

---

## SHORTER COMMUNICATIONS

---

### THE DEVELOPMENT OF THE KALAUPAPA FIELD SYSTEM, MOLOKA‘I ISLAND, HAWAI‘I

MARK D. McCOY

*University of California, Berkeley*

Archaeologists working in Polynesia have addressed the relationship between environment and political economy by contrasting chiefdoms centred on irrigated “wet” and rain-fed “dry” agricultural systems. This approach has made major contributions to our understanding of the evolution of a complex, hierarchical society (Kirch 1994, Ladefoged 1993a). The Hawaiian Islands exemplify this wet/dry dichotomy, and syntheses of historical trends have been primarily based upon a few key settlement pattern studies on windward valleys and leeward field systems (Clark and Kirch 1983; Green 1980; Kirch 1984, 1994; Kirch and Kelly 1975; Rosendahl 1972, 1994; Tuggle and Griffin 1973). Recent research has concentrated on the latter type of agricultural system, especially the Kohala and Kona Field Systems in the leeward west Hawai‘i Island as well as other leeward locations that lack formal field systems (J. Allen 1991; M.S. Allen 2001, 2004; Coil 2004; Dega and Kirch 2002; Graves *et al.* 2002; Kirch *et al.* 2004; Ladefoged and Graves 2000; Ladefoged *et al.* 1996, 2003; McCoy 2000; Vitousek *et al.* 2004). Here I present and discuss a rare example of an intensive dryland system located in a wet, windward environment to further examine the historical associations between environment, agriculture and social development in Hawai‘i’s culture history.

The Kalaupapa Field System—a 9km<sup>2</sup> grid of rain-fed plots, defined by low stone field walls, covering the Kalaupapa Peninsula, Moloka‘i Island—is ideally suited to studying the relationship between environment and political economy, because of its natural isolation, its location adjacent to several windward valleys and its excellent archaeological preservation. This field system was largely ignored in previous discussions of Hawaiian agriculture because it was initially assessed to be a 19th century construction (Ladefoged 1990, 1993b).

In this article I use radiocarbon dates from sites within and outside the field system to present the first detailed chronology of settlement and agricultural development in the Kalaupapa region from A.D. 800 to 1866.<sup>1</sup> I begin with a brief overview of the local environment, culture history and oral traditions, and of the history of archaeological fieldwork. Next, a series of 27 radiocarbon dates are summarised. Finally, the origins and development of the field system are discussed in relation to population expansion, the first appearance of Moloka‘i high chiefs (*ali‘i nui*) in the 15th century, the rise and fall of an independent windward polity in the island’s Ko‘olau District (*moku*) in the 17th century, and the reintensification of the fields in the 19th century during the Great Māhele land division.

## ENVIRONMENT

Moloka‘i Island can be divided into three ecological provinces based on rainfall, exposure to northeast trade winds and landform (see Kirch 1990): (i) the wet, windward valleys of the north shore, (ii) the dry, leeward valleys of the south shore, and (iii) the arid rocklands of the island’s west end (Fig. 1). North shore valleys are typically large, with an amphitheatre shape and permanent streams. Both land and sea travel between these valleys is difficult, even today, since each was carved from a sheer cliff rising over 610m above sea level along a coast with dangerously rough winter surf.

The Kalaupapa Peninsula, located at the western end of these valleys, is a unique landform born of a volcanic rejuvenation centred on the Kauhakō Crater (circa 330 thousand years ago) at the base of the north shore’s cliffs (Fig. 2) (Clague *et al.* 1982, MacDonald *et al.* 1983). The low elevation of the peninsula—at its highest point only 123m above sea level—causes correspondingly low rainfall (900-1300mm annually) despite its windward location (Foote *et al.* 1972, Sterns and MacDonald 1947). However, thanks to its independent geological history, the peninsula is home to a series of nutrient rich soils similar to those on younger islands (McCoy *et al.* 2004).

Adjacent to the peninsula is a distinctly different, wet ecological zone with colluvial soils distributed at the bottoms of the short Waihānau and Wai‘ale‘ia Valleys, the large Waikolu Valley and along the base of the cliffs (Foote *et al.* 1972). While only the Waikolu Valley has perennial flow today, both the Waihānau and Wai‘ale‘ia Valleys have substantial intermittent streams that may have had more regular flow in the past. Indeed, the entire area is covered in a network of agricultural terraces that rival the density of the dryland fields (Somers 1985). In addition, this ecological zone is dominated by a patchwork of colluvial soils similar to locations on Kaua‘i Island, where soil scientists have found evidence of nutrient rejuvenation attributed to the exposure of fresh weathering surfaces of re-deposited stones (Vitousek *et al.* 2003).

## MOLOKA‘I ISLAND CULTURE HISTORY AND ORAL TRADITIONS

Following Kirch’s (1985) synthesis of Hawai‘i’s culture history, Weisler (1989:128) summarised Moloka‘i Island’s history as follows: (i) initial settlement located with “easy access to inland and coastal marine resources” in the Colonisation Period (300-600), (ii) occupation of windward valleys by the Development Period (600-1100), (iii) permanent occupation of leeward areas in the Expansion Period (1100-1650), and (iv) final occupation of the remaining parts of the island by the Proto-Historic Period (1650-1795). In the years since this summary, the larger regional debate between short and long chronologies of East Polynesia has increased the range of estimates proposed for colonisation in the Hawaiian Islands to as early as A.D.100 and to as late as sometime after 800 or 900 (Anderson and Sinoto 2002; Athens and Ward 1993; Athens *et al.* 1999, 2002; Chun and Spriggs 1987; Dye 1992; Graves and Addison 1995; Hunt and Holson 1991; Masse and Tuggle 1998; Tuggle and Spriggs 2000). In addition, it is significant that Weisler’s (1989:128) description of early island land use was made in opposition to Athens’ (1985) view that people “were making use of the entire island at a[n] early time period—presumably by A.D. 1200 or perhaps

