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Hawaiian Adze Production and Distribution

Implications for the Development of Chiefdoms

Barbara Lass

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Contents

Acknowledgments	v
Chapter 1	
Introduction	1
Chapter 2	
Hawaiian Chiefdoms and the Study of Cultural Complexity	3
Chapter 3	
Redistribution in the Development of Hawaiian Chiefdoms	13
Chapter 4	
Specialization in Hawaiian Adze Production	29
Chapter 5	
Craft Specialization and Homogeneity in Finished Adzes	51
Chapter 6	
Implications for the Development of Chiefdoms	65
Appendixes	
A: Chronological Placement of Sites	71
B: Collections and Sampling Strategy	73
C: Thin-Section Preparation <i>by Jo Ann Sinton</i>	77
D: Number of Artifacts of Various Raw Material Types by District, Locality, and Site	77
Bibliography	79
Index	89

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Barbara Lass

Chapter 1

Introduction

Polynesian chiefdoms, including those of Hawai'i, have been the focus of classic research on the development of chiefdoms and cultural complexity. Sahlins (1958) and Service (1962, 1975) used ethnographic and ethnohistoric data from Hawai'i and other parts of Polynesia to propose that the centralized control and redistribution of differentially occurring natural resources were crucial to the development of societies with hereditary leadership and social stratification. Their work directed attention to environmental diversity, specialized production, and resource redistribution as significant factors in the development of cultural complexity. However, there have been few explicit attempts to test Service's original hypothesis with archaeological data. This study of the production, distribution, and use of precontact stone adzes on the island of Hawai'i uses archaeological evidence to examine the role of a material resource in the development of Hawaiian chiefdoms.

The Hawaiian Islands are an ideal setting within which to address questions concerning cultural complexity. There is rich ethnohistoric information on Hawaiian chiefdoms, and extensive archaeological research has been conducted in several parts of the Hawaiian Islands, including the island of Hawai'i which is the focus of this study. Archaeological evidence documents a trend toward increased cultural complexity from initial colonization to the time of European contact, and research focused on Hawaiian culture is ideally suited to evaluating well-known hypotheses about cultural complexity originally formulated by such researchers as Sahlins (1958), Service (1962, 1975), and Earle (1978) using the Hawaiian example.

Study of stone adzes is also well suited for investigating the role of an important material resource within the development of a complex chiefdom. Stone adzes and the by-products of adze manufacture are well preserved, and large numbers of previously excavated adzes and adze fragments exist in the collections of the Bernice P. Bishop Museum and other artifact repositories in Hawai'i. Furthermore, the loci of adze manufacture are preserved at several identified sites, and finished adzes can be traced to these and other sources with the aid of petrographic and geochemical analyses.

Chapter 2 begins with a discussion of Service's hypothesis that chiefdoms with social stratification and centralized redistribution develop in areas where necessary resources are differentially available so that regional specialization in production and the centralized redistribution of goods by a powerful political leader are inevitable. Service's work inspired many similar adaptationist approaches to the development of cultural complexity, including political approaches in which the deliberate efforts of leaders or would-be leaders to enhance or extend their influence are emphasized. These approaches maintain that redistribution of necessary resources was not a central concern of leaders and did not contribute to the development of cultural complexity. In both adaptationist and political explanations for increases in cultural complexity, ethnohistoric information on Hawaiian chiefdoms has been used extensively. However, neither approach has been well tested with archaeological data from Hawai'i. The primary goal of this research, then, is to see whether one differentially available good, stone adzes, was subject to redistribution and/or special-

ized production in the development of Hawaiian chiefdoms.

Chapter 3 addresses the question whether the adzes manufactured at scattered sources of suitable stone were subject to centralized redistribution. Redistribution has been broadly defined and used to describe a variety of economic processes involving the collection and dispersal of goods. Adaptationist approaches to cultural complexity tend to define redistribution as the centralized distribution of necessities. Political approaches (Earle 1978) maintain that redistribution like that carried out in Hawai'i was actually mobilization, or the collection and use of food and wealth items to support the elite and their projects. Here, archaeological data on the regional distribution of adzes from different sources on the island of Hawai'i are used to examine these spatial distributions throughout Hawaiian prehistory. This evidence suggests that adzes were probably not at any time subject to collection and subsequent distribution by the chiefs and that redistribution of the type proposed in adaptationist approaches did not play a role in the development of Hawaiian chiefdoms.

Chapter 4 examines craft specialization, another important component of adaptationist and political approaches. In adaptationist approaches, redistribution is the outgrowth of regionally specialized production that occurs as a result of ecological or environmental variability. In political approaches, regional specialization in the production of necessities is an aspect of the subsistence economy which is carried out by independent specialists or craftspersons who are not directed or sponsored in any way. Meanwhile, attached specialists are those sponsored or supported by leaders and usually produce wealth items that can be used by leaders to enhance their influence (Brumfiel and Earle 1987; Earle 1981).

Hawaiian chiefs could have had a vested interest in controlling the production of certain necessities like adzes because adzes were tools used by craft specialists in significant activities such as the construction of canoes, houses, and temples for, or under the sponsorship of, chiefs. Possible archaeological indicators of craft specialization, in particular attached specialization, include standardization in the manufacturing process, high rate of production, high degree of success in the completion of artifacts, and

high degree of apparent skill in manufacture. These indicators are examined for the Pololū adze-manufacturing site on the island of Hawai'i. Results are compared to the results of similar analyses already conducted for the Mauna Kea adze quarry (Cleghorn 1982) where it is often assumed that attached specialists worked. Although there are several problems in applying standard indicators of specialization, no real evidence suggests that Hawaiian adze production was carried out by attached specialists. Instead, adze production was most likely carried out by independent specialists or nonspecialists.

The discussion of specialization and adze manufacture is continued in chapter 5, where the degree of standardization or homogeneity in finished adzes from Hawaiian habitation sites is discussed. Again, there is no evidence for attached craft specialization mainly because the apparent standardization in the form and size of Hawaiian adzes can be better explained by factors other than craft specialization: cultural norms or standards unrelated to specialization, the intended use or function of adzes, and constraints and opportunities provided by the type of raw material used.

This research suggests that adzes were not subject to redistribution or to specialization as suggested in adaptationist approaches to the development of cultural complexity. The key to cultural complexity is a leader's control over the production and distribution of wealth items that can be used for political purposes and not the control of such utilitarian resources as adzes or stone for adze manufacture. By emphasizing the distinction between necessities and wealth items, however, political approaches have mistakenly implied that items like adzes are relatively insignificant in the development of complex societies. In chapter 6, adzes and tools like them may be seen as representing a link between subsistence goods and wealth items. Hawaiian adzes were used by craft specialists to construct canoes, houses, and temples for the chiefs. Like wealth items, these products of specialized labor served to symbolize a chief's power and influence. Attached or independent specialists who made and used adzes in the performance of tasks for the chiefs may have been motivated to create and use special adzes manufactured by particularly skilled individuals and/or acquired from particular sources of stone without direction from the chiefs.

Chapter 2

Hawaiian Chieftdoms and the Study of Cultural Complexity

The origin and development of the urban state and the development of food production which preceded the appearance of early state societies have been topics of long-standing interest among anthropologists. However, the specific study of societies that on a continuum of cultural complexity lie somewhere between the earliest food-producing societies and fully developed states was largely neglected until Service (1962) defined four types or levels of social organization: band, tribe, chieftdom, and state. The chieftdom was considered the critical transition between essentially egalitarian tribes and fully developed states.

According to Service, the two key features that distinguish the chieftdom from the tribe are permanently centralized redistribution of resources and social stratification. Redistribution occurs through the hereditary office of chief, and all members of society are ranked according to genealogical distance from the chief. In addition to being the agent of redistribution, the chief may also subsidize craft specialization and public works. Chieftdoms tend to be theocratic in that religion and ritual are used to sanctify and legitimize the office of chief and the social ranking system. In contrast to states, chieftdoms are organized according to principles of kinship, and they lack a civil bureaucracy with institutionalized coercive power. Service identified ethnographic and historic examples of chieftdoms in several parts of the world including Polynesia and, in particular, the Hawaiian Islands (1962:133–169, 143–144).

CULTURAL COMPLEXITY

The term *complex societies* is often used to refer to both chieftdoms and states as defined by Service.

However, there are difficulties associated with defining complex societies in this way. Terms like chieftdom are ideal concepts in what is a continuum of cultural complexity; types of societies cannot be defined by trait lists so that cultures with certain characteristics such as redistribution are considered somehow complex whereas others are not. Increasingly, anthropologists agree that cultural complexity should be measured in terms of continuous variables, and a number of researchers have attempted to identify and define the essential variables that actually change in increasing complexity (Flannery 1972; McGuire 1983; Tainter 1977).

