

Settlement Pattern Change in Hawai'i: Testing a Model for the Cultural Response to Population Collapse



MARIA SWEENEY

SUBSTANTIAL CHANGES OCCURRED in the Hawaiian islands after European contact in 1778. The breaking of *kapu* in 1819 and the great *māhele* (land division) of 1848 are testimonials to some of the major structural reorganizations that took place during this time. The process of urbanization and the imposition of a market economy also attest to historic change. Certain aspects of change are manifested in the archaeological record, and these may provide evidence regarding the processes associated with structural transformations in post-Contact Hawai'i. In particular, the issue of population collapse can be addressed through the study of historic architectural change. This paper compares several aspects of Hawaiian settlement patterns in the prehistoric and historic periods, in order to examine the nature of architectural change in residential areas.

AN ETHNOHISTORIC MODEL

Few settlement pattern studies in Hawai'i focus on change between the prehistoric and historic eras. However, one recent study (Ladefoged 1987, 1991) proposed that a change in the traditional concept of purity may be associated with changes in Hawaiian house forms in the historic period at the Hawai'i Volcanoes National Park. Ladefoged postulates that "the historic de-emphasis of *mana* [supernatural or divine power]" led to an ideological transformation in which the spatial separation of potentially polluting activities within Hawaiian households diminished in importance.

Traditionally, a residential complex comprised "a cluster of separate houses and shelters, each structure restricted to certain household members and used for specific functions" (Weissler and Kirch 1985:141). The major differences between prehistoric and historic settlement patterns in Volcanoes National Park included an increase in the number of spatially defined areas within architectural features and an increase in the density of features associated with residential complexes in the his-

Maria Sweeney is a graduate student in the Department of Anthropology, University of Hawaii, Honolulu, HI.

Asian Perspectives, Vol. 31, no. 1, © 1992 by University of Hawaii Press. All rights reserved.

toric period (Ladefoged 1987:183). These architectural changes in households and settlements are thought to reflect a "structural transformation of Hawaiian society during the historic era" (Ladefoged 1991:67). A series of political, economic, and religious changes led Hawaiians to "incorporate foreign notions of domestic space possibly in an effort to symbolically associate themselves with Europeans for economic gain" (Ladefoged 1991:67).

The breakdown of household activity segregation and changes in the Hawaiian concepts of purity, or *mana*, may not have awaited this series of political, economic, and religious changes that occurred after missionization. Instead, settlement pattern change may predate the arrival of missionaries in the 1820s. Missionary accounts reveal that the imposition of Christianity on Hawaiians was facilitated by the breaking of *kapu* before the missionaries' arrival (Stewart 1970; Bingham 1981; Ellis 1969). Settlement pattern change during the historic period must also be considered in relation to the substantial loss of the native Hawaiian population, which accompanied European contact and American missionization. Stannard (1988) charges that diseases introduced by Europeans had a tremendous effect on the Hawaiian population, beginning with first contact when coastal populations would have been the most heavily hit. The subsequent decline in population was catastrophic; Stannard (1988:50) argues that between 1778 and the early 1890s the total population of the islands dropped 90–95 percent. Under this scenario, disease must have affected whole communities, undoubtedly reducing the total number of people within groups, altering the distribution of population across settlements within traditional land units, and changing the population's age structure.

The loss in numbers in particular areas may also be due to a shift of populations to urban centers (Daws 1967). Internal migration, then, might have redistributed portions of the population. This kind of shift would have been especially noticeable on O'ahu, where since the 1800s the Honolulu harbor has functioned as a major trading center. In 1820, Liholiho opened up venues for trade by allowing most chiefs a share in the enterprise (Kuykendall 1947:89). This, in turn, may have resulted in the movement of chiefs, who formerly resided in outer areas, to urban centers or port towns. For chiefs living in remote areas or environments of low productivity, the opportunity to participate in or manage trade would have been advantageous. In addition to the serious effect of disease, emigration to urban areas would have contributed to the depopulation of rural communities.

One study has found that research on settlement patterns can be a valuable means to detect major demographic changes as a result of European contact (Ramenofsky 1987). Unfortunately, previous settlement pattern studies in Hawai'i have not been directed toward this kind of topic or analysis. In part, this reflects the archaeological emphasis on investigating the prehistoric period and an unstated but pervasive belief that Hawaiian culture changed little during the nineteenth century. Moreover, archaeologists' ability to infer occupation during different portions of the historic period is hampered by methodological problems. Typically, the presence or absence of historic artifacts and materials determines the temporal classification for a site or set of features. However, archaeologists most often are dating not the earliest phase of the historic period, but rather the time period represented by the incorporation of European goods in different areas of the archipelago. The time lag between first European contact, the introduction of foreign goods, and the spread of these items to nonurban and peripheral areas is still unclear. More rigorous chronological con-

control is necessary in order to document archaeologically the effects of historic-period disease, concomitant population collapse, and migration. Unfortunately, the data available at this time do not permit direct measurement of population collapse, but only of the resulting spatial reorganization that occurred during the historic period.

Nevertheless, I describe a model to explain the process by which these changes may have occurred throughout the islands and the impact such changes would have left on the archaeological record. European contact brought disease to the archipelago in the years before nonnative populations became established. These diseases quickly spread through a pristine population to the various Hawaiian islands, resulting in an initial population collapse, much of it concentrated along the coast. Later, trade and contact continued to expose Hawaiian populations to several unfamiliar diseases to which they had little or no resistance. Patterns of spatial population distribution began to change, where increased mortality affecting people of all ages caused traditional production to fall. This loss of numbers stimulated inland dwellers, or those who lived there seasonally, to move seaward where they could rely on coastal resources. The surviving inhabitants of a community may have taken the opportunity to move into dwellings formerly occupied by their relatives, to take them over or to maintain them. Expansion of European trade further stimulated a movement toward the coast where trade opportunities occurred and away from less optimal areas inland. A further attritional drop in population was experienced as Hawaiian populations aggregated into these coastal settlements. Depopulation at this magnitude, combined with relocation and decreased production, created stress on the traditional cultural system of Hawaiians and paved the way for rapid social and ideological change.

Ramenofsky (1987) has argued that when a change in demographic patterns at the time of European contact is catastrophic—that is, due to rapid depopulation—significant change should be indicated through a major shift in settlement location, changes in population density, and possibly differences in the structural arrangement of homes. If change is not catastrophic, then attritional patterns of change will be indicated by relative stability in these variables. In the remainder of this paper, I investigate the nature of settlement pattern change during the historic period.