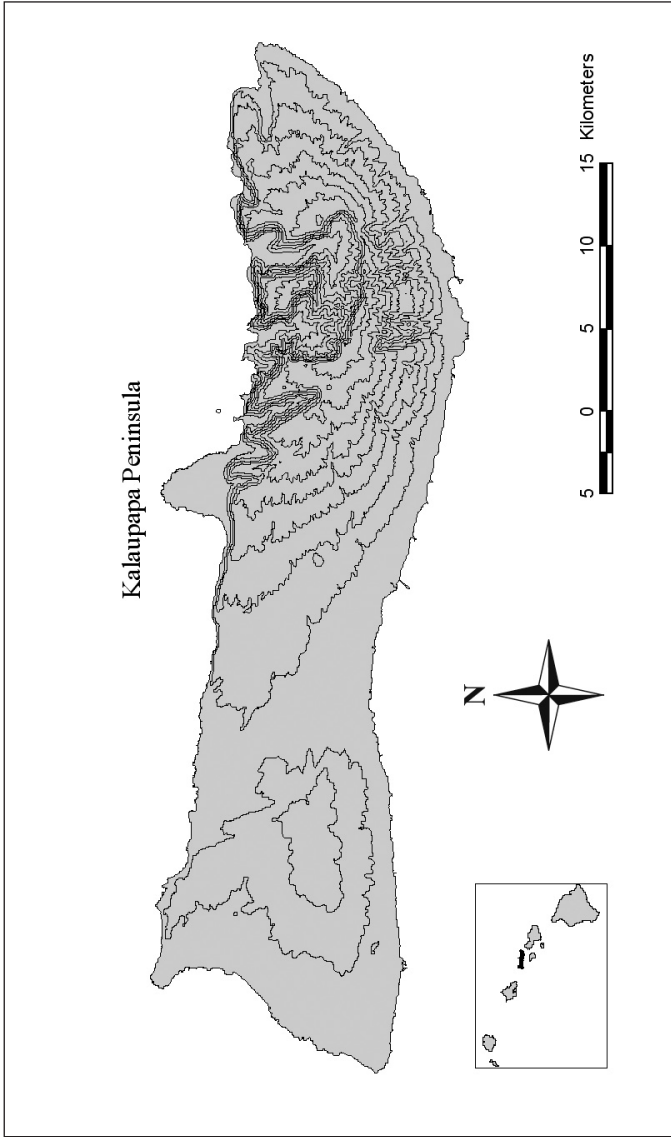


Figure 1. Molokai Island, Hawaii (500ft elevation contours).

earlier”, and that “leeward areas were apparently viewed in a more favorable light by early occupants of Moloka‘i than what prehistorians have often assumed” (Athens 1985 cited in Denham *et al.* 1999:37). Although evidence from Kalaupapa cannot resolve this debate conclusively, it does speak to how people on Moloka‘i used the landscape when faced with adjacent wet and dry environments.

In addition, archaeologists have constructed parallel chronologies based on oral traditions (Table 1). The first such proposed chronologies used estimated 25-year long “generations” and the birth years of chiefs to place the genealogies of ruling families along a timeline that stretched back several centuries before European contact (Hommon 1976, Summers 1971). Recently, the preferred method of anchoring oral traditions in time has shifted to reconstructing 20-year long “reigns” of chiefs (Cachola-Abad 2000; Cordy 1996, 2000; Kolb 1991, 1994). In my summary of these traditions on Moloka‘i (McCoy, in press), I reinterpreted Summers’ (1971) chiefly chronology using the 20-year reign method to allow comparisons with recent summaries of the political history of major islands in the Hawaiian archipelago (Cachola-Abad 2000; Cordy 1996, 2000; Kolb 1991, 1994).

Table 1: Culture Historical Periods (adapted from Kirch 1985, Summers 1971, Weisler 1989).

<i>Culture Historical Periods</i>	<i>Chiefly Chronology</i>	<i>Political History</i>
Foundation Period (800-1200)	–	–
Early Expansion Period (1200-1400)	–	–
Late Expansion Period (1400-1650)	Kamauaua Dynasty (1360-1460)  Gap in Chiefly Genealogy (1460-1700)	Consolidation (1360-1460)  Fragmentation (1460-1720)
Proto-Historic Period (1650-1795)	Kaiakea Dynasty (1700-1795)	Internal Competition (1720-1740)  Unification (1740-1780)  Occupation (1780-1795)

While the scale of Moloka‘i’s polities never reached the same geographic or militaristic magnitude of those in other Hawaiian islands, oral traditions describe two ruling dynasties and several important trends. The first dynasty is marked by the initial consolidation of the island under a single ruler (1360-1460). Subsequent fragmentation of this hierarchy (1460-1720) corresponds to the rise of independent district level polities that, after an intense civil war (1720-1740), eventually came under the rule of the second dynasty (1740-1780). Finally, the Island came to be occupied by the more powerful polities of O‘ahu, Maui and eventually Hawai‘i Island (1780-1795).

#### ARCHAEOLOGY ON THE KALAUPAPA PENINSULA

Despite the quarantine on the Kalaupapa Settlement for patients of Hansen’s Disease (leprosy) enforced between 1866 to 1969, the region has been included in several major archaeological research programmes. Bishop Museum ethnologist John Stokes made a geographically extensive study of Kalaupapa during his island-wide survey of religious sites (Stokes 1909). In the 1930s, Southwick Phelps included several Kalaupapa sites in his summary of Moloka‘i Island archaeology, including the first recorded reference to the Kalaupapa Field System (Phelps 1937). Following nearby rockshelter excavations in West Moloka‘i (Kaluakoi) by Bonk (1954) in the 1950s, Richard Pearson initiated the first modern research in the Kalaupapa region with his excavations at Kaupikiawa Rockshelter in 1966 (Hirata and Potts 1967, Pearson *et al.* 1974). Some 20 years later, charcoal samples from the site were submitted for radiocarbon dating as part of Weisler’s (1989) summary of the Moloka‘i’s culture history. One sample returned results that were interpreted as evidence of the initial presence of people in the region at around A.D. 1000 (Weisler 1989; see also Kirch 2002, Kirch *et al.* 2003).

The Kalaupapa fields were subject to a series of systematic surveys and excavations for the first time in the late 1980s and early 1990s (Athens 1989; Goodwin 1994; Ladefoged 1990, 1993b) (Fig. 2). Based on his survey of the northern portion of the peninsula, Ladefoged (1990:182) described “two main types of agricultural complexes... alignments with enclosures around them, and alignments without enclosures”. The density of plots within the later type suggested “possible intensification of an earlier field system”. With a series of seven radiocarbon dates, Ladefoged (1993b) went on to argue the entire field system was primarily the result of a historic period boom in the production of potatoes for “gold rush” markets in California. Concurrent surveys within the fields, sponsored National Park Service, resulted in the identification of a unique religious structure through an intensive survey in an area known as Makapulapai—a low hill in the centre of the peninsula (Manning and Neller in prep.). A dense concentration of 60 burial platforms and terraces was recorded and interpreted as correlating with oral traditions of a battle that took place “at the sandbar at Kalaupapa” just before European contact (Fornander 1916-17, Manning and Neller, in prep., McCoy, in prep.).