Variables that seem particularly appropriate in examining Hawaiian chieftdoms are heterogeneity, or vertical and/or horizontal differentiation between social groups, and inequality, or the extent to which social differentiation is associated with differences in access to resources, wealth, and power. Increased heterogeneity can involve several different changes. First, there can be an increase in the number of organizational levels in a culture. In a society with individual households and local communities, for example, there are two levels of organization. If the local communities then form a regional polity, the number of organizational levels and the amount of heterogeneity has increased. Heterogeneity also increases when dimensions of potential differentiation between individuals and groups are added; most societies categorize individuals on the basis of age and sex, but additional dimensions of differentiation can be based on ethnicity, religion, occupation, kinship, wealth, and political influence. Heterogeneity is further increased if the dimensions of social differentiation are independent of each other, that is, if

membership in one social group is not necessarily a predictor of membership in any or all other social categories (McGuire 1983).

Traditionally, many researchers have viewed a shift from egalitarian, kin-based societies to societies with social stratification as the key in the appearance of complex societies; social stratification is usually defined as the existence of social classes marked by significant differences in access to economic resources. However, the term *social stratification* has been broadly used to refer to both inequality and heterogeneity and to various aspects of heterogeneity as well. Societies are often categorized or ranked according to their apparent degree of social stratification (Sahlins 1958). Actually, however, societies have varied forms and degrees of differentiation and inequality, and these can change and vary independently of each other over time. If differentiation and inequality are enhanced to produce increased complexity, this change is gradual, subtle, and continuous. We can say that societies have become more complex over time, but it is difficult and probably not useful to distinguish between societies that are clearly complex and those that are not.

This research evaluates factors that may have contributed to increased cultural complexity in Hawaiian chiefdoms. Specifically, it examines the extent to which ecological diversity, specialized production, and centralized redistribution of differentially available resources could have contributed to differentiation between social groups and to economic and political inequalities between them. It is not necessary to decide if Hawaiian chiefdoms represent complex societies or whether to label them as such, but it must be shown that cultural complexity did in fact increase in Hawaiian societies over time.

Cultural Complexity in Precontact Hawai'i

The Hawaiian Islands were probably first inhabited by AD 300–500 as part of a larger seaward migration into eastern Polynesia (Kirch 1982:68, 1985:67–68). The windward sides of the major islands seem to have been occupied earliest with the occupation of the drier leeward coasts occurring by AD 1000–1100 (Cordy 1974). Colonization of the Hawaiian Islands probably involved substantial social and environmental adaptation by an initially small population rather than the transplantation of an entire Polynesian society (Kirch 1984:83–89). In recent years, several researchers have used a growing body of archaeological evidence to construct chronological sequences of culture change for Hawai'i (Cordy

1974; Hommon 1976, 1986; Kirch 1985:298–308; Spriggs 1988). Kirch's sequence of five periods is used as the basis of the following discussion.

The Colonization period (AD 300–600) is represented by only a few archaeological components. These early sites yield stone adzes, one-piece fish-hooks, and evidence of pole-and-thatch dwellings with pebble-paved floors, hearths, and subfloor burials. The first colonists of Hawai'i apparently brought domesticated plants and animals with them although archaeological evidence of early domesticates is scarce. Some archaeologists have suggested that the first Hawaiian societies were representative of ancestral Polynesian society, and, like more typical postcontact Polynesian cultures, they probably had hereditary chieftainship of corporate kin groups with little to no separation between elite and commoners (Earle 1978; Kirch 1984, 1985). However, there is little archaeological evidence to support this reconstruction.

By the end of the Developmental period (AD 600–1100), sites were located throughout the Hawaiian Islands, and population growth seems to be indicated by this expansion of settlement. The first known permanent house structures are found during this period, and fishing gear is more elaborate. Frequencies of domesticated pig and dog bones seem to increase over time as well. There is no evidence of irrigation, but geomorphic evidence indicates erosion that may have been related to intensification of agriculture. One elaborate burial is dated to this period and may indicate a degree of status differentiation.

The Expansion period (AD 1100–1650) is characterized by a number of changes. Settlement expanded into drier, marginal environments indicating further population growth. Evidence for irrigation, elaborate dryland farming, and the construction of fishponds is also present for this period. Several architectural changes include the existence of separate houses and cookhouses, the construction of field shelters, and the erection of large temples. Elaborate ornaments may indicate further rank differentiation. The Expansion period encompasses the critical changes that produced the characteristic chiefdoms of the Protohistoric (AD 1650–1795) and Historic (post AD 1795) periods.

Some archaeological research has focused specifically on defining and documenting increased cultural complexity in Hawaiian chiefdoms over time. Cordy (1981), for example, maintained that it is necessary to define what actually changed in the devel-

opment of Hawaiian chiefdoms before the causes of change can be addressed. He suggested that increased cultural complexity involves increased structural differentiation: vertical differentiation, or social ranking, is one type. Cordy used the term *social ranking* for several different aspects of cultural complexity, including the number of organizational or administrative levels, the number of social classes, and the degree of inequality between classes. He also suggested that population growth was an essential component of increased cultural complexity. Testing the proposition that population growth, territorial expansion, and social ranking had occurred together in the development of Hawaiian chiefdoms, he used architectural and burial data to suggest that this had been the case. Kirch (1983), however, questioned some of the assumptions underlying Cordy's conclusions; for example, Cordy proposed that the amount of time and labor apparently invested in the construction of burial facilities, houses, and temples was a reflection of social ranking, but this assumption has not been verified by other research.

In another archaeological study that examined increased cultural complexity in Hawai'i, Hommon (1976, 1986) suggested that the key to the appearance of Hawaiian chiefdoms was the disintegration of traditional kin groups, the subsequent distinction between elite and commoner classes, and the emergence of the *ahupua'a* (local community), which was economically self-sufficient, socially isolated, and politically dominated by the chiefly elite. Hommon studied settlement pattern changes and suggested that there was population growth and inland expansion after AD 1400. He equated this inland expansion with the emergence of the *ahupua'a*. However, there is not necessarily a correlation between territorial expansion and the appearance of the *ahupua'a* as the type of community which Hommon describes.

In summary, most researchers would agree that cultural complexity increased over time in Hawai'i. It is known that the Hawaiian Islands were colonized by a small group from elsewhere in Polynesia and that significant change occurred from the time of first colonization to the time of European contact. Population growth, agricultural intensification, and architectural elaboration are evident in the archaeological record. These trends are often cited as indicators of increasing cultural complexity, and it seems reasonable to assume that they reflect or are at least related to increased heterogeneity and inequality. Archaeological studies that have focused specifically

on documenting changes in components of complexity such as social ranking (Cordy 1981; Hommon 1976, 1986) also suggest that cultural complexity increased over time, but the results of these studies remain somewhat inconclusive.

Cultural Complexity in Postcontact Hawaiian Chiefdoms

Anthropologists have traditionally regarded the Hawaiian chiefdoms described at the time of European contact as highly stratified and complex in comparison to other Polynesian societies (Goldman 1970; Sahlins 1958).

Heterogeneity was represented by the territorial hierarchy of economic or administrative units: the household, the *ahupua'a*, the district, and the chiefdom. Each can be conceived of as an organizational level within Hawaiian society. Handy and Pukui (1972) suggested that another type of economic unit, the *'ohana*, may have existed within the *ahupua'a*. They proposed that the *'ohana* consisted of several related households or families and was associated with a territorial division of the *ahupua'a* called the *'ili* which, like the *ahupua'a*, crosscut all environmental zones. Within the *'ohana* economically specialized households would have cooperated. However, researchers have debated whether the *'ohana* actually existed and what the nature of this social unit would have been (Earle 1978:143–146, 157; Sahlins 1973).

The Hawaiian hierarchy of land divisions was similar to that found in many other Polynesian societies (Kirch 1984:258), but Hawaiian chiefdoms definitely had a higher degree of heterogeneity and inequality in several other respects. In the typical Polynesian society, individuals were ranked by kinship distance to the paramount chief. Population growth and subsequent fissioning of an original population led to the existence of a number of lineages within which people were ranked internally by genealogical distance from the lineage chief and outside of which the lineage chief was ranked by kinship distance from the paramount chief. The territorial hierarchy of land divisions corresponded. Chiefs were not members of an elite class but simply high-ranking members of their local groups (Earle 1978:10–11; Johnson and Earle 1987:225–227). In Hawai'i, however, there was a clear division between the elite (*ali'i*) and the commoners (*maka'ainana*). Chiefs had their own ranking system based on genealogical distance from the senior descent line. The use of both male and female lines in

determining inheritance and multiple intermarriages created a complex web of kin ties within the ali'i. Genealogies were reviewed with the ascendancy of each new paramount; higher-ranking members of the ali'i were generally appointed as the heads of districts with lesser chiefs administering the ahupua'a or serving as managers (*konohiki*). In contrast, commoners did not keep genealogies and had no system of ranking (Earle 1978:11–16; Hommon 1976; Sahlins 1981, 1985).

There were definite economic inequalities between the elite and the commoner classes. The ali'i, for example, had preferential access to such exotic goods as the feathers of particular birds which were used to make cloaks and helmets that served as symbols of status (Earle 1987a; Hommon 1976:116). Certain choice foods were also reserved for the high chiefs (Sahlins 1958:17). The chiefly class controlled access to land. In return for labor and goods which were periodically collected as taxation or tribute, the right to use land for agriculture was granted to commoners by the *konohiki* and/or other chiefs. The goods collected included agricultural produce, which was used to feed the ali'i as well as the large retinue of the paramount chief (Earle 1978; Hommon 1976; Sahlins 1958, 1972, 1981, 1985).