BACKGROUND TO THE STUDY

The *ahupua'a* (land units) of Lapakahi, Hawai'i, and Mākaha Valley, O'ahu, were selected for study because they are the best documented traditional land divisions for the Hawaiian archipelago (Fig. 1). An *ahupua'a* is the Hawaiian equivalent of a community, but here it represents a land unit, often extending from the ocean to the mountains. Kirch (1984:28) defines the *ahupua'a* as "a radial land division, under the control of a chief, and sometimes considered to be an economically self-sufficient unit." The initial occupations of Lapakahi and Mākaha Valley are believed to have occurred at roughly the same time: A.D. 1300 for Lapakahi (Tuggle and Griffin 1973:61) and A.D. 1100 for Mākaha Valley (Green 1970a:104). Both locations are characterized by early coastal occupation followed by movement inland. Both *ahupua'a* are located on leeward coasts, and in certain respects are considered less than optimal settlement areas. Both have a good representation of features suitable for this analysis from both the pre-Contact and post-Contact eras (Table 1). The *ahupua'a* of Lapakahi covers an area of approximately 9 km² and has a low-cliffed

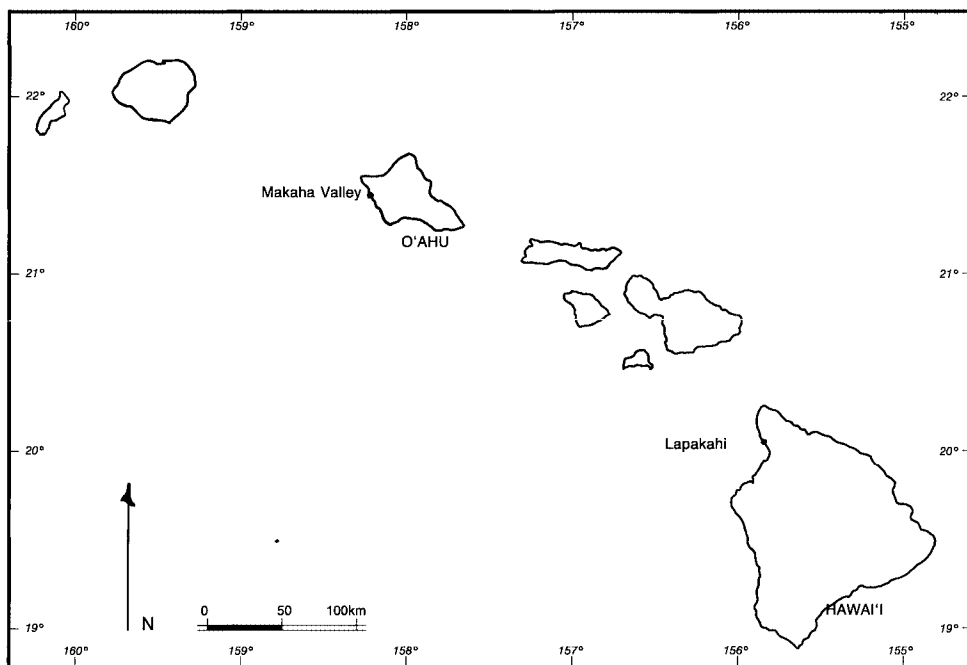


Fig. 1. Map of the Hawaiian Islands showing locations for Lapakahi on Hawai'i and Mākaha Valley on O'ahu.

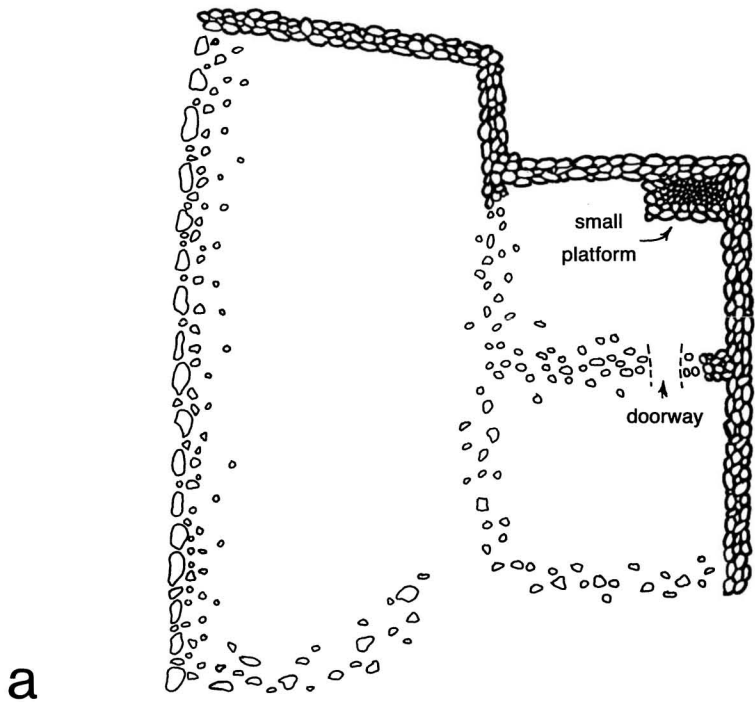
volcanic coast with an undissected upland. Mākaha Valley covers an area of approximately 15 km² and is located in the Waianae range, where the lower reaches are located on a sandy plain and the upper area is composed of cliffs and valleys.

The data were compiled from the published site reports for Lapakahi (Pearson 1969; Newman 1968, 1970; Rosendahl 1972; Tuggle and Griffin 1973) and Mākaha Valley (Green 1969, 1970*b*, 1980; Ladd 1973; Ladd and Yen 1972; Neller 1984). Supplemental information was obtained from the field records for both *ahupua'a*, on file at the Bishop Museum, Honolulu.