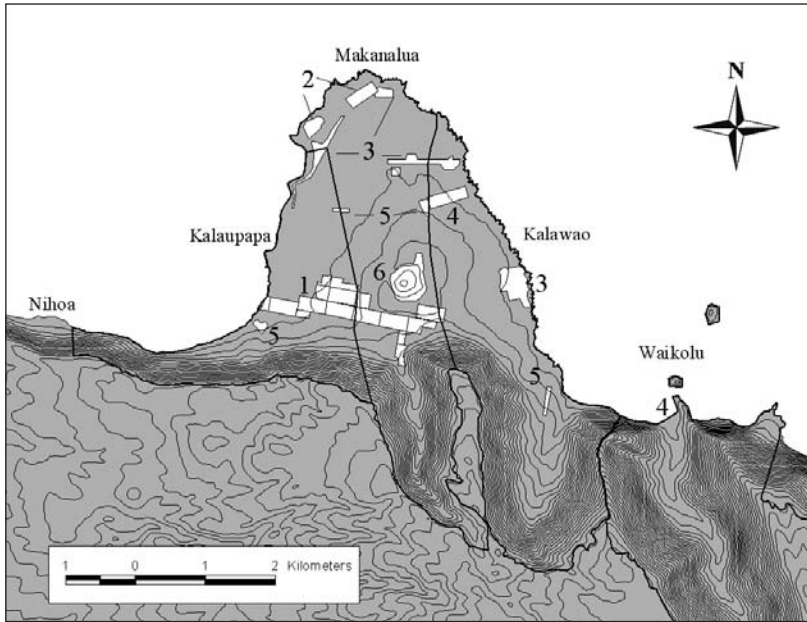


Figure 2. Major Surveys (100ft elevation contours) of the Kalaupapa Region, Moloka'i Island: (1) Somers 1985, (2) Ladefoged 1990, (3) Manning and Neller in prep., (4) Kirch 2002, (5) McCoy 2002, (6) Rechtman and Henry 2002.

Recent work by a team from the University of California, Berkeley, which included surveys in different ecological zones—specifically, the peninsula and several valleys, revealed a remarkably well-preserved archaeological landscape across the region (Kirch 2002:112-13). A wide transect across the centre of the field system, mapped by plane table and alidade, showed a pattern not seen in Ladefoged's (1990) earlier survey. Instead of enclosed fields associated with the historic era, the team found only dense rows of unenclosed alignments and substantial house sites quite unlike the temporary shelters found in other Hawaiian field systems. These findings, combined with a re-evaluation of Kaupikiawa Rockshelter and a date from pondfield deposits in the Waikolu Valley, suggested that early agricultural development in the area was first concentrated in valleys with permanent streams and, perhaps more significantly, that most of the Kalaupapa Field System was in fact likely to have been built before European contact (Kirch 2002:105-7).

Over three field seasons, between 2002 and 2004, extensive surveys and test excavations were conducted within the Kalaupapa Field System (McCoy 2002, 2003a, 2004). In total, 14 percent (456.7 acres/184.8 hectares) of the local area has been intensively surveyed over the past 20 years.<sup>2</sup> This data has been integrated into a single Geographic

Information Systems database. Weisler and Kirch's (1985) hierarchical classification of complexes, compound structures, features and components was employed to break up the continuous archaeological landscape into analytically meaningful subdivisions in the database. It currently includes 222 complexes and compound structures, 74 multiple component features and 204 single component features. The results of this research will be described in detail elsewhere; below I summarise several major findings that are important for understanding the chronology of the fields.

### RADIOCARBON DATING

A total of 27 radiocarbon dates from 20 sites in the Kalaupapa region are presented in Table 2 and Figure 3. Most of the samples are from sites within the field system; a few samples from valley and colluvial environments and a single date from the isolated Nihoa Landshelf provide important contextual information. The only dates on material from the region not reported here are those from natural deposits and a group of dates obtained on unidentified charcoal at a single historic period site (Neller n.d.; see McCoy 2005). Dates are described following a scheme of five periods: the Foundation Period (800-1200), the early and late phases of the Expansion Period (1200-1400 and 1400-1650), the Proto-Historic Period (1650-1795) and the Historic Period (1795-1866).<sup>3</sup>

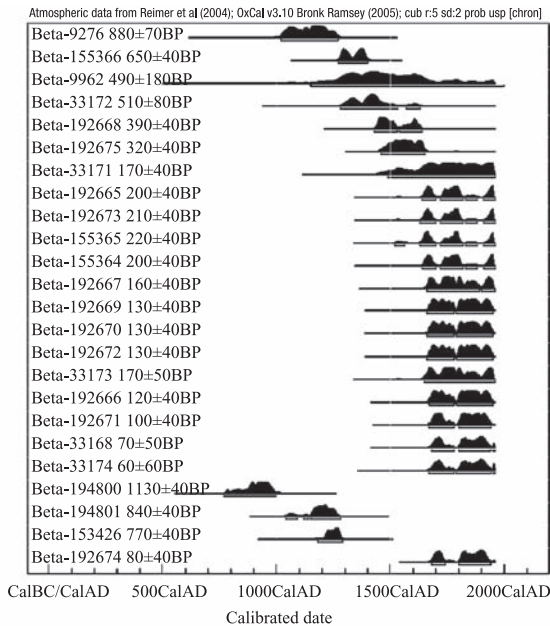


Figure 3. Calibrated Radiocarbon Dates from the Kalaupapa Region, Hawai'i.

Table 2: Radiocarbon Dates from the Kalaupapa Region, Hawai'i.

Laboratory No. (Beta-)	State Site 50-60-03-	Provenience	Material	Measured <sup>14</sup> C Age B.P.	<sup>13</sup> C/ <sup>12</sup> C Ratio (‰)	Conventional <sup>14</sup> C Age B.P.	Calibrated Age (1σ) A.D.	Calibrated Age (2σ) A.D.	Source
-9276	312	Sq 7, Layer D, 23-30 cm	charcoal	-	26.44	880+/-70	1040 - 1220	1020 - 1270	Weisler (1989)
-155366	312	Unit A, Layer VIIb	<i>Antidesma</i> sp.	670+/-40	26.5	650+/-40	1280 - 1390	1270 - 1400	Kirch (2002)
-9962	312	Sq 7, Layer D, 35.5 cm	charcoal	-	23.28	490+/-180	1290 - 1640	1150 - 2000	Weisler (1989)
-33172	1803	Feature 8	charcoal	350+/-80	15.2	510+/-80	1300 - 1460	1280 - 1630	Ladefoged (1990)
-192668	2265	Site C, TU 2, Layer I, Level 1	Unidentified dicot. twig	380+/-40	24.1	390+/-40	1440 - 1620	1430 - 1640	McCoy (rprtd. here)
-192675	2298	Test pit S-48, Layer I	cf. <i>Scaevola</i>	340+/-40	26	320+/-40	1510 - 1650	1460 - 1650	McCoy (rprtd. here)
-33171	1811	Feature 12	charcoal	10+/-120	15.4	170+/-120	1650 - 1960	1490 - 1960	Ladefoged (1990)
-192665	2248	Site A, TU 1, Layer I, Level 1	<i>Chenopodium</i>	190+/-40	24.5	200+/-40	1650 - 1960	1640 - 1960	McCoy (rprtd. here)
-192673	2080	Site H, TU 2, Layer I, Level 1	<i>Chenopodium</i>	220+/-40	25.7	210+/-40	1640 - 1960	1630 - 1960	McCoy (rprtd. here)
-155365	312	Unit A, Layer IV/IV	<i>Chenopodium</i> sp.	240+/-40	26.4	220+/-40	1640 - 1960	1520 - 1960	Kirch (2002)
-155364	312	Unit A, Layer Iia	<i>Sida</i> sp.	200+/-40	24.8	200+/-40	1650 - 1960	1640 - 1960	Kirch (2002)
-192667	2259	Site B, TU 2, Layer I, Level 1	<i>Poaceae</i>	100.7 % modern 0.5	11.6	160+/-40	1660 - 1950	1660 - 1960	McCoy (rprtd. here)