Thus, one significant type of social differentiation was represented by the division between the ali'i and the commoners as well as the ranking system among the ali'i themselves, both of which were based on descent. The occupations of priests and craft laborers were, however, determined independently of their inherited rank, which "might vary from high to low" (Sahlins: 1958:14). Craft laborers apparently included canoe builders and house builders; there were also other specialists such as healers (Sahlins 1958:115–116). In addition to relatives and various hangers-on, the paramount chief's retinue contained advisors, genealogists, messengers, priests, and craftspersons (Hommon 1976:115). It is unclear when or to what extent occupational specialization was directed or sponsored by the ali'i.

DEVELOPMENT OF CHIEFDOMS

Service originally proposed that the social stratification characteristic of chiefdoms is the result of regional specialization and centralized redistribution of resources in areas with sedentism and marked ecological diversity (1962, 1975). His hypothesis was based, in part, on Sahlins' (1958) comparative study of social stratification in Polynesia. Using ethnographic and ethnohistoric data, Sahlins proposed a

direct relationship between degree of social stratification and level of subsistence productivity; specifically, he stated that in areas of high productivity, a chief is able to gain status and prestige through the redistribution of surplus. The position of chief is the key to the remainder of the social ranking system with all individuals simply ranking themselves according to genealogical distance from the chief.

In ecologically differentiated areas, Service proposed that centrally located sedentary settlements with preferential access to varied resources will emerge as redistributive centers. Because they are not as dependent on intervillage exchange as most villages, these central villages simply receive resources from some villages and pass them on to others. In the central settlement, this redistribution is carried out primarily by the local Big Man, an individual who achieves status mainly by accumulating and distributing material goods. As the regional redistribution system becomes more efficient, villages are encouraged to specialize in production. Still greater efficiency leads to greater overall production and redistribution, and the central Big Man gains further prestige through redistributive activities from which he is able to extend his influence over craft specialization, public works, and ritual. With increased prestige and influence, Service argued, Big Man positions may become hereditary offices, and this development "naturally carries the possibility of other statuses of high degree" (1962:139). Like Sahlins, he maintained that, "It is the presence of the office of chief that makes a chiefdom" (Service 1962:140). Redistribution and social stratification, the key features in Service's definition of the chiefdom, were causally related in his hypothesis of chiefdom development. Consistent with an evolutionary and ecological perspective, social organization is proposed to have changed in response to environmental circumstances.

The work of Sahlins and Service contributed to a larger movement toward evolutionary and ecological approaches in anthropology, and some attempts to invoke ecological differentiation and redistribution of resources as explanations for the development of cultural complexity followed their ideas quite closely.

Adaptationist Approaches

Like Service, some cultural anthropologists (Fried 1960) and archaeologists (Gall and Saxe 1977; Peebles 1971) maintained that chiefdoms and/or states developed in areas with environmental diversity where

regional specialization and centralized redistribution were efficient means of improving and diversifying overall productivity and ensuring widespread access to resources. Other archaeologists emphasized the importance of redistribution in dealing with failures or perturbations in resource availability (Halstead and O'Shea 1982; Isbell 1978). Similar hypotheses were also applied to explain the emergence of states with petty market exchange (Sanders and Price 1968).

Other versions of these adaptationist approaches proposed that complex societies with centralized leadership developed in some areas in order to organize long-distance trade needed to obtain basic resources (Rathje 1971, 1972). Others emphasized the control of production rather than exchange; following Wittfogel (1957), some proposed that the management of irrigation facilities or similar large-scale projects led to the emergence of public leaders and the subsequent development of complex societies (Leeds 1969; Redman 1978). Related hypotheses stressed the role of the acquisition and control of such scarce resources as agricultural land in promoting leaders and centralized governing systems (Carneiro 1970; Dumond 1972; Gumerman 1986). Similar hypotheses maintain that the coping or decision-making abilities of a society are enhanced by means of a hierarchy with ascribed statuses and elite control (Johnson 1978; Peebles and Kus 1977; Wright 1969, 1977; Wright and Johnson 1975). All of these hypotheses emphasize the role of environmental factors and a need for centralized management as keys to the emergence of cultural complexity.

A number of archaeological studies have focused on the development of Hawaiian chieftdoms, and several adaptationist arguments have been put forth. For example, Cordy (1974) proposed that population pressure led to warfare and/or major social reorganization which favored the emergence of leaders in a hierarchical organization. Similarly, Kirch (1980, 1982) suggested that population pressure led to warfare and agricultural intensification; the participation of certain individuals in war and economic management enhanced their status and eventually resulted in the appearance of chiefs and a distinction between the chiefly and commoner classes.

Other studies have emphasized the importance of environmental factors but have been less explicit in outlining causal relationships. Cordy (1981) proposed that population growth and social ranking increased together over time in the Hawaiian Islands. He did not explain how or why this may have occurred although he seems to imply that in the face

of population pressure a social organization with hereditary leadership and a political hierarchy would have enhanced the decision-making capabilities of Hawaiian groups. Hommon (1976, 1986) documented territorial expansion and equated this with the development of the *ahupua'a* within an organizational hierarchy. He implies that population growth, competition for land and other resources, and a need for territorial expansion were underlying factors in the development of Hawaiian chieftdoms although he does not explain the process of change in detail.

Political Approaches

Sahlins' (1958) original conclusions concerning the direct and causal relationship between high productivity, resource redistribution, and social stratification have been criticized because his primary measure of productivity was the extent and frequency of redistribution. He assumed that material redistributed by a chief was simply naturally occurring surplus and failed to consider whether any features of the social organization itself might account for high productivity and the creation of apparent surplus. Revising his earlier viewpoint, Sahlins suggested that "too frequently and mechanically anthropologists attribute the appearance of chieftainship to the production of surplus" (1972:140). Instead, he proposed that centralized leadership itself can bring about surplus production. Households may deliberately produce surplus above and beyond their own needs in order to provide tribute to the chief; the chief in turn uses this surplus to fund public events and projects which not only bring him more status and renown but may also improve the productive capabilities of individual households.

Goldman (1970) also rejected Sahlins' original ideas regarding surplus and social stratification, suggesting instead that intense status rivalry typical of Polynesian culture was the factor that contributed to increased social stratification. He proposed that redistribution was a ritual activity that was the prerogative of social status earned through other activities such as warfare. Goldman, in turn, was criticized for presenting a tautological argument in which he attempted to explain social stratification in terms of status rivalry which is itself an aspect of social stratification (Howard 1972).

Using ethnohistoric and archaeological data from Hawai'i, Earle (1978) tested three well-known adaptationist hypotheses concerning the development of cultural complexity and in particular the

development of hereditary chieftainship. He rejected the idea that leadership had developed in response to the requirements of irrigation (Wittfogel 1957) because the extent and complexity of Hawaiian irrigation systems were apparently not so great that they would have required centralized control and coordination. Rejecting also the idea that population pressure and subsequent warfare over agricultural land had required leadership (Carneiro 1970), Earle maintained that Hawaiian warfare was not conquest warfare which resulted in territorial expansion and required some sort of administration but was actually a form of political rivalry or competition between leaders who had already been established for other reasons. Earle also rejected the hypothesis that ecological diversity had brought about centralized redistribution of resources which had instigated the appearance of hereditary leaders (Sahlins 1958; Service 1962, 1975). Earle pointed out that the Hawaiian *ahupua'a* was deliberately laid out to encompass all relevant environmental zones so that the need for exchange and centralized redistribution did not exist (fig. 3.2). Furthermore, he claimed that the redistribution characteristic of Hawaiian chiefdoms was actually a form of taxation used to support the elite rather than the widespread redistribution of necessities. He proposed a dual economy for Hawaiian chiefdoms consisting of the political economy which supported the elite through periodic taxation and the subsistence economy characteristic of the self-sufficient local communities within the chiefdom.

Consistent with a politically oriented approach, Earle proposed that in Hawai'i it was the deliberate efforts of individuals to enhance their status which contributed to increased cultural complexity over time. The initial Hawaiian societies were similar to typical Polynesian cultures which had a system of hereditary ranking based on genealogical distance from a senior line of descent and ultimately a divine ancestor. High-ranking individuals were incipient public leaders or chiefs. As senior-ranking individuals who were closest to the divine ancestors, they probably received or collected offerings from people of lower rank which would have been used to sponsor rituals, feasts, and other activities. Would-be chiefs could have deliberately invested in such prestige-enhancing activities as the construction of temples or warfare. In Hawai'i, the presence of large islands with abundant resources and the potential for high productivity allowed leaders to collect ample resources and invest them in status-earning activities, including agricultural intensification, which

ensured that even more resources would be available for future investment (Earle 1978; Kirch 1984: 62–69; Sahlins 1972:139–148).