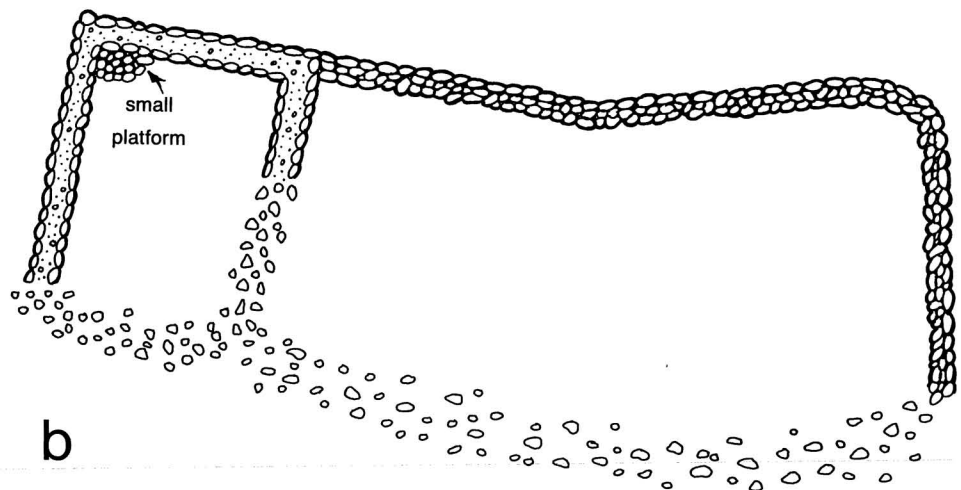
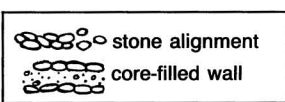
The unit of analysis for much of this study is the *feature*, here defined as a structure not linked morphologically to any other structure (Fig. 2). *Components* represent subunits of space within a feature that are morphologically distinct from other spaces but always contiguous to one another. For example, areas marked off by rock alignments, walls, and pavings represent components (Fig. 3). Only features located in residential complexes are the domain of this analysis. The definition of a complex follows that of Ladefoged (1987:38): "three or more residential components or features that are separated from other residential components or features by 40 or more meters." Figure 4 shows an example of a residential complex in lower Mākaha Valley. This complex includes features associated with a house structure, with cooking and food processing, and with tool manufacturing and maintenance. Indications of agricultural activity are also present in the form of planting mounds and terraces. Several observations about each feature within a residential complex were recorded: (1) the period of occupation (prehistoric or historic); (2) its location, whether inland

TABLE 1. BREAKDOWN OF FEATURES AND COMPLEXES USED IN THE ANALYSIS OF SETTLEMENT PATTERNS AT LAPAKAHI AND MĀKAHA VALLEY

| LAPAKAHI | COAST | | INLAND | | TOTAL (<i>n</i>) | |
|--------------------|--------------|-----------|--------------|-----------|--------------------|-----------|
| | FEATURES | COMPLEXES | FEATURES | COMPLEXES | FEATURES | COMPLEXES |
| Prehistoric (%) | 30.7 | 34.5 | 25.7 | 24.1 | 79 | 17 |
| Historic (%) | 39.3 | 37.9 | 4.3 | 3.5 | 61 | 12 |
| Total (<i>n</i>) | 98 | 21 | 42 | 8 | 140 | 29 |
| MĀKAHA VALLEY | LOWER VALLEY | | UPPER VALLEY | | TOTAL (<i>n</i>) | |
| | FEATURES | COMPLEXES | FEATURES | COMPLEXES | FEATURES | COMPLEXES |
| Prehistoric (%) | 66.4 | 69.2 | 2.6 | 3.9 | 80 | 19 |
| Historic (%) | 25.9 | 23.1 | 5.2 | 3.9 | 36 | 7 |
| Total (<i>n</i>) | 107 | 24 | 9 | 2 | 116 | 26 |



a



b

Fig. 2. Examples of two Hawaiian archaeological features, each with more than one component: a, house with two rooms, small platform, and large terrace area; b, structure with single room, small platform, and side terrace area.

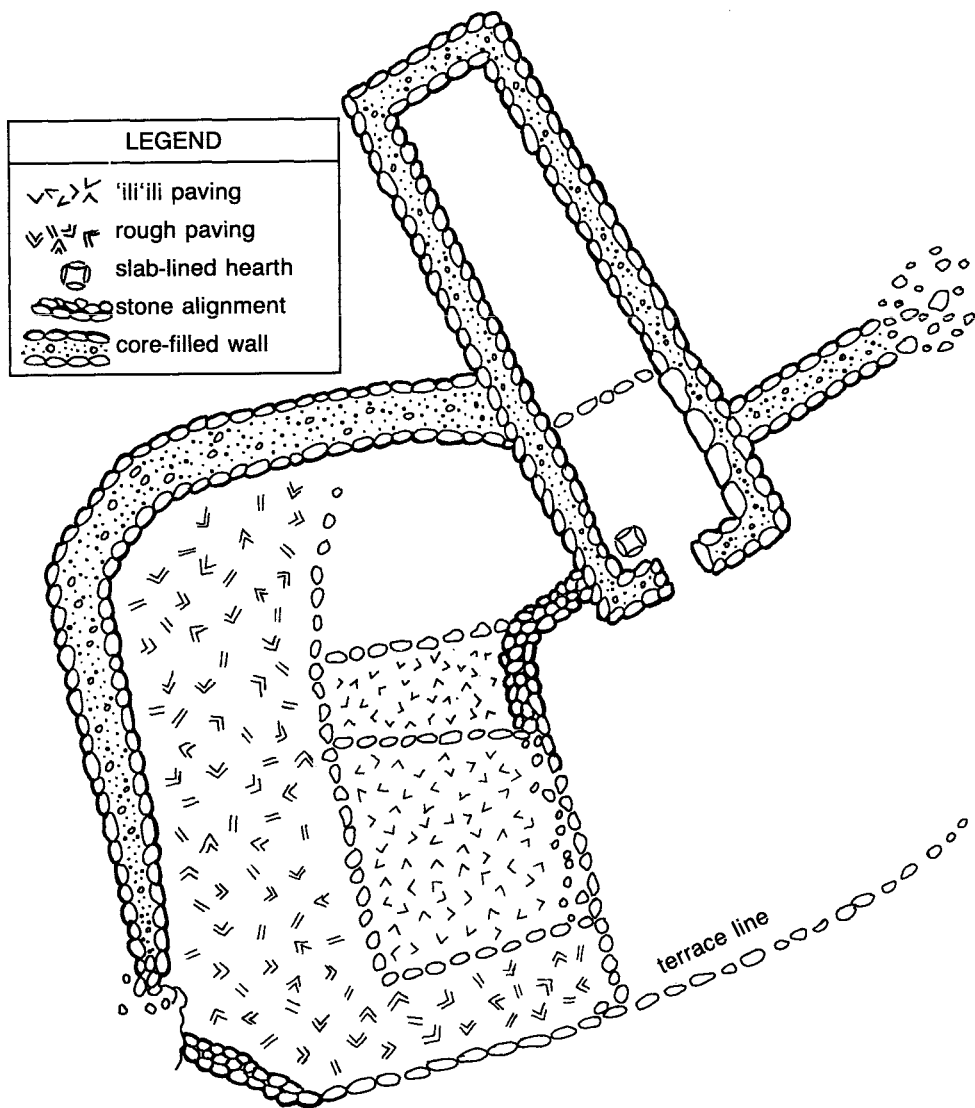


Fig. 3. Complex feature from Lapakahi with possible canoe shed or house foundation, slab-lined hearth, and three separate paved areas on an adjacent terrace area.

or coastal; (3) the area it occupied; (4) the number of components it contained; (5) its morphological type; and (5) its functional feature type.