-192669	2267	Site D, TU 1, Layer I, Level 3	<i>Chamaesyce</i>	101.1 % modern 0.5	11.6	130+/-40	1680 - 1940	1660 - 1950	McCoy (rprtd. here)
-192670	2232	Site E, TU 2, Layer I, Level 1	<i>Osteomeles</i>	140+/-40	25.5	130+/-40	1680 - 1940	1660 - 1950	McCoy (rprtd. here)
-192672	2080	Site H, TU 1, Layer I, Level 1	<i>Chenopodium</i>	140+/-40	25.5	130+/-40	1680 - 1940	1660 - 1950	McCoy (rprtd. here)
-33173	1812	Feature 13	charcoal	140+/-50	22.8	170+/-50	1660 - 1960	1650 - 1960	Ladefoged (1990)
-192666	2259	Site B, TU 1, Layer I, Level 1	<i>Chamaesyce</i>	101 % modern 0.5	12.8	120+/-40	1680 - 1930	1670 - 1950	McCoy (rprtd. here)
-192671	2087	Site F, TU 1, Layer I, Level 1	<i>Chamaesyce</i>	101.3 % modern 0.5	12	100+/-40	1690 - 1920	1670 - 1940	McCoy (rprtd. here)
-9275	312	Sq 3, Layer 5, 30-38 cm	charcoal	-	28.71	<120	-	-	Weisler (1989)
-33168	1824	Feature 28	charcoal	110+/-50	27.8	70+/-50	1690 - 1920	1680 - 1960	Ladefoged (1990)
-33174	1826	Feature 31	charcoal	101.3 % modern 0.6	15.1	60+/-60	1690 - 1920	1670 - 1960	Ladefoged (1990)
-33170	1816	Feature 18	charcoal	102.8 % modern 0.6	13.1	100.4 % modern 0.6	-	-	Ladefoged (1990)
-33169	1821	Feature 23	charcoal	102 % modern 0.9	17.2	100.4 % modern 0.9	-	-	Ladefoged (1990)
-194800	2270	KLW-2	charcoal	1180+/-40	28.1	1130+/-40	880 - 980	770 - 1000	McCoy (rprtd. here)
-194801	2303	Site T	charcoal	90+/-40	28.7	840+/-40	1160 - 1255	1040 - 1280	McCoy (rprtd. here)
-153426	2027	WK-1, Section B	<i>Pritchardia</i> sp.	780+/-40	25.7	770+/-40	1220 - 1275	1180 - 1290	Kirch (2002)
-192674	2110	Site J, NI-6	<i>Chenopodium</i>	90+/-40	25.6	80+/-40	1690 - 1920	1680 - 1940	McCoy (rprtd. here)

In all, the chronometric data reviewed here represents the largest body of absolute dates from a single Hawaiian field system. Given the enormous size of other field systems—for example, the Kona Field System, currently known through only 11 dates (M.S. Allen 2004), is over 15 times larger than the Kalaupapa Field System—this also represents the largest sample fraction of features dated by absolute methods.

#### *Foundation Period (800-1200)*

The first signs of people in the area are bracketed by three calibrated radiocarbon dates to between 800 and 1200. The scant evidence from this era—here lumped into a single “Foundation Period” similar to Hommon’s (1976, 1986) “Phase I”—cannot be divided into separate phases of colonisation and development (Kirch 1985). In fact, based on strict chronometric hygiene criteria (e.g., Anderson 1991, Spriggs and Anderson 1993) all three would be rejected since they either do not unambiguously correspond to anthropogenic burning (Beta-194800), come from deposits with material dated to a later period (Beta-9276), or are on unidentified charcoal (Beta-194801, -194800).<sup>4</sup> Nonetheless, the earliest and most reliable of these dates come from the wet colluvial zone. This evidence agrees with the general pattern of settlement found throughout the archipelago and is thus interpreted as indicating the colluvial area and windward valleys were the original location of settlement and agricultural development.

Overall, while the absence of dated habitation sites in the Kalaupapa region until sometime between 1060-1270 (Beta-194801) tends to support a late colonisation of the island, more work on this period is necessary to test this interpretation and to draw out the processes of colonisation and development.

#### *Expansion Period (1200-1650)*

New evidence from what is defined here as the early phase of the Expansion Period (1200-1400) indicates that people were taking advantage of both wetland and dryland environments for agricultural development after 1200. A sample from pondfield deposits in the Waikolu Valley adjacent to the peninsula suggests clearing and cultivation was underway at least by the 13th century (Beta-153426, Kirch 2002:103-5). The lowest level of Kaupikiawa Rockshelter—recently redated to 1200-1300 (Beta-155364) along with new dates from upper layers (Beta-155365 and -155366)—has been interpreted as marking the beginning of 400-500 years of washed-in charcoal and sediment accumulation that “indirectly reflects human activity on the northern end of the Kalaupapa Peninsula, particularly burning of the native dryland forest, possibly associated with horticultural activities” (Kirch *et al.* 2003:24).

Although limited swidden cultivation in dryland environments may have begun as early as 1200 and continued through the 13th century (Beta-33172), widespread burning across the Kalaupapa Peninsula, which signals of the beginning of the Kalaupapa Field System, does not commence until 1450-1550 (Beta-192668 and -192675). Currently there is no evidence that the expansion of the field system was accompanied by the occupation of the peninsula itself, because all six dates before 1650 are from deposits without artefacts or other remains indicative of domestic life. While further research will help resolve this aspect of regional culture history,

the evidence to date supports the notion that the valleys and the colluvial area to the south continued to be the primary zone of occupation throughout the Expansion Period (Beta-194801).

#### *Proto-Historic Period (1650-1795)*

In the Proto-Historic Period (650-1795) a rapid occupation of the peninsula is indicated by samples from four house sites (Beta-33168, -192665, -192672 and -192671), two rockshelters (Beta-9275, -155365, -155366 and -192669), an animal enclosure (Beta-33171), a possible shrine (Beta-33173) and a site interpreted as a men's house (*mua*) (Beta-192666). This transition is readily detectable in rockshelter deposits since levels with artefacts and discarded food remains—including the remains of shellfish, fish and domestic animals—have all been found to date after 1650 (Kirch *et al.* 2003:24-25). This expansion also appears to have included the occupation of the isolated Nihoa Landshef west of the peninsula late in pre-contact history (Beta-192674). The simplest, most straightforward interpretation of this pattern is as a natural by-product of population increase. However, this would contradict demographic reconstructions that indicate the Proto-Historic Period was a stage of population stability or slight decline (Clark 1988, Dye and Komori 1992).