Like Goldman, Earle emphasized preexisting features of basic Polynesian social organization to explain the development of Hawaiian chiefdoms, but like Sahlins and Service he related increased status and prestige to resource control and environmental circumstances. In contrast to Sahlins and Service, however, Earle argued that it is not distribution of resources but rather the use of resources to finance other activities that is the key to chieftainship. Various such political models have been offered as alternatives to the explanations for cultural complexity originally derived from Sahlins and Service. These models favor the notion that emerging elites consciously used material resources to deliberately obtain or enhance power and reject the idea that centralized leadership is a natural consequence of environmental settings where economic control is beneficial, efficient, or adaptive (Brumfiel and Earle 1987).

An early version of such a political model was proposed by Flannery (1968) when he suggested that in early Mesoamerica long-distance trade in exotics was carried out by incipient elites in order to enhance their status. Such exchange was, however, an effective mechanism for creating and maintaining social ties between groups which could be advantageous during times of food shortages or other stress, according to Flannery. This dual role for centrally controlled exchange has also been suggested by ethnographers for a number of nonstate societies with hereditary chiefs and Big Men (Brunton 1975; Dalton 1977; Strathern 1971).

Recent approaches emphasize more exclusively the goals of local leaders. These politically oriented hypotheses do not assume that the actions of elite leaders automatically confer any advantages to the society in general. In fact, local rulers may deliberately maintain social inequalities, and their societies may be characterized by dissension. Several, not mutually exclusive, versions of such political models exist, and they differ in demonstrating how the use or control of material resources actually results in enhanced power and leadership (Brumfiel and Earle 1987):

- Control of external trade produces income which leaders can invest in such areas as the support of armies or craft specialists (Santley 1984).

- Control over such basic resources as subsistence crops can allow coercive power (Sanders 1984).
- Control and display of wealth items can be used to attract political allies (Stephen Shennan 1982; Susan Shennan 1982).
- Control of certain wealth goods and/or items and symbols of ritual significance can be used to enhance status and power through simple display. In Hawai'i, the accumulation and display of particular exotic and symbolically significant items such as feather cloaks apparently provided one of the foundations for chiefly power (Earle 1978, 1987a; Kaeppler 1985).

In addition to Earle's (1978) work, other studies of Hawaiian culture change have emphasized the importance of sociopolitical factors and, in particular, the deliberate actions and motivations of the chiefly elite. In his discussion of population pressure, warfare, and intensification of agriculture, Kirch (1980, 1982) pointed out that other factors were probably also involved. For example, warfare and agricultural intensification may sometimes have been undertaken not because of population pressure but because leaders could use these activities to fund and enhance their political influence (Earle 1978; Sahlins 1972). More recently, Kirch (1984) has stressed a systemic approach in which the development of Hawaiian chiefdoms is attributed to the interrelationship of factors including population growth, territorial expansion, competition for resources, agricultural intensification, and political competition between leaders. Intensified production and/or territorial expansion could have been the result of chiefly political competition (Spriggs 1988). In addition, Spriggs proposed that instead of being the result of population growth, Hawaiian political organization could actually have led to population growth as leaders encouraged expansion of military and/or labor forces for their own use or gain. Long-distance exchange networks through which prestige was obtained in Western Polynesian societies broke down or were not feasible in Eastern Polynesia, including Hawai'i, according to Friedman (1982), so that political rivalry manifested itself in warfare and other sorts of competition which required agricultural intensification.

Political approaches to the development of cultural complexity originated as a response to adaptationist hypotheses, and they seem to oppose

adaptationist ideas by emphasizing the importance of the political actions of leaders rather than systemic responses to ecological conditions. However, political approaches are essentially an outgrowth of adaptationist theories and are rooted in materialist ideas. In these approaches, political control is based on the use of material resources and/or exploitation of labor; political power derives from control of productive resources which may include stored food, technology, conquest warfare, or external trade. Furthermore, opportunities for various kinds and degrees of control are provided by environmental conditions (Earle 1978; Earle 1987b; Johnson and Earle 1987). Recent political approaches have been explicitly concerned with synthesizing original adaptationist ideas with political concerns to show "how problems of survival create needs for leadership and, at the same time, opportunities for control" (Earle 1987b:297).

Traditionally, political approaches have focused on the role of elite leaders in the development of cultural complexity. Often, a distinction is made between the political economy within which leaders use resources to maintain or extend their influence and the subsistence economy within which the nonelite maintain self-sufficient households (Earle 1978; Johnson and Earle 1987:11–15). Until comparatively recently, political approaches did not consider the subsistence economy in any detail and did not specifically analyze the articulation between the political and subsistence economies—the necessary interrelationship between elite leaders and commoners.

More recently, however, political researchers have begun to examine the subsistence economy in more detail and to ask, "Why do people choose to give up their autonomy, and for what?" (Hastorf 1990:149). Their answers to this question are rooted in adaptationist ideas. First, it is suggested that people may agree to political domination if they receive (or at least perceive that they do) tangible benefits from centralized leadership; such benefits might include construction and maintenance of irrigation works (Earle 1978; Johnson and Earle 1987:14–15) or organized defense against outside aggression (Hastorf 1990). In addition, ideology can be used by the elite as a justification for political domination. In Hawai'i, for example, chiefs were believed to be semidivine descendants of the gods whose rank and accompanying powers were simply predetermined; furthermore, by controlling sacred symbols of power such as feather cloaks and sponsoring the construction

of temples and the enactment of public rituals chiefs reinforced their sacred connotations and provided ideological or ritual benefits to the population at large (Earle 1987b:298–300).

ROLE OF REDISTRIBUTION

The term *redistribution* has been broadly and variously used to refer to several different economic processes that happen to involve the centralized collection and subsequent dispersal of goods. Polanyi was the first to define redistribution in proposing that there were three main forms of economic integration: reciprocity, redistribution, and market exchange. The key feature of redistribution was “collecting into, and distributing from, a center”; that is, “redistribution obtains within a group to the extent to which the allocation of goods is collected in one hand...” (1968:149).

Polanyi claimed that redistribution was found in all types of societies at all levels of cultural complexity, and reciprocity, redistribution, and market exchange were not sequential evolutionary stages of economic development (1968:156). On the other hand, Service (1962, 1975) proposed that redistribution was characteristic of chiefdoms which, to him, did represent an evolutionary stage in cultural development. Furthermore, redistribution contributed to the development of chiefdoms as societies with centralized, hereditary leadership and social stratification. Like Polanyi, Service considered redistribution to be the centralized pooling and subsequent dispersal of goods. He implied that redistributed goods could include a variety of items but emphasized the importance of redistributing food and other necessities. This definition is consistent with the adaptationist approach in which redistribution is seen as a logical response to environmental diversity and differential availability of resources.

Earle (1977) has pointed out, however, that the term redistribution as it was used by Polanyi and others actually refers to several significantly different economic processes:

- Leveling practices such as the potlatch which result in the reallocation of wealth.
- Householding or sharing resources within a domestic unit.
- Sharing of resources acquired through cooperative labor beyond the household level as in dividing meat from a communal hunt.
- Mobilization in which a central authority appropriates goods as tribute or taxation.

Redistribution as Mobilization

The redistribution Service described for Polynesian chiefdoms has been described as mobilization. Redistribution was limited and served only to support the elite and to fund warfare and public projects initiated by the chiefs. Redistribution did not serve to guarantee that everyone received all available resources (Earle 1977, 1978). In Hawai‘i, “the king distributed it [collected goods] among the chiefs and the companies of soldiery throughout the land. . . No share of this property, however, was given to the people” (Malo 1951:143).

There are two basic ways in which mobilization can be carried out: wealth finance and staple finance. In wealth finance, personnel who provide administrative services or other support for the ruling elite are provided with wealth items or valuables. In staple finance, food and other necessities are collected and distributed to key personnel. The main form of mobilization in Hawaiian chiefdoms consisted of staple finance (Brumfiel and Earle 1987; Earle 1987a, 1987b: 294–297).

In staple finance, it is usually difficult for one or a few individuals at a single location to carry out the actual collection, transport, storage, and allocation of large quantities of food and other bulky goods within a region. One way of dealing with such logistical problems is to organize a hierarchy of administrative units (such as the Hawaiian chiefdoms, districts, and ahupua‘a) and then use this structure to concentrate resources at relatively few locations. In Hawai‘i, another solution was provided by the fact that the paramount chief and his retinue did not have a permanent residence at a central place but instead traveled around the chiefdom drawing on the resources of first one community and then another.

Nevertheless, in some ways, staple finance can limit or even prevent the expansion of elite control. It can be difficult to maintain firm administrative control while relying on staple finance because the staples used to support the elite and finance their projects are produced and possessed by commoners. The commoners are not only economically self-sufficient and independent of the elite for their subsistence needs but they can also use their resources to fund revolts and/or back rival leaders. In Hawai‘i, there was frequent political unrest (Earle 1978; Hommon 1976; Sahlins 1972:143–148), and “some of the ancient kings had a wholesome fear of the people” (Malo 1951:195).

Wealth finance can be used to counteract some

of these limitations. In Hawai'i, for example, the paramount chief collected exotic feathers and supported craft specialists who manufactured feather cloaks. These were then given to high-ranking individuals as symbols signifying their close relationship to the paramount. Because the paramount chief was regarded as semidivine, the feather cloaks symbolized and reinforced the idea that leadership by high-ranking individuals was divinely sanctioned. Cloaks were material symbols of a religious system that justified and maintained differences in status and power (Earle 1987a; Kaeppler 1985).