The historic era is defined as the time after A.D. 1778, although as indicated above archaeologists' ability to infer historic-period occupation is best after A.D. 1820. Only features dated to c. A.D. 1500–1775 are included in the prehistoric period, in order to limit an overrepresentation of prehistoric sites. During this late prehistoric period there is evidence for inland expansion of Hawaiian populations at both Lapakahi and Mākaha Valley. Excavation data, radiocarbon dates, and pre-Contact material culture are used to assign a prehistoric occupation date to a feature. Historic

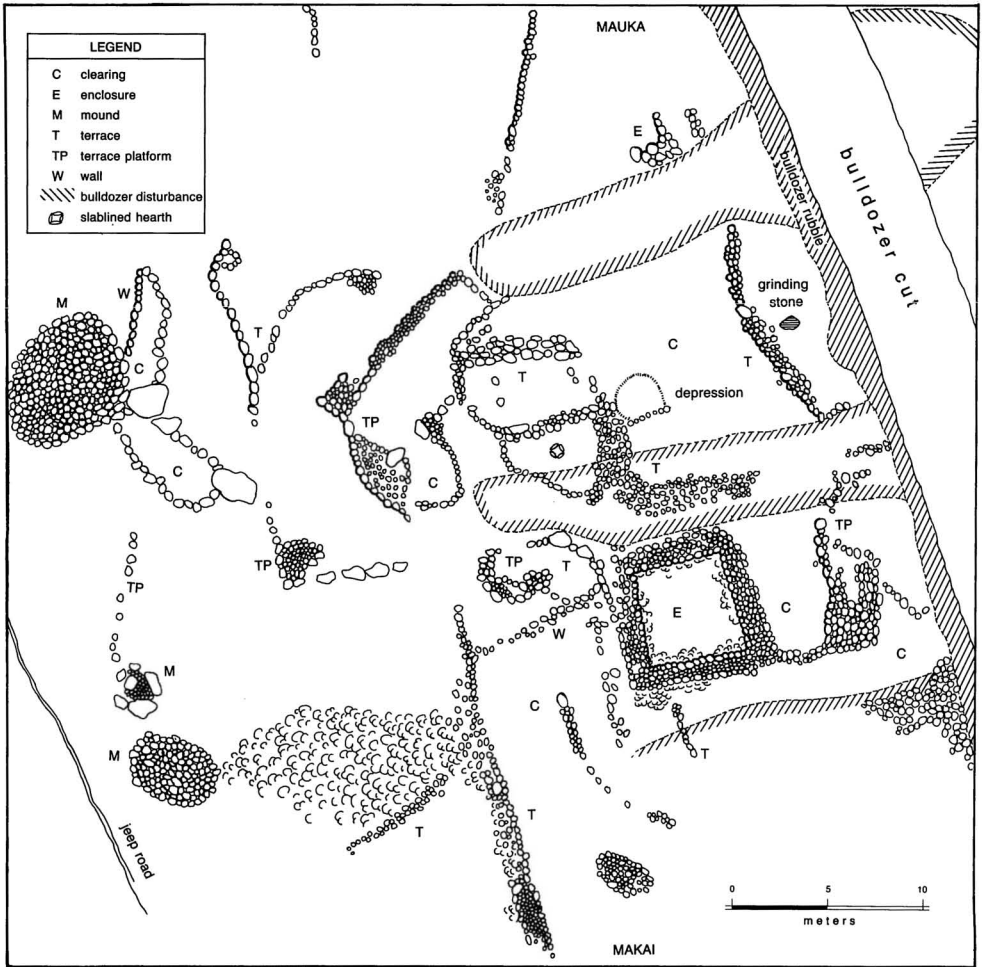


Fig. 4. Example of a residential complex from lower Mākaha Valley. This complex includes a house structure, cooking area, stone manufacturing area, and several possible garden locations.

occupation is inferred by the presence of historic artifacts and through ethnohistoric documentation. Because the presence or absence of historic artifacts plays a considerable role in determining historic occupation, temporal assignments occasionally may be in error. Generally, this will result in historic features being assigned a pre-historic age. Because this analysis will attempt to identify temporal differences, the effect of such errors would be to obscure settlement pattern change. Thus, this analysis is conservative in its identification and estimation of temporal change.

The definition of coastal and inland locations varied slightly between the two *ahupua'a* used in the study. At Lapakahi, coastal complexes are those that fall within 150 m horizontally from the coast, where elevations ranged from sea level to 50 m; inland features are those located more than 3000 m from the coast (Tuggle and Griffin 1973:20). The intervening area is characterized as having no residential occupation, although lack of an adequate survey for this area makes such an infer-

ence tentative (Tuggle and Griffin 1973:4). For Mākaha Valley, the *ahupua'a* is characterized by a lower valley or dry-zone occupation and an upper valley or wet-zone occupation (Green 1969:5). The lower valley elevations range from sea level up to 150 m, covering a horizontal distance from the coast to the inland boundary of 4000 m. The upper valley reaches to well over 550 m in height (Ladd in Green 1969:27).

The area covered by a feature was calculated from scale map drawings and was defined by the interior portion of the contiguously bounded space of a structure. The area of each residential complex was calculated as the area within the perimeter drawn around the associated features. The number of components within each feature is a count of the number of morphologically distinct spaces within a feature. For example, four components are represented in the feature of Figure 2a, three in Figure 2b, and eight (including the hearth) in Figure 3.

Morphological feature types are (1) C/L shapes, i.e., semicircular walls (so-called by Hawaiian archaeologists because they resemble these letters in plan view); (2) platforms; (3) enclosures; (4) terraces; (5) mounds; (6) pits; (7) firepits; (8) walls; and (9) trails. The description and definition of these types are discussed by Kirch (1985:247–273).

Functional types consist of residential, production, ceremonial, and special-use categories. Residential function is inferred by the presence of “domestic” items, such as household artifacts, midden, storage areas, firepits, and earth ovens. Production refers to garden plots, animal pens, and agricultural mounds and terraces within a complex. Ceremonial function refers to *heiau* (temples), shrines, and burials. Special-use features for this study refer to trails that cross-cut the area of the complex. Functional designations follow those assigned in the aforementioned reports.