In terms of agriculture, there is good evidence that people continued to actively cultivate the entire area throughout this period (Beta-33174, -192673, -192667 and -192670). Unfortunately, although charcoal evidence is valuable in the Expansion Period as an indicator of swidden practices followed by expansion, this evidence alone is not necessarily a good proxy measure of the process of intensification (see Ladefoged *et al.* 2003, Leach 1999, McCoy 2000). Nonetheless, as in other parts of the islands, the intense field system created out of this process would eventually have been largely abandoned at the end of this period owing to contact-era population collapse. Several observations from survey and excavation support this scenario, including the lack of historic sites and artefacts outside the coastal zone, a widespread pattern of robbing field wall stones to build large walls, and later historical census data that tracks general depopulation (McCoy 2003b, 2005).

Finally, oral traditions, dated through genealogical reckoning to around 1720-1740, suggest it was during this same period that the Makapulapai burial monument was built in the centre of the peninsula (Manning and Neller, in prep., McCoy 2005, in prep.).

#### *Historic Period (1795-1866)*

Following the abandonment of the field system at the end of the 18th century, settlement shifted to small house sites spread along the coast and local roadways. The introduction of cattle in 1830 precipitated the construction of large, architecturally distinct walls to protect fields and yards from roving animals (Greene 1985). In 1849, portions of the fields were reactivated and intensified to supply potatoes and other crops to California's "gold rush" markets (Ladefoged 1993b). The increased value of dry lands (*kula*) that could produce crops for export may explain why Kirch (2002) found that commoners had disproportionately greater difficulty in securing rights to land within communities dominated by high ranking elites (McCoy 2003b). Overall,

the 1850s rejuvenation was cut short in 1866 when local residents were relocated to create a leprosarium. Agricultural activity on the peninsula essentially ceased after this period, with the exception of house gardens and short-lived, small farmsteads (Rechtman and Henry 2002).

## INTERPRETATIONS

The chronology of the Kalaupapa Field System gives us a valuable opportunity to examine the specific historical relationships between agriculture and population expansion, political economy and the relative worth of land in the 19th century.

First, the history of settlement and early agricultural development in the windward Kalaupapa region tends to confirm larger trends seen across the Hawaiian Islands: specifically, the early exploitation of well-watered environments during the Foundation Period (800-1200) and the initiation of dryland horticulture in the early Expansion Period (c. 1200-1300). While these results favour Wiesler's (1989) characterisation of island scale expansion on Moloka‘i, we cannot rule out Athen's (1985) suggestion that some dry, leeward environments were utilised before 1200 (see also Denham *et al.* 1999). Indeed, evidence from other major field systems is equivocal on this topic. The earliest reported evidence of cultivation in the Kohala Field System dates to around 1300 yet the earliest date from the Kona Field System—although not clearly attributable to agricultural activities—does not allow us to rule out the use of dry environments before 1300 (reported as 1018-1277A.D., Beta-128504) (M.S. Allen 2004; see Kirch 2000 for a review of Kohala).

Second, and perhaps more importantly, it appears that not only is there a correlation between rich, geologically young soils and Hawaiian dryland intensive agricultural systems (Vitousek *et al.* 2004), but also the creation of these large-scale systems around 1400 appears to have been nearly simultaneous in both windward and leeward districts. Consequently, the origins of these fields cannot be simply attributed to adaptation to leeward environments, but they must be related to larger processes. There are a number of equally attractive, alternative hypotheses to explain concurrent construction of field systems in the Hawaiian Islands, including the late introduction of the sweet potato (*Ipomoea batatas*), population pressure, an increased demand for social production to fuel the political economy, or a combination of some or all of these (see Kirch 1994). Only further research will help resolve this issue, although it may be telling that 15th century oral traditions referring to the first generations of high chiefs who controlled whole island territories, immediately pre-date this shift in the Hawaiian economy. In fact, M.S. Allen's (2004) recent analysis of the Kona Field System again points to the close relationship between large-scale political change, attested to in oral traditions, and agricultural development. In the case of Kalaupapa, the first evidence of large-scale agriculture seems to have occurred well after oral traditions record the appearance of the first island-wide chiefs, and closely follows upon the rise of the independent Ko‘olau polity.

Third, while the correspondence between the origins of the field system and the rise of the Ko‘olau polity is admittedly tenuous, signs of increased control in late pre-contact history strongly correlate with the fall of Ko‘olau and the unification of the

island. Specifically, the late occupation of the peninsula during a period of population stability is interpreted as a sign of increased control. Similar observations have been made in the late development of the southern, marginal region of the Kohala Field System, interpreted by Ladefoged and Graves (2000) as a sign of increasing chiefly control (see also Ladefoged *et al.* 2003, McCoy 2000).

The construction of a monumental burial complex overlooking the area—the largest single structure on the peninsula—also suggests an attempt to influence people’s lives through the ritual landscape during this period. Kolb (1994, 1997), noting a correspondence between the size of religious architecture and the scale of socio-political control reported in oral traditions, suggested a decrease in the size of temples (*heiau*) late in the pre-contact history of Maui Island was indicative of power moving from the district or island scale to the community scale. Kirch and Sharp’s (2005) recent dating of temple (*heiau*) offerings on Maui and Moloka‘i—interpreted as indicating the construction of a geographically extensive temple system over a short period between 1580-1640—again confirms the correlation between political control hierarchies and ritual construction (see also Kirch 1990). In Kalaupapa, the construction of a burial monument, spread over five times the surface area of the next largest structure in the region, would appear to also conform to this relationship, if in a post-hoc manner, by commemorating the subjugation of a district (*moku*) scale polity. In this case, the construction of the monument may have been an attempt to resist outside political control by shaping the social landscape in such a way that it could serve to re-enforce Ko‘olau group identity, developed during the rise of the polity. The location of the monument within the fields, rather than on the coast where oral traditions put the location of the battle, again may have worked to reinforce socio-political relations formed over the previous period.

Finally, the historic period transformation of the landscape has important implications for the interpretation of 19th century land claim records. Although other examples surely exist, the Kalaupapa Field System is currently the only documented case of historic period reintensification of a formal dryland field system attributable to the boom in Hawaiian agriculture following the 1849 discovery of gold in California (Ladefoged 1993b). Documents from the Great Māhele land division—a process coeval with re-intensification—suggest that commoners had a disproportionately difficult time securing land claims (Kirch 2002). If the boom in potato exports raised the value of abandoned fields, this pattern may be explained as a by-product of the elite’s attempts to secure their share of the market at the expense of commoners. Future analysis of land claim records from the historic period should take care to account for this apparent rise in the value of some dry lands (*kula*) in the 19th century.

\* \* \*

The Kalaupapa Field System, although initially regarded as a 19th century phenomenon, has a remarkably long history with several important implications for the association between agriculture, environment and political economy in traditional Hawaiian society. The chronology presented here supports a generalised settlement model that proposes a preference for wet environments across time and the initial use

of dry environments for small-scale swidden agriculture during the early Expansion Period (c. 1200-1400). However, the limited evidence of either dryland horticulture, dating to the 13th century, or early use of wetland environments, during what is called here the Foundation Period (800-1200), makes it difficult to characterize these stages of agricultural development (Leach 1999). Nonetheless, the use of a cross-section of island environments, later codified in community territories (*ahupua‘a*), does appear to have its roots in the Expansion Period even in windward districts (Hommon 1976, 1986).