In addition, commoners had little motivation to challenge chiefly power because they, as well as the elite, benefited from the public projects sponsored through staple finance. Irrigation works and fishponds, for example, increased local productivity (Earle 1977:226). Perhaps more importantly, in their role as descendants of divine ancestors, the chiefs also sponsored the construction of temples and the enactment of crucial rituals. Therefore, resources mobilized by the chiefs were redistributed to the people, but they were converted to public services rather than reallocated directly as material goods.

The interpretation of redistribution as mobilization was an integral part of the political approach to chiefdom development. According to Earle (1978), the actual collection and distribution of necessities did not take place in Hawai'i and therefore did not contribute to the development of cultural complexity there. Instead, it was the deliberate mobilization, use, and investment of resources by an emerging elite that contributed to the development of Hawaiian chiefdoms. The interpretation of Hawaiian redistribution as mobilization has influenced others to conclude that redistribution in chiefdoms and other complex societies also does not consist of the simple collection and dispersal of necessities and does not contribute to the growth of cultural complexity in the manner originally suggested by Service (Feinman and Neitzel 1984; Muller 1987; Peebles and Kus 1977). However, neither Service's scenario nor the rejection of it has been well tested with archaeological data and in particular with archaeological data from Hawai'i.

Redistribution in Hawai'i

Service was inspired to suggest that exchange and, eventually, the centralized redistribution of resources took place in Hawai'i because of the great ecological diversity found on each island. There are marked changes in climate and vegetation as altitude in-

creases with distance from the coast (Krajina 1972), and there are also dramatic environmental differences between the wet, windward sides and the dry, leeward coasts of the larger islands (Kirch 1985:25). However, as Earle pointed out in his rejection of Service's hypothesis, Hawaiian chiefdoms, at the time of European contact at least, were divided into territorial units (ahupua'a) that included parts of all available environmental zones so that there was no need for resource redistribution. Further, ecological differences between larger regions were apparently resolved through the pursuit of different subsistence strategies rather than reliance on exchange. The ahupua'a are usually assumed to have been economically self-sufficient. They are also described as being socially isolated, with mobility and ties, including intermarriage, between ahupua'a being rare. In fact, the chiefs and konohiki may have actively discouraged population movements in order to maintain an adequate labor force within each community (Earle 1978; Hommon 1976). It is usually assumed that there would have been little trade or exchange of resources between the ahupua'a.

Earle's original research on Hawai'i did not address the fact, however, that certain resources are not uniformly available throughout the Hawaiian Islands. Certain resources, including stone for adze manufacture, were localized in their distribution and may not have been found within every ahupua'a. Some ahupua'a were wider inland than at the coast and included large areas in the island interior including, sometimes, the summits of mountains. These ahupua'a often contained upland resources that other communities did not, including some known sources of adze stone (Cleghorn et al. 1985; Lyons 1875; McCoy 1990).

There is little information on how differentially available resources may actually have been acquired in Hawai'i. Postcontact accounts indicate that some districts exchanged differentially available items such as bark cloth (*tapa*), mats, and some foods through barter at small markets (Ellis 1963:229-230); it is unclear, however, if and to what extent this practice may have been influenced by Europeans after contact (Hommon 1976:70) or at least to what extent the description of this practice may have been affected by Western bias. Other accounts indicate that there was exchange of food, certain woods, and other materials between districts (Handy and Handy 1972:314-315; Hommon 1976:69), but the way in which these goods were actually exchanged is not specified. It has been suggested that some resources,

Chapter 2

including adzes, were distributed by means of unregulated, small-scale, informal exchanges among individuals (Earle 1987a:66; Handy and Handy 1972:314–316; Johnson and Earle 1987:233), but again there is little evidence to indicate whether this kind of exchange took place. In one specific reference to the acquisition of adzes, Malo does say that an adze was “an object of barter with this one and that one and thus came into the hands of the canoe maker” (1951:51).

In sum, the ethnohistoric accounts upon which

Earle relied for his conclusions provide little information on Hawaiian trade, exchange, or resource acquisition. Furthermore, postcontact descriptions do not indicate how the means of resource acquisition may have changed over time in Hawaiian chiefdoms. It is thus important to supplement ethnohistoric information with archaeological evidence. This research, then, will reexamine the applicability of Service’s hypothesis in Hawai’i and to reevaluate the adaptationist and political ideas derived from his work with archaeological data.

Chapter 3

Redistribution in the Development of Hawaiian Chiefdoms

In interest in the role of resource control and distribution in the development of cultural complexity was accompanied by archaeological studies designed to document the movement of prehistoric resources and correlate the spatial distribution of artifacts or raw materials with mechanisms of resource acquisition. Such studies are often referred to as exchange studies even though the actual exchange of one thing for another is not always involved in the acquisition of resources. For example, individuals or small groups of people can acquire raw materials such as stone through direct access or actual travel to and from desired sources without participating in any sort of exchange transaction.

In archaeological studies, the term *redistribution* is frequently used but not often well defined. However, the collection and eventual dispersal of materials from a central place is almost always assumed. Following Service, most studies also assume that redistribution consists of the widespread distribution of necessary resources and that some administrative authority is responsible for this distribution.

REGIONAL EXCHANGE STUDIES

Regional Distribution Patterns

One way of attempting to determine precontact means of exchange or acquisition consists of measuring regional or directional changes in the archaeological occurrence of raw materials from different sources. Renfrew and others first used this approach while analyzing the distribution of obsidian in the Near East. When the relative abundance of obsidian at archaeological sites was plotted against site distance from the source, the plotted line was flat for

sites located near the source, but dropped off steeply after a certain point. This was interpreted to indicate an initial supply zone within which people were able or willing to make direct trips to the source followed by an area within which down-the-line reciprocal exchange took place (Renfrew, Dixon, and Cann 1968). Later, Renfrew considered additional mechanisms for acquiring materials. He proposed, for example, that when redistribution from central places occurred, the clear falloff patterns seen in reciprocal exchange would be absent; instead, curves plotting material abundance against distance from the source would show a series of peaks and valleys with peaks representing central places where materials were collected for distribution and also disproportionately retained by the elite (1975; 1977:85-87). Variations of Renfrew's models have been applied in cases where factors such as topographic variability (Findlow and Bolognese 1982), varying site types (Sidrys 1976, 1977), the existence of definite transportation routes, and cultural boundaries (Ericson 1977) were present.

Some archaeological studies that measure regional changes in the occurrence of different types of raw material have focused specifically on stone axes or adzes (Cummins 1979; Elliot, Ellman, and Hodder 1978; McBryde 1978, 1984; McBryde and Harrison 1981). Cummins examined the regional distribution of stone axes from different sources in England and Wales. He measured the abundance of axes from different sources by calculating the percentage of axes from each source among all of the axes recovered within areal units of standardized size. In general, the percentages of each type of stone decreased

with distance from the sources, and Cummins suggested that this clear falloff in occurrence with distance from the source indicated that axes had been acquired through direct access and/or informal, hand-to-hand exchange. However, for two of the types of stone considered, highest abundance was not near the sources but rather at some distance away. Here, Cummins suggested that axes had been taken from their sources directly to more distant centers from which they were then dispersed. However, he pointed out that the process by which axes were taken to distant centers and distributed did not necessarily reflect formal redistribution of any kind. In this case, Cummins suggested that small groups of people who lived far from stone sources made occasional trips to quarries to collect stone and/or make axes which they then brought back to their settlements in large quantities to distribute informally.

The observation that similar spatial patterns of raw material occurrence may reflect more than one means of resource acquisition raises questions about the validity of regional distribution studies. In fact, spatial models of prehistoric exchange are often regarded as too simplistic to provide accurate and mutually exclusive identifications of past exchange mechanisms. It is simply "very difficult to identify different exchange systems from artifact distributions alone" (Hodder and Lane 1982:214). In actuality, models for prehistoric exchange are best viewed as starting points for comparison; once it has been determined how and to what degree archaeological patterns deviate from the models, other more qualitative and area-specific analyses can be carried out. Moreover, regional studies of resource distribution make an important assumption that the quantity of a material at a site is an accurate indicator of how extensively it was actually used at that location (Torrence 1986:22–23). However, many factors, including varying rates and types of material or artifact discard and inconsistencies in site excavation and artifact recovery in a region, can affect the archaeological occurrence of different materials, and such factors must also be considered when interpreting spatial distribution patterns.

Changes In Artifact Size Over Distance

When compared to other artifacts that have been the focus of regional distribution studies, adzes are unique in having a long use-life during which they are frequently resharpened by their users. This fact has led several researchers to propose that data on

changes in adze size with distance from the original source can also be used in reconstructing regional exchange systems. With direct access and/or down-the-line exchange, adzes may become smaller with increasing distance from their source because of increased transport costs, causing tools to be retained longer and resharpened more frequently at greater distances from the source. In a system of down-the-line exchange, individuals near the source may also retain large adzes for their own use and pass smaller tools on in the exchange system (Hodder 1978:87; Hodder and Lane 1982; McBryde and Harrison 1981).