ANALYSIS OF AHUPUA'A SETTLEMENT PATTERNS

A major shift in the location of human occupation is the first indication of settlement pattern change. Such a shift is evident at Lapakahi, where fewer features and complexes were occupied in the inland portion of the *ahupua'a* during the historic era (Table 1). At Mākaha Valley, it would appear that inland occupation remained relatively stable. However, there is a dramatic reduction in the number of features and complexes dated to the historic period at Mākaha. It is somewhat difficult to measure the potential population loss within these two areas, given the uncertainty about representative samples. Although historic features are usually the easiest to locate since they are often represented by visible surface architecture, the greatest number of features and complexes found in both areas were assigned to the prehistoric time period (Table 1). Both *ahupua'a*, then, experienced population loss. On present evidence, the loss seems to have taken place in different types of areas—inland for Lapakahi, coastal for Mākaha. Both cases are congruent with the model for population loss in less than optimal *ahupua'a*.

Density of occupation, in terms of the number or area of homes in relation to land space, is a second measure to determine potential demographic change. Green (1970a) has suggested that density should be employed as a variable to distinguish between historic and prehistoric occupation, with increased population density for settlements occupied during the historic period in Polynesia. Yet at what scale should density be measured? One solution is to consider settlement patterns in terms of the proximity of features to one another. This can be tested by comparing the

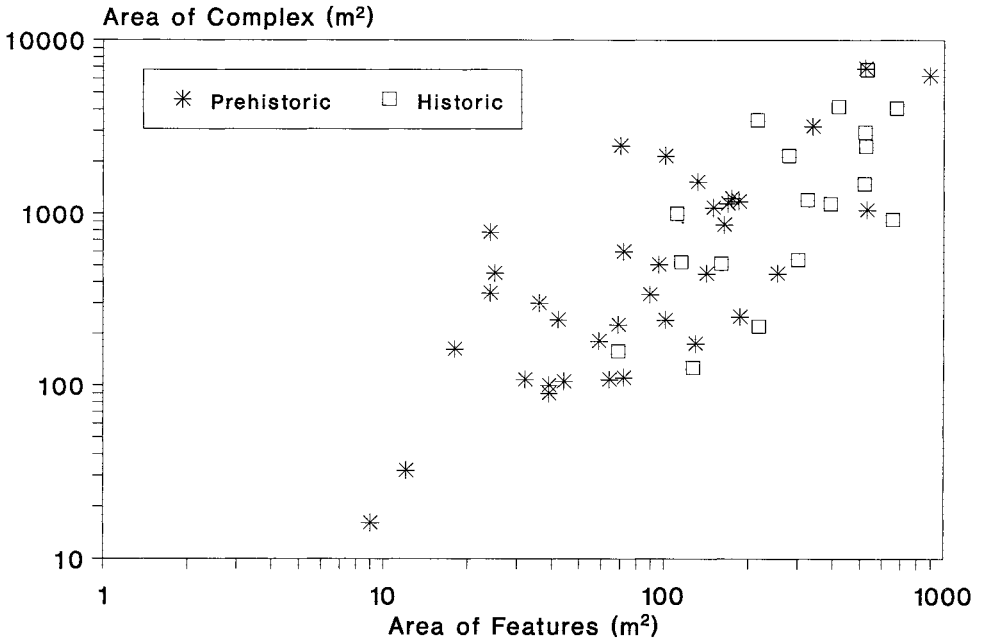


Fig. 5. Covariation between the total area of a complex and the total area encompassed by architectural features within the complex, for both Mākaka Valley and Lapakahi residential complexes.

sum of the area of features in a complex with the area of the whole complex by temporal period. For both Lapakahi and Mākaha Valley, the size of the complex and the area occupied by features within the complex are significantly correlated (Fig. 5). Thus, as the total size of features increases, the area of the complex also increases. This indicates that changing density should be examined on a regional scale, since it tends to be conditioned by how the area is delimited for analysis. The problem would then rest in adequate sampling of *ahupua'a* to enable a comparative assessment of total residential space used over time.

It is possible to examine how much residential space was used across the two time periods. Earlier, Ladefoged (1987) found that the total area of features per complex was greater during the historic period. A small coefficient of variation during this period also suggested a greater degree of uniformity in the amount of area Hawaiians employed for residential occupation (Ladefoged 1987:150). Both Lapakahi and Mākaha Valley have a greater mean total area of features within residential complexes in the historic period (Table 2, Fig. 6).¹ While the coefficients of variation for total feature area are too large to argue for relative uniformity in the historic period, the mean differences in total areas are significantly different over time. On average, historic features are approximately three times larger than prehistoric-period features. These two *ahupua'a* follow the pattern Ladefoged observed, where historic-period occupation was not more dense in terms of total land use, but residential complexes were larger in size.

Thus, the archaeological evidence from both Lapakahi and Mākaha Valley suggests that the actual number of residential complexes diminished over time (Table 1),

TABLE 2. T-TEST ON THE AREA OF FEATURES IN RESIDENTIAL COMPLEXES BY TIME AND BY *ĀHUPUA*'A

| | NO. OF CASES | MEAN | STANDARD DEVIATION | COEFFICIENT OF VARIATION |
|---|--------------|---------|--------------------|--------------------------|
| LĀPAKAHI | | | | |
| Prehistoric | 79 | 38.710 | 55.718 | 144 |
| Historic | 61 | 112.861 | 143.126 | 127 |
| F = 6.60 ($p < 0.01$) | | | | |
| t = 4.21 D.F. = 138 1-tail probability < 0.01 | | | | |
| MĀKAHA VALLEY | | | | |
| Prehistoric | 80 | 23.976 | 44.211 | 184 |
| Historic | 36 | 80.089 | 83.412 | 104 |
| F = 3.56 ($p < 0.01$) | | | | |
| t = 4.73 D.F. = 114 1-tail probability < 0.01 | | | | |