The rapid expansion of agriculture in the late Expansion Period (1400-1650)—here defined as the earliest phase of the Kalaupapa Field System—demonstrates that this aspect of the Hawaiian economy was not solely the natural by-product of population expansion into leeward districts. The coincidence between the initiation of dryland intensive agriculture and the rise of a polity centred on the windward communities of the Ko‘olau District is tantalising, but current archaeological evidence does not allow us to directly comment on the relationship between these processes. In the future, research on ritual sites in and around agricultural field systems will help build a more holistic picture of the evolution of ritual and agricultural landscapes and a fuller understanding of Hawaiian culture history (see, for an example, Mulrooney and Ladefoged 2005).

Finally, in the Proto-Historic Period (1650-1795) the construction of a monumental scale ritual structure and the sudden occupation of the fields during relative population stability are together interpreted as signs of increasing political control in this newly used landscape. In this case, oral traditions allow us to associate this shift with the fall of the Ko‘olau polity and the political unification of the island (1740-1795). Naturally, a more fine-grained demographic model for the Hawaiian Islands would help test this presumed association between social production and political economy. Overall, Oceanic archaeologists should continue to examine the relationship between environment and political economy by identifying examples of chiefdoms that developed in diverse island environments.

#### ACKNOWLEDGEMENTS

Radiocarbon dates not reported elsewhere were funded by a grant from the Arizona Memorial Museum Association to the author; in Kalaupapa logistical support was provided The National Park Service; excavations were conducted under ARPA permit from the United States Department of the Interior. Special thanks are owed to Patrick Kirch for introducing me to Kalaupapa and for his continued support, and to project volunteers for their hard work. I would also like to thank the following individuals, groups and institutions for their assistance and support: Jennifer Cerny, David Duffy, Rob Hommon, Ka ‘Ohana o Kalaupapa, the State of Hawai‘i’s Department of Hawaiian Homelands and Department of Health, Thegn Ladefoged and Tom Workman. Thanks also to the Polynesian Society’s editors for all their efforts in editing this article’s final draft.

## NOTES

1. Since all dates cited in this article are obviously A.D., the abbreviation will not be used again.
2. This estimate is based on the portion of level, habitable land surveyed within the three communities of Kalaupapa, Makanalua, and Kalawao. It is important to keep in mind that, in this case, habitable land only accounts for just over half the total area within these territories (e.g., approximately 13.2km<sup>2</sup> out of 20.8km<sup>2</sup>), but is greater than the total area covered by the Kalaupapa Field System (9km<sup>2</sup>).
3. This scheme differs slightly from previous culture histories (Hommon 1976, Kirch 1985, Weisler 1989), specifically in the proposed “Foundation Period” and slightly later start of the Expansion Period. The Foundation Period groups processes of “colonisation” and “development” into a single period but is not meant to replace these phases as defined elsewhere.
4. These samples were split before they were sent in for age determinations so identification is still possible.

## REFERENCES

- Allen, J., 1991. The role of agriculture in the evolution of the pre-contact Hawaiian state. *Asian Perspectives*, 30:117-32.
- Allen, Melinda S., 2001. *Gardens of Lono: Archaeological Investigations at the Amy B.H. Greenwell Ethnobotanical Garden, Kealakekua, Hawai‘i*. Honolulu: Bernice P. Bishop Museum.
- 2004. Bet-hedging strategies, agricultural change, and unpredictable environments: Historical development of dryland agriculture in Kona, Hawaii. *Journal of Anthropological Archaeology*, 23(2):196-224.
- Anderson, Atholl J., 1991. The chronology of colonization in New Zealand. *Antiquity*, 65:767-95.
- Anderson, Atholl J. and Yosihiko Sinoto, 2002. New radiocarbon ages of colonization sites in East Polynesia. *Asian Perspectives*, 41:2.
- Athens, J. Stephen, 1985. *Prehistoric Investigations at an Upland Site on the Leeward Slopes of Central Molokai*. Honolulu: International Archaeological Research Institute, Inc.
- 1989. *Archaeological Reconnaissance, Airport Improvement Project, Kalaupapa, Molokai*. Honolulu: International Archaeological Research Institute, Inc.
- Athens, J. Stephen and Jerome V. Ward, 1993. Environmental change and prehistoric Polynesian settlement in Hawai‘i. *Asian Perspectives*, 32(2):205-23.
- Athens, J. Stephen, Jerome V. Ward, H. David Tuggle, and David J. Welch, 1999. *Environment, Vegetation Change, and Early Human Settlement on the ‘Ewa Plain: A Cultural Resource Inventory of Naval Air Station, Barbers Point O‘ahu, Hawai‘i, Part III: Paleoenvironmental Investigations*. Prepared for Pacific Division, Naval Facilities Engineering Command, U.S. Navy by International Archaeological Research Institute, Inc.

- Athens, J. Stephen, Jerome V. Ward, H. David Tuggle, and David J. Welch, 2002. Avifaunal extinctions, vegetation change, and Polynesian impacts in prehistoric Hawai'i. *Archaeology in Oceania*, 37:57-78.
- Bonk, William J. 1954. Archaeological Excavations on West Molokai. Unpublished M.A. thesis, University of Hawai'i, Manoa.
- Cachola-Abad, C. Kehau, 2000. The Evolution of Hawaiian Socio-Political Complexity: An Analysis of Hawaiian Oral Traditions. Unpublished Ph.D. dissertation, University of Hawai'i, Manoa.
- Chun, M.N. and Matthew Spriggs, 1987. New terms suggested for early Hawaiian history. *Ka Wai Ola Oha, Monthly Newspaper of the Office of Hawaiian Affairs*, 4(2):4.
- Clague, D.A., C. Dao-gong, R. Murnane, M.H. Beeson, A. Lanphere, G.B. Dalrymple, W. Friesen and R.T. Holcomb, 1982. Age and petrology of Kalaupapa Basalt, Molokai, Hawaii. *Pacific Science*, 36(4):411-20.
- Clark, Jeffery T., 1988. Paleodemography in leeward Hawai'i. *Archaeology in Oceania*, 23:22-30.
- Clark, Jeffery T. and Patrick V. Kirch, 1983. *Archaeological Investigations in the Mudlant-Waimea-Kawaihae Road Corridor, Island of Hawaii: An Interdisciplinary Study of Environmental Transect*. Department of Anthropology Report No. 83-1. Honolulu: Bernice P. Bishop Museum.
- Coil, James, 2004. "The Beauty That Was": Archaeological Investigations of Ancient Hawaiian Agriculture and Environmental Change in Kahikinui, Maui, Hawaiian Islands. Unpublished Ph.D. dissertation, University of California, Berkeley.
- Cordy, Ross, 1996. The rise and fall of the O'ahu Kingdom: A brief overview of O'ahu's history. In J.M. Davidson, G. Irwin, B.F. Leach, A. Pawley and D. Brown (eds), *Oceanic Culture History: Essays in Honour of Roger Green*. Auckland: New Zealand Journal of Archaeology Special Publication, pp. 591-613.
- 2000. *Exalted Sits the Chief: The Ancient History of Hawaii Island*. Honolulu: Mutual Publishing.
- Dega, Michael F. and Patrick V. Kirch, 2002. A modified culture history of Anahulu Valley, O'ahu, Hawai'i, and its significance for Hawaiian prehistory. *Journal of the Polynesian Society*, 111: 107-26.
- Denham, Tim, Francis J. Eble, Barbara Winsborough and Jerome V. Ward, 1999. Palaeoenvironmental and archaeological investigations at 'Ohi'apilo Pond, leeward coast of Moloka'i. *Hawaiian Archaeology*, 7:35-60.
- Dye, Thomas S., 1992. The South Point radiocarbon dates thirty years later. *New Zealand Journal of Archaeology*, 14:89-97.
- Dye, Thomas S. and E. Komori, 1992. A pre-censal population history of Hawai'i. *New Zealand Journal of Archaeology*, 14:113-28.
- Foote, Donald E., Elmer L. Hill, Sakuichi Nakamura and Floyd Stephens, 1972. *Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii*. United States Department of Agriculture. Washington D.C.: United States Printing Office.
- Fornander, Abraham, 1916-17. *Hawaiian Antiquities and Folk-lore*. Bernice P. Bishop Museum Memoirs 4. Honolulu.