Change in the bevel angle of adzes with distance from their sources may also be indicative of direct access and/or down-the-line exchange. In a study of New Guinea axes, Hughes noted that as distance from the source increased the bevel angle or angle at which the front and back surfaces of the tool meet to form the cutting edge (fig. 3.1) became more obtuse; he attributed this to the fact that axes at locations relatively far from sources were used longer and resharpened more often than others (1977:162,164).

SITE-SPECIFIC ANALYSES

In addition to regional exchange studies, some researchers have investigated the types and amounts of raw materials represented within individual archaeological sites. The goal of such studies is to determine how a single community may have acquired a particular resource and/or how certain materials were distributed or allocated within a community.

In the now-classic study of obsidian in Mesoamerican households, Pires-Ferreira (1975, 1976; Winter and Pires-Ferreira 1976) suggested that if obsidian had been acquired through reciprocal exchange by individual households, there would be variation between households both in the specific

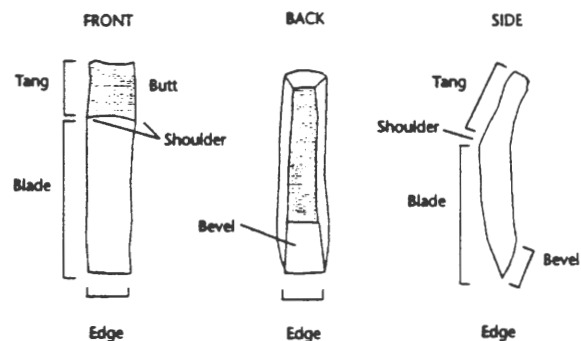


Figure 3.1
Parts of an adze. After Cleghorn 1982

sources of obsidian used and the proportions of obsidian from various sources that were used; more sources would also probably be represented. With centralized redistribution within or from outside the community, fewer sources would be used; there would also be more uniformity between households in the sources used and in the proportions of obsidian from each source. The suggestions made by Pires-Ferreira have also been applied to lithic workshops (Spence 1981; Spence, Kimberlin, and Harbottle 1984).

Studies of adze exchange focused at the intrasite level that are similar to those carried out by Pires-Ferreira are not feasible. Adzes are generally manufactured at sources of stone away from habitation sites, so that lithic debris associated with adze production is not found within household contexts. The use of different raw materials can only be estimated on the basis of finished tools, which may have been transported long distances from their original site of acquisition. Moreover, relatively few adzes would have been used by any one household, and, in addition, adzes are not always recovered in household contexts but rather at other locations where they were used, lost, or discarded.

It may be possible, however, to extend some of the principles that have been used in comparing the raw materials in households to the comparison of entire communities or sites. Using such an approach, Clark and Lee (1984) suggested that the variable use of several types of obsidian at sites in Mesoamerica argued against a regionally centralized system of stone distribution. In other words, like the households in Pires-Ferreira's research, each site probably acquired its obsidian independently. In later time periods, however, there was greater uniformity between sites in the obsidian sources used, and they suggested that this indicated a shift toward regional redistribution. Increasing uniformity in the obsidian sources used was reflected primarily in an increased reliance on one main source of obsidian at all sites.

There are conflicting opinions, though, on whether uniformity in the specific sources of materials used and/or in the percentages of various materials within households, workshops, or communities necessarily indicates centralized redistribution. In particular, informal exchange and sharing between households or villages could result in uniformity in the sources of materials used just as well as formalized redistribution. There may be no way of differentiating between formal redistribution and

simple sharing, but if resources are locally available and can be obtained through direct access, then informal acquisition and unregulated sharing seem more likely than formal redistribution (Parry 1987).

Several approaches that attempt to identify redistribution and other types of resource acquisition using archaeological evidence have been described. These include regional studies concerned with measuring changes in the occurrence and relative abundance of materials with distance from their sources, regional studies focused specifically on stone adzes which measure changes in adze size and bevel angle with distance from their sources, and site studies which propose that the types and proportions of various raw materials between households, workshops, or entire communities reflect the means of resource acquisition.

There are problems associated with each of these efforts to determine how prehistoric resources were acquired. The major difficulty, however, is that there is no simple, straightforward correlation between spatial or archaeological patterning in the occurrence of various raw materials and the complex economic or social processes that produced the patterns. Attempts have been made to correlate particular spatial patterns with specific kinds of exchange or acquisition. The basic premises behind these correlations are logical. It seems reasonable to assume, for example, that if materials are acquired through informal down-the-line exchange, they will be scarcer at a greater distance from their source and that such a pattern will be disrupted by the existence of centralized redistribution. In any real case, however, there are many geographical and socioeconomic factors that affect the archaeological distribution of artifacts and cause these distributions to differ from those described in models.

In this research, suggested correlations between archaeological distributions and prehistoric means of resource acquisition are used only as models for initial comparison. These models are a place to start or a framework within which to begin examining the regional distribution of Hawaiian adzes from various sources. There may be no conclusive archaeological evidence that demonstrates how Hawaiian adzes were acquired. However, identifying some of the reasons why the distribution of Hawaiian adzes does not conform to ideal spatial patterns may provide interesting clues and valuable insights on the acquisition of resources in precontact Hawai'i.

Prior to this research, no adzes from Hawaiian habitation sites had been traced to their original

sources, and so the primary aim in selecting the sample of adzes for this study was to obtain artifacts from a range of temporal periods and a wide variety of sites. Very few artifacts from any given site, however, were sourced. Thus, there is no way to meaningfully document the relative abundance of adzes from various sources or to quantify regional differences in the occurrence of adzes made from different materials. Appendix D provides information on the actual numbers of artifacts from various sources found in particular districts, time periods, and sites, but in attempting to determine whether the spatial distribution of Hawaiian adzes from various sources may indicate centralized redistribution, only the presence or absence of materials at sites and the general extent of their occurrence is examined. This fact limits the extent to which the data in this study can be compared to previous models that have correlated regional patterns of artifact distribution with specific mechanisms of exchange or acquisition.

Other limitations exist as well. For example, even though some have suggested that adzes may decrease in size with distance from their source (Hodder 1978:87; Hodder and Lane 1982) or that the bevel angle will become more obtuse if down-the-line exchange was present (Hughes 1977:162,164), changes in adze size or bevel angle over distance could not be studied. No complete adzes were sourced because petrographic analysis would have damaged the object. Only four partial adzes from which any data on adze size could be obtained were traced to their original sources; bevel angle measurements could be obtained for only three of these adzes. Thus, sample size is clearly too small to attempt to detect any directional changes in adze size or bevel angle.

In light of the limitations imposed by the nature of the data used for this research, the following approaches are taken. First, although data cannot be used to measure relative abundance of types of material over distance, the question of whether artifacts are necessarily found at sites that are closest to their sources can be considered. If artifacts are found at sites close to the source but not at sites farther away, a decline in abundance with distance from the source may be implied. Second, while available data do not allow comparison of the proportions of various materials found at different archaeological sites, in some cases it is possible to show that more than one type of material is present. If most sites seem to have a similar set of adze stone types, this may indicate centralized redistribution in which adzes from all sources were supplied to all locations.

However, as discussed above, it is debatable whether equitable distribution of materials between sites necessarily implies redistribution. Specifically, informal sharing and cooperation could result in sites having the same several types of raw material. This may be especially likely to occur if materials can be acquired locally and relatively easily through direct access. Third, redistribution may be indicated by an increasing reliance on one or a few primary sources of raw material over time. On the island of Hawai'i, use of Mauna Kea material would probably be expected to increase over time if redistribution of adzes had developed. Finally, regardless of how redistribution may specifically be reflected in the archaeological record, some sort of temporal change in the patterns of use or distribution of raw materials would probably be expected if a system of centralized redistribution had developed over time. In other words, if redistribution developed over time in Hawai'i, some aspect of this change would probably be reflected in the sources used and/or the regional distribution of materials.

DATA AND METHODOLOGY

The island of Hawai'i (fig. 3.2) was chosen as the region of focus for this study primarily because a large body of existing archaeological data from the island is available. Extensive archaeological research has been carried out on the island of Hawai'i; many sites have been dated, and numerous artifacts from these sites, including stone adzes, are curated in archaeological collections. In addition, the locations of several sources of adze stone on the island of Hawai'i are known (fig. 3.3), and preliminary research has shown that stone from these sources could be distinguished by using petrographic analysis

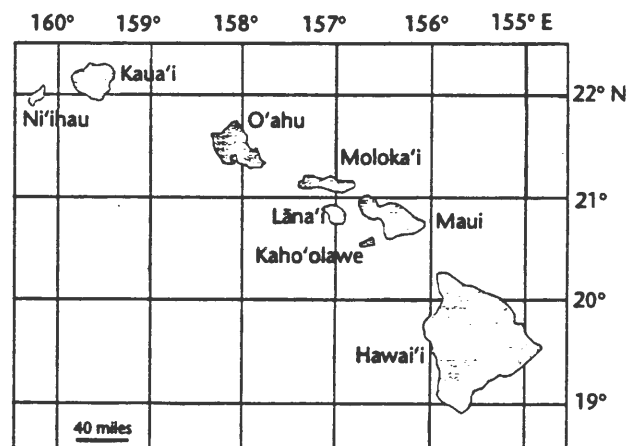


Figure 3.2
The Hawaiian Islands.