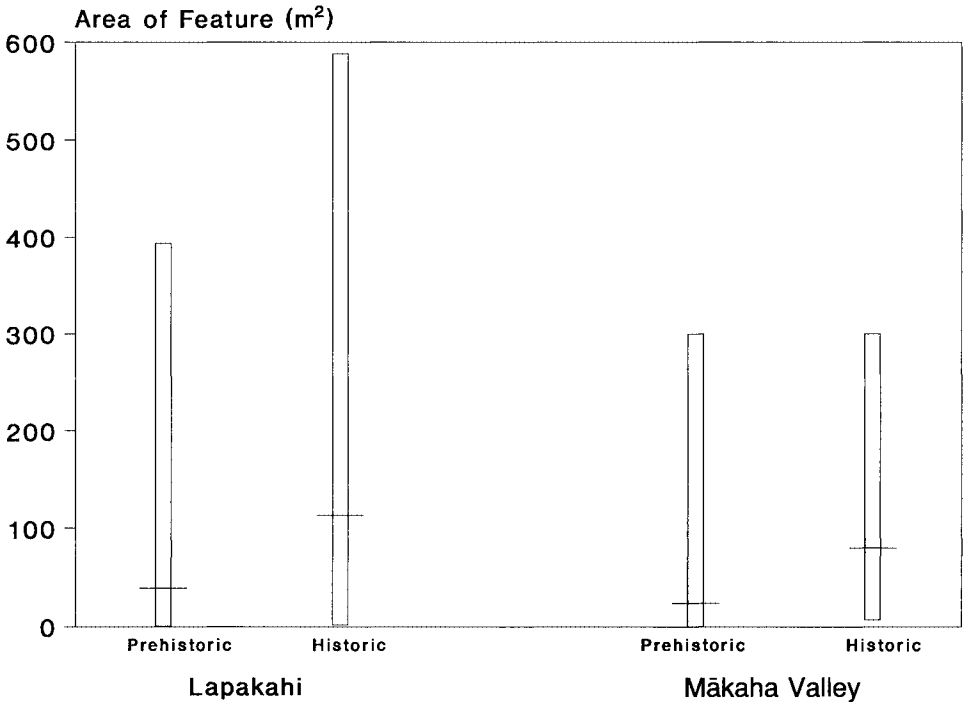


Fig. 6. Average total area (horizontal line) and overall range (vertical bar) encompassed by architectural features within residential complexes, for both prehistoric and historic complexes at Lapakahi and Mākaha Valley.

TABLE 3. T-TEST ON THE NUMBER OF FEATURES IN COMPLEXES BY TIME AND BY AHUPUA'A

| | NO. OF CASES | MEAN | STANDARD DEVIATION | COEFFICIENT OF VARIATION |
|--|--------------|-------|-----------------------|-----------------------------|
| LAPAKAHI | | | | |
| Prehistoric | 17 | 4.882 | 2.446 | 50 |
| Historic | 12 | 4.667 | 2.348 | 50 |
| F = 1.09 ($p = 0.912$) | | | | |
| t = -0.24 D.F. = 27 2-tail probability = 0.814 | | | | |
| MĀKAHA VALLEY | | | | |
| Prehistoric | 19 | 4.316 | 2.029 | 47 |
| Historic | 7 | 5.143 | 3.024 | 59 |
| F = 2.22 ($p = 0.177$) | | | | |
| t = 0.81 D.F. = 24 2-tail probability = 0.428 | | | | |

although at the same time larger residential areas were used in the historic period. If complexes were larger in the post-Contact era, we might also expect that the number of features they contained should also be greater. It is interesting to observe that there are no significant differences in the number of features that make up residential complexes when they are compared by period of occupation (Table 3). Uniformity in the number of features per complex over time is further supported by the similar coefficients of variation (Table 3). Taken in conjunction with the previous analyses showing a decrease in the total number of features and an increase in the total feature area, this finding of no change in the number of features within residential complexes is congruent with the hypothesis of historic-period population loss. Thus, a change in the density of occupation during the historic period is identified for Lapakahi by a shift in the location of the population to the coast. For Mākaha Valley, a decrease in the number of coastal complexes and features during the historic period is direct evidence of a decrease in the population density during that time.

A third method to examine the archaeological record for evidence of collapse is to monitor changes in the structural arrangement of households. One measure of this is to compare the number of components per feature, and to calculate the distribution of morphological and functional feature types within residential complexes over time. Ladefoged (1987, 1991) examined the number of components per feature. He argued that a higher number of components per feature in the historic era indicated that there was less segregation of space. If components can also be seen as functional units within a feature, then it could be argued that more activities were performed within each feature in the historic era.

At both Lapakahi and Mākaha Valley, there is a significant difference between the number of components per feature found in the prehistoric period and the number found in the historic period (Table 4). As expected, more components are found later in time. There is also evidence for greater uniformity in the number of components per feature in the prehistoric period, as indicated by the smaller coefficient of variation for both Lapakahi and Mākaha Valley (Table 4). This is congruent with Ladefoged's (1991) hypothesis that traditional Hawaiian concepts pertaining to the

TABLE 4. T-TEST ON THE NUMBER OF COMPONENTS IN FEATURES BY TIME AND BY AHUPUA'A

| | NO. OF CASES | MEAN | STANDARD DEVIATION | COEFFICIENT OF VARIATION |
|--|--------------|--------|-----------------------|-----------------------------|
| LAPAKAHI | | | | |
| Prehistoric | 79 | 1.4937 | 0.766 | 51 |
| Historic | 61 | 2.8033 | 3.005 | 107 |
| F = 15.39 ($p = 0.000$) | | | | |
| t = 3.32 D.F. = 66.04 1-tail probability < 0.01 | | | | |
| MĀKAHA VALLEY | | | | |
| Prehistoric | 80 | 1.3875 | 0.787 | 57 |
| Historic | 36 | 2.0556 | 1.655 | 81 |
| F = 4.42 ($p = 0.000$) | | | | |
| t = 2.31 D.F. = 42.30 1-tail probability = 0.025 | | | | |

spatial separation of activities were changing during the historic period. The result was greater variability in the mean number of components per feature for historic-period structures.

I have shown that there is no significant difference over time in the number of features in a complex (Table 3), despite decreasing numbers of both features and complexes. The increase in the number of components in historic-period features suggests that instead of building new features, Hawaiians very early conserved labor by investing in preexisting structures. They expanded features horizontally by making additions, or by segmenting already existing domestic space. Under this interpretation, new spaces were created in existing household architecture. Yet there is another possibility: As depopulation and relocation occurred, people may have moved into larger, preexisting multicomponent households, in the process abandoning their smaller structures.

There may also be differences evident in morphological feature types over time if Hawaiian house-building patterns changed. Morphological types are treated here as ordinal data since, at best, their frequencies may reflect relative abundances in terms of their rank orders (see Grayson 1984). Morphological feature types show no significant temporal differences in their frequency of occurrence within a complex at either Mākaha Valley or Lapakahi (Table 5). The larger morphological types, such as platforms and enclosures, are more frequent in the historic period than are C-shaped or L-shaped structures, which tend to be smaller and contain fewer components.

