 2004), we expect that this infrastructure was connected, which would require at least some level of cooperation across elevational gradients. It is also likely that communities were socially integrated across the field system based on evidence of lithic (Quintus *et al.* 2026) and faunal (i.e., presence of fish bone) transport to the area, even if practical management occurred at a smaller spatial scale. Social integration would have been an important risk management strategy in such a volcanically active location (after Allen 2004). This integration took advantage of the moving window of cultivatable space throughout the year along the elevational gradient of Kaʻū (Kagawa-Viviani *et al.* 2018). These elements of integration are consistent with a growing recognition of more complex land tenure in Hawaiʻi. Farmers had an active role in environmental management with long-term land access, while higher scales of social organization could mobilize when needed and extract resources to support that mission.

9. Conclusions

Considerable social change occurred within Hawaiʻi during the 17th and 18th centuries AD, most notably enhanced extraction of surplus resources (Dye 2014; Hommon 2013; Kirch 2010). This led to changes in the agricultural strategies used (Allen 2004). A debate has occurred about what this meant for how agriculture was managed and how the daily lives of the community were affected (see Dye 2021; Hommon 2020). Of course, increased surplus extraction inevitably changed the social dynamics of all communities, but the intensity and scale of these changes were unevenly distributed (Ladefoged *et al.* 2020; Quintus 2025). Our results add to the growing body of evidence that some locations retained local management autonomy, with limited evidence of changes in land tenure and land use, during the 17th and 18th centuries AD. Changes did occur, in that fields were progressively segmented and forests were reduced, but there is no evidence that this is tied to regional political dynamics. Instead, we interpret our results as indicating the persistence of a local group of landholders that was encompassed within rather than replaced in the emergent overarching stewardship of 17th and 18th-century AD Hawaiʻi Island. Local management of agriculture was persistent in Hawaiʻi, with additional layers of political influence added over time. This degree of local management was a product, in part, of the distance from social centres and the gravity of political authority in those centres.

Supplementary Materials

The supporting information can be downloaded at https://doi.org/10.70460/jpa.v16i2.394

S1: Excavation and Model Methods; S2: Bayesian Model Code for OxCal

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Data Availability Statement.

Data are provided in tables in the main text and in supplementary information. The sharing of spatial data is restricted by the National Park Service.

Partnerships

Archaeological research was completed under a permit to conduct archaeological activities in Hawaiʻi assigned to Seth Quintus. Permits were also issued for research on National Park lands. Communities were involved in this research process in several ways. First, the HVNP kupuna council reviewed project details before the initiation of work. Second, community groups were hosted during excavation across field seasons and encouraged to participate if they were interested. These community groups included members of the general community as well as targeted schools. Finally, data has been distributed to communities through a series of public events, hosted both at Kahuku and at the summit visitor centre at Kīlauea.

Conflicts of Interest

The authors declare no conflicts of interest.

Author Contributions

Conceptualization, S.Q. and S.R.T; methodology, S.Q., D.F., C.W., and G.M.; formal analysis, S.Q. and D.F.; writing—original draft preparation, S.Q.; writing—review and editing, S.Q., D.F., C.W., G.M., and S.R.T.; project administration, S.Q. and S.R.T; funding acquisition, S.Q. and S.R.T. All authors have read and agreed to the published version of the manuscript.

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