(Cleghorn et al. 1985).

Adzes and axes are both tools used in chopping, shaping, or otherwise working wood. On adzes, the cutting edge is perpendicular to the handle or shaft onto which the tool is hafted; axes have cutting edges that are parallel to the shaft. It is sometimes difficult to tell whether an unhafted tool would have been used as an axe or an adze (Steensberg 1980). Most Hawaiian woodworking tools, however, were probably adzes, and all the Hawaiian tools analyzed in this study are referred to as adzes.

For the analyses conducted in this research, a complete adze is defined as an artifact containing at least portions of the front, back, butt, cutting edge, and midportion of the original tool (fig. 3.1). A partial adze is a recognizable portion or portions of a complete adze. Unfortunately, in petrographic analysis a portion of the artifact being sourced must be permanently removed. For this reason, no complete adzes and only four partial adzes were subjected to petrographic analysis; almost all of the artifacts that were sourced are adze fragments. An adze fragment is defined as having polish on at least one artifact surface but not being complete enough to identify which part of an adze it came from. Adzes were apparently the only Hawaiian stone tools that were polished. It is relatively easy to recognize polish and therefore to identify adze fragments on which polished areas stand out in contrast to other rough or broken surfaces.

The primary concern in selecting artifacts for petrographic analysis was to obtain a sample of adzes or adze fragments for each of several time periods. The periods were defined as:

- before AD 1100
- AD 1100–1400
- AD 1400–1650
- AD 1650–1800
- after AD 1800

They were defined with an effort to divide the precontact period in Hawai'i into units of equivalent length, to identify periods so that their starting/ending dates corresponded to significant cultural changes or historical events, and to name periods that were comparable to those defined by other researchers.

Previously excavated archaeological sites on the island of Hawai'i from which adzes, partial adzes, and adze fragments had been recovered were placed in one of the time periods listed above on the basis

of published or otherwise recorded dates determined through radiocarbon and/or hydration rind dating of volcanic glass. Appendix A discusses the general problems associated with radiocarbon and hydration rind dating, explains the procedures used in this study to place specific sites within one of the defined time periods, and discusses the particular rationale behind classifying some especially problematic sites.

The specific number of adze artifacts dating to each time period was determined for the collections at the Bernice P. Bishop Museum. Complete adzes and artifacts too small for petrographic analysis (less than the size of a dime) were excluded from the population. Then a sample of twenty was selected at random for each time period. (The sample size was determined primarily by the amount of funds available for petrographic analysis.) There were no sites that date specifically to the period AD 1100–1400, and therefore no sample of artifacts was obtained for this single period. However, a number of sites had dates that spanned more than a single period including, in some cases, the period AD 1100–1400. These were classified as sites with long sequences of dates, and a sample of twenty artifacts was randomly selected from this category as well.

As more adzes, partial adzes, and adze fragments were located in collections other than those at the Bishop Museum, additional artifacts were randomly selected for petrographic analysis. They were chosen from sites that would expand the geographical extent of the study and/or represent specific types of sites not already included in the artifact sample from the Bishop Museum. Artifacts in this supplemental group were classified according to the time periods described above, but no effort was made to select an equal number of artifacts from each time period. Again, there were no sites that dated to the period AD 1100–1400. The number of artifacts selected from each site was based on several factors. These included funds available for analysis and the curators' willingness to allow artifacts to be damaged. Appendix B describes the specific collections used for this research and explains the sampling procedure and rationale behind selecting artifacts from specific sites.

In the end, a total of 155 partial adzes or adze fragments were submitted for petrographic analysis. They are from thirty-eight archaeological sites in nineteen localities on the island of Hawai'i (fig. 3.4). A locality is defined as an area within which at least one but more often several archaeological sites

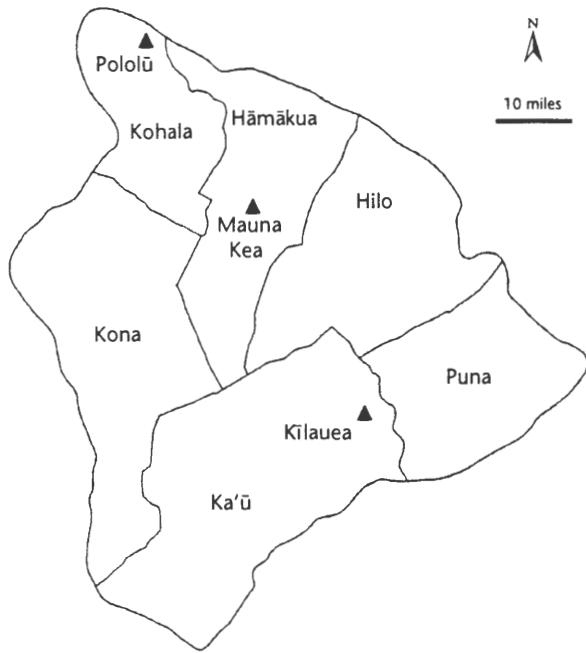


Figure 3.3
Known sources of adze stone. Base map source: Hawai'i County Department of Land and Natural Resources 1987

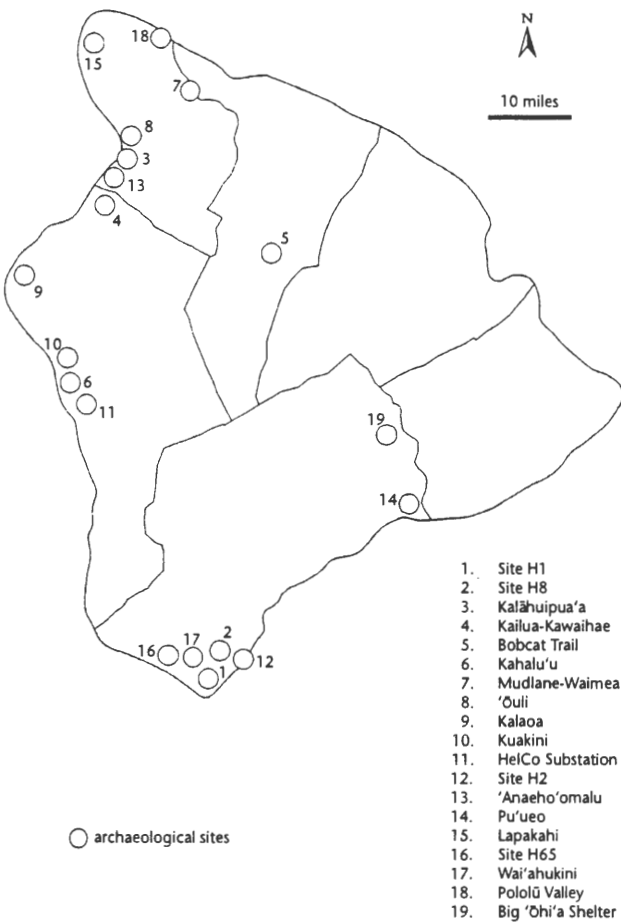


Figure 3.4
Localities for petrographic analysis. Base map source: Hawai'i County Department of Land and Natural Resources 1987

have been excavated as part of the same research project. As fig. 3.4 illustrates, almost all of the localities from which adzes were obtained are located on the west coast of Hawai'i; this regional bias reflects the fact that most archaeological fieldwork has taken place in the dry, leeward portion of the island of Hawai'i, which has been the focus of recent development and accompanying contract archaeology. Table 3.1 provides information on the specific sites from which artifacts were analyzed.

Petrographic Analysis

Petrographic analysis can be used to trace artifacts to their original sources by matching diagnostic characteristics of stone artifacts to characteristics found in material samples collected at quarry sites or other known sources of stone. Petrographic analysis has been used to establish the sources of stone adzes (Chappell 1966; Cummins 1979) and other artifacts made from igneous rock (Mason and Aigner 1987). Previous research in Hawai'i has demonstrated the usefulness of petrographic analysis for differentiating stone from known adze quarries in the Hawaiian Islands (Cleghorn et al. 1985). However, recent studies have shown that geochemical sourcing techniques such as X-ray fluorescence spectrometry (XRF) are necessary to correctly identify some sources of adze stone (Parkes 1986:143–180; Sinton 1993a, Weisler 1989, 1990:43; 1993).

Petrographic analysis requires the preparation of thin-sections of stone for microscopic examination. The thin-sections for this study were prepared by laboratory personnel at the Hawai'i Institute of Geophysics, University of Hawai'i at Manoa, under the supervision of Dr. John Sinton, and the specific procedure used to prepare the thin-sections is described in appendix C. Petrographic descriptions of each thin-section were also provided by the Hawai'i Institute of Geophysics (Withrow 1991:268–300). The petrographic descriptions included information on rock texture, phenocrysts, groundmass or matrix, alteration, and flow structure.