Do the observed changes in feature morphology correlate with patterns in functional feature types? The distribution over time of functional feature types is highly concordant (Table 6). Continuity in functional feature types within residential complexes may in part reflect the archaeological definition of such complexes. On the other hand, the function of a feature is often ambiguous since functions are not directly observable as empirical units but must rather be inferred. Additionally, little functional change may be detected because, as I have previously demonstrated, the number of features within a complex does not change. Finally, it may be possible to

TABLE 5. DISTRIBUTION OF MORPHOLOGICAL FEATURE TYPES BY TIME PERIOD FOR LAPAKAHI AND MĀKAHA VALLEY

| | LAPAKAHI | | MĀKAHA VALLEY | |
|-----------|-------------|----------|---------------|----------|
| | PREHISTORIC | HISTORIC | PREHISTORIC | HISTORIC |
| C/L shape | 27 | 4 | 15 | 2 |
| Platform | 18 | 25 | 17 | 4 |
| Enclosure | 9 | 22 | 24 | 14 |
| Mound | 8 | 1 | 10 | 5 |
| Pit | 5 | 3 | 1 | 0 |
| Terrance | 4 | 1 | 6 | 7 |
| Firepit | 3 | 1 | 5 | 0 |
| Wall | 3 | 3 | 2 | 4 |
| Trail | 2 | 0 | 0 | 0 |
| Unknown | 0 | 1 | 0 | 0 |

Tau = 0.61139, sig. < 0.01

Tau = 0.58694, sig. < 0.01

TABLE 6. DISTRIBUTION OF FUNCTIONAL FEATURE TYPES BY TIME PERIOD FOR LAPAKAHI AND MĀKAHA VALLEY

| | LAPAKAHI | | MĀKAHA VALLEY | |
|-------------|-------------|----------|---------------|----------|
| | PREHISTORIC | HISTORIC | PREHISTORIC | HISTORIC |
| Residential | 55 | 46 | 63 | 18 |
| Production | 12 | 10 | 6 | 8 |
| Ceremonial | 9 | 5 | 10 | 5 |
| Special | 0 | 0 | 0 | 1 |
| Unknown | 3 | 0 | 1 | 4 |

R_s = 0.9742, sig. = 0.002

R_s = 0.9000, sig. = 0.019

observe functional change in complexes if the number of components in a feature, which increases in the historic period, also represents functional units. Functional relations among activities may have changed, and there may be new activities carried out within the residential complex of a household.

CONCLUSIONS

Certain areas in the analysis of Hawaiian settlement patterns still deserve greater attention. Inland survey data tend to lack the detail available for coastal occupation. Lack of data from other *ahupua'a* limited comparison in this study to Lapakahi and MākaHa Valley; in many other cases the variables traditionally collected were not consistently reported, or were not on file. There is a definite need for more excavation to solve the basic problems of determining the period of occupation, the function, and the intensity of use of features. Archaeologists should consider all the lone "residential" features that are scattered in the *ahupua'a*, which by the nature of this analysis were not considered. In the future, regional comparisons should be made

with *ahupua'a* located closer to urban centers, since different processes are likely to have affected the archaeological remains there. This in turn may effect any archipelago-wide generalizations about historic demographic change.

Given these limitations, it is still possible to identify several hypotheses that have received support from the analyses of settlement patterns in Lapakahi and Mākaha Valley. First, there is a decline over time in the number of architectural features and residential complexes occupied in the two *ahupua'a*. The decline is inferred to represent population loss, and it is now dated to the historic period. The relative degree of population loss is difficult to estimate. The number of features and complexes decreases by about 30–60 percent between the prehistoric and historic periods for the two communities. This should be viewed as a conservative estimate, since features dated to the historic period are likely to be more visible on the ground surface than are prehistoric features. In addition, many of the complexes whose occupation is dated to the historic period may have first been occupied during the prehistoric period. These occurrences have not been identified in the present study.

There is also evidence to support the hypothesis that with depopulation came a redistribution of the remaining Hawaiian population within the two *ahupua'a*. The vast majority of historic-period residential complexes are located at or near the coast. In the case of Lapakahi this represents a significant change from the prehistoric settlement pattern. The inland portion of the *ahupua'a* was largely abandoned for permanent residence. This may have had the effect of ameliorating coastal population decline, as the surviving portions of the inland population in Lapakahi moved to the coast to take up residence.

There is evidence for some continuity in the composition of residential complexes during this period of rapid change in population size and distribution. There is a fairly strong linear relationship between the total area devoted to architectural features and the total area encompassed by residential complexes, for both historic and prehistoric time periods at Lapakahi and Mākaha Valley. Roughly the same proportion of morphological feature types is found in residential complexes dated to the two time intervals.

However, there are considerable differences in the organization of space and the overall size of individual features within residential complexes in the prehistoric and historic periods. Historic complexes have more components per feature and larger features than prehistoric complexes (Fig. 7). This suggests that Hawaiians made additions to features with walls, paving, and alignments, thus partitioning contiguous architectural units, or else they chose to occupy larger, multicomponent residential complexes that had been previously abandoned. The results of this analysis also support Ladefoged's (1991:67) hypothesis that "it is possible to tentatively establish the relative age of residential features on the basis of their morphology." Features comprising more than two components, and especially those with three or more components, are more likely to date to the historic era. Residential complexes whose total area of architectural features exceeds 300 m² are also more likely to date to the historic period. The analysis of settlement pattern change presented here is also consistent with Ladefoged's (1991) interpretation that Hawaiian household activities were no longer spatially segregated during the historic period as they had been previously.

Finally, these analyses support the ethnohistoric model of Hawaiian population collapse outlined at the beginning of this paper. They also suggest some of the