- Goodwin, Conrad M., 1994. *A Kalaupapa Sweet Potato Farm: Report on Archaeological Data Recovery Operations, Kalaupapa Airport Improvement Project, Kalaupapa, Molokai, Hawai'i*. Honolulu: International Archaeological Research Institute, Inc.
- Graves, Michael W. and David J. Addison, 1995. The Polynesian settlement of the Hawaiian Archipelago: Integrating models and method in archaeological interpretation. *World Archaeology*, 26:380-99.
- Graves, Michael W., Blaze V. O'Conner and Thegn N. Ladefoged, 2002. Tracking changes in community-scaled organization in Kohala and Kona, Hawai'i Island. In T.N. Ladefoged and M.W. Graves (eds), *Pacific Landscapes: Archaeological Approaches*. Los Osos: The Easter Island Foundation, pp.233-54.
- Green, Roger C. 1980. *Makaha Before 1880 A.D.* Pacific Anthropological Records 31. Honolulu: Bernice P. Bishop Museum.
- Greene, Linda W. 1985. *Exile in Paradise: The Isolation of Hawai'i's Leprosy Victims and Development of Kalaupapa Settlement, 1865 to Present*. Branch of Planning Alaska/Pacific Northwest/Western Team. Denver: United States Department of the Interior, National Park Service.
- Hirata, J. and L. Potts, 1967 MS. A Preliminary Study Based on Midden Analysis: Cave 1, Kalaupapa Peninsula, Molokai. Unpublished manuscript, University of Hawai'i, Manoa.
- Hommon, Robert J., 1976. The Formation of Primitive States in Pre-contact Hawaii. Unpublished Ph.D. dissertation, University of Arizona, Tucson.
- 1986. Social evolution in ancient Hawai'i. In P.V. Kirch (ed.), *Islands Societies: Archaeological Approaches to Evolution and Transformation*. Cambridge: Cambridge University Press, pp.55-68.
- Hunt, Terry L. and R.M. Holson, 1991. An early radiocarbon chronology for the Hawaiian Islands: A preliminary analysis. *Asian Perspectives*, 30(1):147-61.
- Kirch, Patrick V., 1984. *The Evolution of the Polynesian Chiefdoms*. Cambridge: Cambridge University Press.
- 1985. *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory*. Honolulu: University of Hawai'i.
- 1990. Monumental architecture and power in Polynesian chiefdoms: A comparison of Tonga and Hawaii. *Journal of World Archaeology*, 2:206-22.
- 1994. *The Wet and the Dry: Irrigation and Agricultural Intensification in Polynesia*. Chicago: University of Chicago.
- 2000. *On the Road of the Winds: An Archaeological History of the Pacific Islands Before European Contact*. Berkeley: University of California Press.
- 2002. *From the 'Cliffs of Keolewa' to the 'Sea of Papaloa': An Archaeological Reconnaissance of Portions of the Kalaupapa National Historical Park, Moloka'i, Hawaiian Islands*. Berkeley: Archaeological Research Facility, University of California, Berkeley.
- Kirch, Patrick V., Anthony S. Hartshorn, Oliver A. Chadwick, Peter M. Vitousek, D.R. Sherrod, James Coil, Lisa Holm and Warren D. Sharp, 2004. Environment, agriculture, and settlement patterns in a marginal Polynesian landscape. *Proceedings of the National Academy of Science*, 1(26):9936-41.

- Kirch, Patrick V. and Marion Kelly (eds), 1975. *Prehistory and Ecology in a Windward Hawaiian Valley: Halawa Valley, Molokai*. Honolulu: Bernice P. Bishop Museum.
- Kirch, Patrick V., S. O'Day, J. Coil, M. Morgenstein, K. Kawelu and M. Millerstrom, 2003. The Kaupikiawa Rockshelter, Kalaupapa Peninsula, Moloka'i: New investigations and reinterpretation of its significance for Hawaiian prehistory. *People and Culture in Oceania*, 19:1-27.
- Kirch, Patrick V. and Warren D. Sharp, 2005. Coral 230Th dating of the imposition of a ritual control hierarchy in precontact Hawaii. *Science*, 307:102-4.
- Kolb, Michael J., 1991. Social Power, Chiefly Authority, and Ceremonial Architecture in an Island Polity, Maui, Hawaii. Unpublished Ph.D. dissertation, University of California, Los Angeles.
- 1994. Monumentality and the rise of religious authority in precontact Hawaii. *Current Anthropology*, 35(5):521-47.
- 1997. Labor mobilization, ethnohistory, and the archaeology of community in Hawai'i. *Journal of Archaeological Method and Theory*, 4(3-4):265-85.
- Ladefoged, Thegn N., 1990. *A Dryland Agricultural System at Kalaupapa, Moloka'i: Archaeological Inventory Survey, Airport Improvement Project*. Honolulu: International Archaeological Research Institute, Inc.
- 1993a. Evolutionary Process in an Oceanic Chiefdom: Intergroup Aggression and Political Integration in Traditional Rotuman Society. Unpublished Ph.D. dissertation, University of Hawai'i, Manoa.
- 1993b. Hawaiian dryland agricultural intensification and the Pacific economy. *Pacific Studies*, 16(2):119-31.
- Ladefoged, Thegn N. and Michael W. Graves, 2000. Evolutionary theory and the historical development of dry-land agriculture in North Kohala, Hawai'i. *American Antiquity*, 65(3):423-48.
- Ladefoged, Thegn N., Michael W. Graves and Richard P. Jennings, 1996. Dryland agricultural expansion and intensification in Kohala, Hawai'i Island. *Antiquity*, 70:861-80.
- Ladefoged, Thegn N., Michael W. Graves and Mark D. McCoy, 2003. Archaeological evidence for agricultural development in Kohala, Island of Hawai'i. *Journal of Archaeological Science*, 30:923-40.
- Leach, Helen, 1999. Intensification in the Pacific: A critique of the archaeological criteria and their application. *Current Anthropology*, 40:326-28.
- Macdonald, G.A., A.T. Abbott and F.L. Peterson, 1983 [1970]. *Volcanoes in the Sea: The Geology of Hawaii*. 2nd edition. Honolulu: University of Hawaii Press.
- Manning, Elizabeth and Earl Neller, in prep. Makapulapai survey. In M.D. McCoy (ed.), *Kalaupapa Archaeology: A Collection of Five Surveys in the Kalaupapa National Historical Park*. Honolulu: Research Corporation of the University of Hawai'i and The National Park Service, United States Department of the Interior.
- Masse, W. Bruce and H. David Tuggle, 1998. The date of Hawaiian colonization. In C.M. Stevenson, G. Lee, and F.J. Morin (eds), *Easter Island in Pacific Context. Proceedings of the Fourth International Conference on Easter Island and East Polynesia*. Los Osos, California: Bearsville and Cloud Mountain Press, pp. 229-35.

- McCoy, Mark D., 2000. Agricultural Intensification and Land Tenure in Prehistoric Hawai'i. Unpublished M.A. thesis, Department of Anthropology, University of Auckland.
- 2002. Report on Kalaupapa Peninsula Archaeological Project 2002. Report on file with the United States National Park Service and Hawaii State Historic Preservation Office.
- 2003a. Report on Kalaupapa Peninsula Archaeological Project 2003. Report on file with the United States National Park Service and Hawaii State Historic Preservation Office.
- 2003b. Social Organization and Community Structure in the Hawaiian Islands: Developing the Archaeology of Communities on the Kalaupapa Peninsula, Moloka'i Island, Hawai'i. Paper presented at the 68th Annual Meeting of the Society for American Archaeology, 9-13 April 2003, Milwaukee.
- 2004. Report on Kalaupapa Peninsula Archaeological Project 2004. Report on file with the United States National Park Service and Hawaii State Historic Preservation Office.
- 2005. *The Lands of Hina: An Archaeological Overview and Assessment of Kalaupapa National Historical Park, Moloka'i Island*. Technical Report 135. Honolulu: Pacific Cooperative Studies Unit of the University of Hawai'i and National Park Service, United States Department of the Interior.
- in press. *Mo'olelo Kalaupapa: The Archaeology, Oral Traditions and History of Kalaupapa National Historical Park*. Honolulu: Arizona Memorial Museum Association.
- in prep. Conclusions. In M.D. McCoy (ed.), *Kalaupapa Archaeology: A Collection of Five Surveys in the Kalaupapa National Historical Park*. Honolulu: Research Corporation of the University of Hawai'i and National Park Service, United States Department of the Interior.
- McCoy, M.D., Anthony S. Hartshorn and Oliver A. Chadwick, 2004. The Origins of the Kalaupapa Field System: A Geographic Information Systems Based Study of the Kalaupapa Peninsula, Moloka'i Island, Hawai'i. Paper presented at the 2004 Society for Hawaiian Archaeology Meeting, Kailua-Kona.
- Mulrooney, Mara M. and Thegn N. Ladefoged, 2005. Hawaiian *heiau* and agricultural production in the Kohala dryland field system. *Journal of the Polynesian Society*, 114:45-67.
- Neller, n.d. Correspondence on file with National Park Service, Kalaupapa National Historical Park.
- Pearson, Richard, J. Hirata, L. Potts and F. Harby, 1974. Test pitting of Cave 1, Kalaupapa Peninsula, Molokai, Hawaii. *New Zealand Archaeological Association Newsletter*, 17:44-49.
- Phelps, S., 1937 MS. A Regional Study of Molokai. Unpublished manuscript on file in Bernice P. Bishop Museum Archives, Honolulu.
- Rechtman, Robert B. and J.D. Henry, 2002 MS. Archaeological investigations at Kauhako Crater, Kalaupapa National Historical Park (KALA). Report on file with the United States National Park Service.

- Rosendahl, Paul H., 1972. Aboriginal Agriculture and Residence Patterns in Upland Lapakahi, Island of Hawaii. Unpublished Ph.D. dissertation, University of Hawaii, Manoa.
- 1994. Aboriginal Hawaiian structural remains and settlement patterns in the upland agricultural zone at Lapakahi, Island of Hawai‘i. *Hawaiian Archaeology*, 3:14-70.
- Somers, Gary F., 1985. *Kalaupapa, More Than a Leprosy Settlement: Archaeology at Kalaupapa National Historical Park*. Tucson: National Park Service.
- Spriggs, Matthew and Atholl J. Anderson, 1993. Late colonization of East Polynesia. *Antiquity*, 67:200-17.
- Sterns, H.T. and G.A. MacDonald, 1947. *Geology and Ground-Water Resources of the Island of Molokai, Hawaii*. Hawaii Division of Hydrography Bulletin 11. Honolulu.
- Stokes, John F.G., 1909 MS. Heiau of Molokai. In W.T. Bringham (ed.), *The Ancient Worship of the Hawaiian Islanders*. Unpublished manuscript on file in the Bernice P. Bishop Museum.
- Summers, Catherine C., 1971. *Moloka‘i: A Site Survey*. Honolulu: Bernice P. Bishop Museum.
- Tuggle, H. David and P. Bion Griffin (eds), 1973. *Lapakahi, Hawaii: Archaeological Studies*. Honolulu: Social Science Research Institute, University of Hawai‘i.
- Tuggle, H. David and Matthew Spriggs, 2000. The age of the Bellows Dune Site O18, O‘ahu, Hawai‘i, and the antiquity of Hawaiian colonization. *Asian Perspectives*, 39(1-2):165-88.
- Vitousek, Peter, Oliver Chadwick, Pamela Matson, Steven Allison, Louis Derry, Lisa Kettley, Amy Luers, Esther Mecking, Valerie Monastra and Stephen Porder, 2003. Erosion and the rejuvenation of weathering-derived nutrient supply in an old tropical landscape. *Ecosystems*, 6:762-72.
- Vitousek, Peter M., Thegn N. Ladefoged, Patrick V. Kirch, Anthony S. Hartshorn, Michael W. Graves, Sara C. Hotchkiss, Shripad Tuljapurkar and Oliver A. Chadwick, 2004. Soils, agriculture, and society in precontact Hawai‘i. *Science*, 304(5677):1665-69.
- Weisler, Marshall, 1989. Chronometric dating and late Holocene prehistory in the Hawaiian Islands: A critical review of radiocarbon dates Moloka‘i Island. *Radiocarbon*, 31:121-45.
- Weisler, Marshall and Patrick V. Kirch, 1985. The structure of settlement space in a Polynesian chiefdom: Kawela, Molokai, Hawaiian Islands. *New Zealand Journal of Archaeology*, 7:129-58.