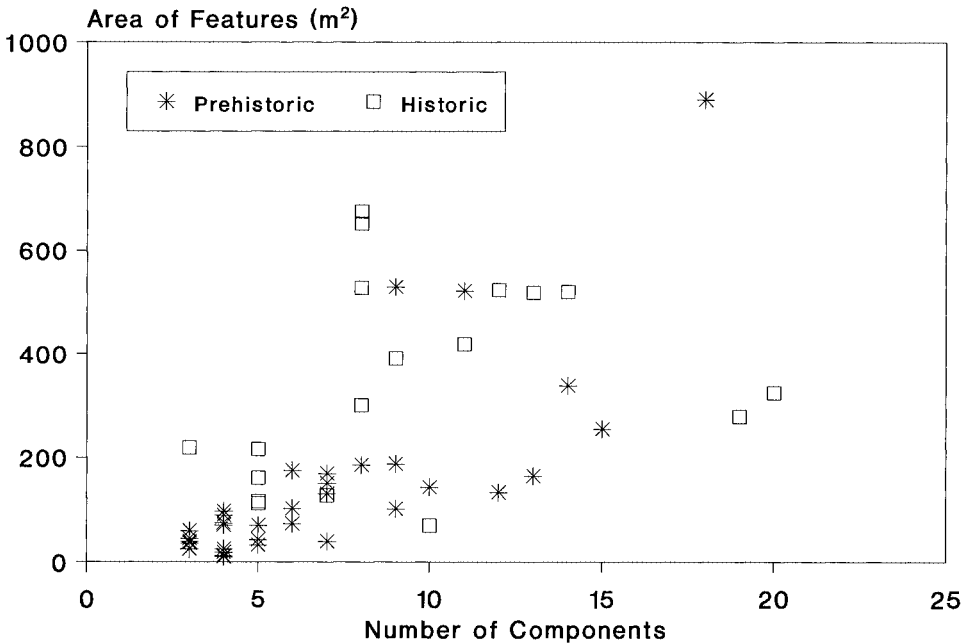


Fig. 7. Covariation between total area of features within residential complexes and ratio of components to features, for both Mākaha Valley and Lapakahi complexes.

dimensions of archaeological variability that will repay additional refinement and investigation. As Ramenofsky (1987) has concluded, most of these changes preceded direct observation and documentation by European historic sources; thus their detection and eventual resolution will depend upon archaeological methods.

NOTES

1. It should be noted that there is one outlier complex that is not included in Figure 6. This is Koaie Village at Lapakahi, which, by definition, is categorized as a single complex. Even if it were included, the correlation would still be significant ($R_s = 0.6690$, sig. < 0.01).

ACKNOWLEDGMENTS

I am deeply indebted to Dr. Michael Graves for his encouragement as well as for helping to transform the original manuscript into a readable format. Thanks are also due to Dr. Terry Hunt for his suggestions, and to fellow graduate students who listened.

REFERENCES

- BINGHAM, HIRAM
 1981 *A Residence of Twenty-one Years in the Sandwich Islands (1820–1841)*. Rutland, VT: Charles E. Tuttle.
- DAWS, GAVAN
 1967 Honolulu in the nineteenth century: Notes on the emergence of urban society in Hawaii. *Journal of Pacific History* 2:77–96.

- ELLIS, WILLIAM
1969 *Polynesian Researches: Hawaii*. Reprint of 1842 ed. Rutland, VT: Charles E. Tuttle.
- GRAYSON, D. K.
1984 *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas*. New York: Academic Press.
- GREEN, ROGER C.
1970 *Settlement Pattern Archaeology in Polynesia*. Studies in Oceanic Culture History Vol. 1, ed. R. C. Green and M. Kelly. Pacific Anthropological Records No. 11. Honolulu: Bishop Museum.
1980 *Makaha before 1880 A.D.: Makaha Valley Historical Project Summary Report No. 5*. Pacific Anthropological Records No. 31. Honolulu: Bishop Museum.
- GREEN, ROGER C., ED.
1969 *Makaha Valley Historical Project: Interim Report No. 1*. Pacific Anthropological Records No. 4. Honolulu: Bishop Museum.
1970b *Makaha Valley Historical Project: Interim Report No. 2*. Pacific Anthropological Records No. 10. Honolulu: Bishop Museum.
- KIRCH, PATRICK V.
1984 *The Evolution of the Polynesian Chiefdoms*. Cambridge: Cambridge University Press.
1985 *Feathered Gods and Fishhooks*. Honolulu: University of Hawaii Press.
- KUYKENDALL, RALPH S.
1947 *The Hawaiian Kingdom: 1778-1854*. Honolulu: University of Hawaii Press.
- LADD, EDMUND J., ED.
1973 *Makaha Valley Historical Project: Interim Report No. 4*. Pacific Anthropological Records No. 19. Honolulu: Bishop Museum.
- LADD, EDMUND J., AND D. E. YEN, EDS.
1972 *Makaha Valley Historical Project: Interim Report No. 3*. Pacific Anthropological Records No. 18. Honolulu: Bishop Museum.
- LADEFOGED, THEGN N.
1987 Settlement pattern analysis and relational data bases: An archaeological study in Hawai'i Volcanoes National Park. M.A. thesis, University of Hawaii, Honolulu.
1991 Hawaiian architectural transformations during the early historic era. *Asian Perspectives* 30(1):57-69.
- NELLER, EARL
1984 *An Archaeological Reconnaissance survey of Site Area 997, Mākaha Valley, O'ahu*. Honolulu: State Historic Preservation Office.
- NEWMAN, T. STELL
1968 *The Archaeology of North Kohala: A Progress Report on Archaeological Research*. State Archaeological Journal 68-2. Honolulu: Department of Land and Natural Resources.
1970 *Hawaiian Fishing and Farming on the Island of Hawaii in A.D. 1778*. Honolulu: Department of Land and Natural Resources Division of State Parks.
- PEARSON, RICHARD, ED.
1969 *Archaeology on the island of Hawaii*. Asian and Pacific Archaeology Series No. 3. Honolulu: University of Hawaii.
- RAMENOFSKY, ANN F.
1987 *Vectors of Death: The Archaeology of European Contact*. Albuquerque: University of New Mexico Press.
- ROSENDAHL, PAUL H.
1972 Aboriginal agriculture and residence patterns in upland Lapakahi. Ph.D. diss., University of Hawaii, Honolulu.
- STANNARD, DAVID
1988 *Before the Horror: The Population of Hawai'i on the Eve of Western Contact*. Honolulu: University of Hawaii Press.
- STEWART, C. S.
1970 *Journal of a Residence in the Sandwich Islands during the Years 1823, 1824, and 1825*. Honolulu: University of Hawaii Press.

TUGGLE, H. DAVID, AND P. BION GRIFFIN, Eds.

1973 *Lapakahi, Hawaii: Archaeological Studies*. Asian and Pacific Archaeological Series No. 5. Honolulu: Social Science Research Institute, University of Hawaii.

WEISSLER, M., AND P. V. KIRCH

1985 The structure of settlement space at Kawela, Moloka'i, Hawaiian Islands. *New Zealand Journal of Archaeology* 7:129-158.

ABSTRACT

The population collapse in the Hawaiian islands after European contact is discussed in relation to aspects of change and continuity identified between settlement patterns of the prehistoric and historic periods for two traditional territorial units on the islands of O'ahu and Hawai'i. In addition to a decline in the absolute number of residential complexes occupied during the historic period, most features occupied after European contact contain more components, resulting in an increase in horizontal space associated with each residential complex. KEYWORDS: Hawaiian settlement patterns, Historic architectural change, Historic demographic collapse.