Rock texture. Texture is measured in terms of the number of grains per millimeter (g/mm). In igneous rocks, texture is determined largely by rate of cooling with more rapid cooling producing finer grained stone (Anderson 1988:478; Chapman 1988a: 293–294). In general, stone that is finer-grained and more glassy is preferred for tool manufacture.

Presence and type of phenocrysts. Phenocrysts

Table 3.1
Sites used in petrographic analysis

Site	No. on Fig. 3.4	Period	Collection	Reference
H1	1	before AD 1100	Bishop Museum	Emory and Sinoto 1969; Goto 1986; Green 1971; Kirch 1985
H8	2	before AD 1100	Bishop Museum	Emory and Sinoto 1969; Emory, Bonk, and Sinoto 1969; Goto 1986; Green 1971; Kirch 1985
324	3	AD 1400–1650	Bishop Museum	Kirch 1979
368	3	AD 1400–1650	Bishop Museum	Kirch 1979
701A	4	AD 1400–1650	Bishop Museum	Rosendahl 1973
5004	5	AD 1400–1650	Paul H. Rosendahl, Inc.	Haun 1986
D4-48	6	AD 1400–1650	Bishop Museum	Kirch 1973
D4-51	6	AD 1400–1650	Bishop Museum	Kirch 1973
7702	6	AD 1400–1650	Paul H. Rosendahl, Inc.	Hay et al. 1986
2727	7	AD 1650–1800	Bishop Museum	Clark and Kirch 1983
5998	7	AD 1650–1800	Bishop Museum	Clark and Kirch 1983
8825	7	AD 1650–1800	Bishop Museum	Clark and Kirch 1983
5625	8	AD 1650–1800	Paul H. Rosendahl	Rosendahl, Inc. and Kaschko 1983
5627	8	AD 1650–1800	Paul H. Rosendahl	Rosendahl, Inc. and Kaschko 1983
8010	8	AD 1650–1800	Paul H. Rosendahl	Rosendahl, Inc. and Kaschko 1983
8018	8	AD 1650–1800	Paul H. Rosendahl	Rosendahl, Inc. and Kaschko 1983
4-16-6	9	AD 1650–1800		Cordy 1981
D6-21	10	AD 1650–1800	Bishop Museum	Schilt 1984
D6-41	10	AD 1650–1800	Bishop Museum	Toenjes 1986
D7-27	10	AD 1650–1800	Bishop Museum	Schilt 1984
D8-52	10	AD 1650–1800	Bishop Museum	Schilt 1984
5611	6	AD 1650–1800	Paul H. Rosendahl, Inc.	Hay et al. 1986
7702	6	after AD 1800	Paul H. Rosendahl, Inc.	Hay et al. 1986
T-1	11	after AD 1800	Paul H. Rosendahl, Inc.	Bath and Rosendahl 1984
H2	12	after AD 1800	Bishop Museum	Emory and Sinoto 1969
2732	7	after AD 1800	Bishop Museum	Clark and Kirch 1973
2776	7	after AD 1800	Bishop Museum	Clark and Kirch 1973
8824	7	after AD 1800	Bishop Museum	Clark and Kirch 1973
303	13	after AD 1800	Bishop Museum	Barrera 1972
73	14	after AD 1800	Paul H. Rosendahl, Inc.	Spear 1987
6941	15	long sequence	State Historic Sites Div.	Tuggle and Griffin 1973
355	3	long sequence	Bishop Museum	Kirch 1979
1349	4	long sequence	Bishop Museum	Rosendahl 1973
H65	16	long sequence	Bishop Museum	Kirch 1985; Soehren 1966
22-64	17	long sequence	Bishop Museum	Sinoto and Kelly 1975
22-248	17	long sequence	Bishop Museum	Sinoto and Kelly 1975
4838	18	no date	University of Hawai'i	Tuggle 1976, 1987
Big 'Ōhi'a	19	no date	—	Withrow 1987

are relatively large mineral crystals that are dispersed in a finer-grained matrix or groundmass and are usually formed during slow cooling when magma is deeply buried; later, when the magma is erupted the surrounding matrix forms during more rapid cooling (Chapman 1988a:294, 1988b). Shape, color, and other optical properties of phenocrysts indicate what specific minerals they represent (Hutchison 1974).

Groundmass or matrix. The types and percentages of minerals making up the groundmass or matrix surrounding the phenocrysts can be determined. Igneous rocks are composed of only a few primary minerals. In Hawaiian rocks, and particularly among

those used for adze manufacture, these basic minerals tend to be even more narrowly confined to those rich in magnesium and iron such as pyroxene and olivine. Other minerals that occur in small or trace amounts are more diagnostic for the purposes of petrographic analysis. Examples of such minerals include apatite and biotite (Chapman 1988a:298–300; MacDonald, Abbott, and Peterson 1986:126–129).

Alteration of the original magma. One type of alteration was observed in a number of the thin-sections examined for this study: the presence of the reddish mineral iddingsite. Prior to eruption, gases in magma sometimes cause olivine pheno-

Table 3.2
Artifacts per type of raw material

Material	Artifacts	Percentage
Mauna Kea	102	65.8
Unidentified sources	20	12.9
Pololū	9	5.8
Kīlauea	8*	5.2
Type B	7	4.5
Type A	5	3.2
Type C	4	2.5
Total	155	100.0

*Includes three artifacts from Big 'Ōhi'a site



Figure 3.5
Mauna Kea adze quarry.



Figure 3.6
Shrine at Mauna Kea quarry.

crysts to become unstable and to begin changing into iddingsite. After eruption when gases escape and olivine resumes crystallization, a distinctive rim of iddingsite may be visible at the perimeter of olivine phenocrysts (MacDonald, Abbott, and Peterson 1986:131).

Flow structure. The term *flow structure* refers to several types of directional features resulting from the



Figure 3.7
Pololū Valley.



Figure 3.8a
Raw material from Mauna Kea adze quarry.

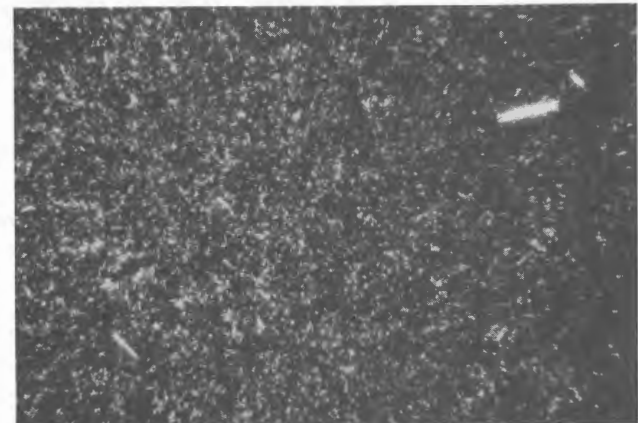


Figure 3.8b
Matching thin-section from site 4838, Pololū.

flowage of molten material during mineral crystallization (Chapman 1988a:297–298). Among the thin-sections examined in this study, some exhibited flow structure in the form of streaks of small phenocrysts which were oriented parallel to each other.

The sources of adze stone used in a region tend to be petrographically similar in many ways since the same basic properties are preferred for tool manufacture. Thus, it is best to rely on sets of characteris-

Table 3.3
Diagnostic petrographic characteristics of raw material types

Material	Texture (g/mm)	Phenocrysts	Matrix	Other
Mauna Kea	70–260; most 130+	Plagioclase feldspar	Plagioclase feldspar, pyroxene, iron oxides	
Pololū	50–150; most 100	Plagioclase feldspar (smaller than in Mauna Kea material); sometimes biotite	Plagioclase feldspar, pyroxene, and sometimes olivine, biotite	Flow structure
Kīlauea	60–140; but only one sample > 100	Olivine	Plagioclase feldspar, pyroxene, iron oxides, and sometimes olivine	
Type A	35–55	Pyroxene	Plagioclase feldspar, pyroxene, iron oxides	
Type B	60–120	Plagioclase feldspar and olivine; some olivine hopper-shaped	Plagioclase feldspar, pyroxene, iron oxides, and olivine	Sometimes flow structure
Type C	50–80	Plagioclase feldspar and olivine	Plagioclase feldspar, pyroxene, iron oxides	Some alteration vs. none in type B

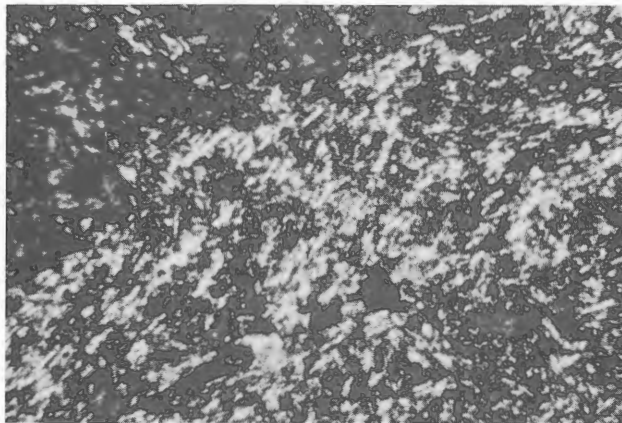


Figure 3.9a
Raw material from Pololū adze-manufacturing site.

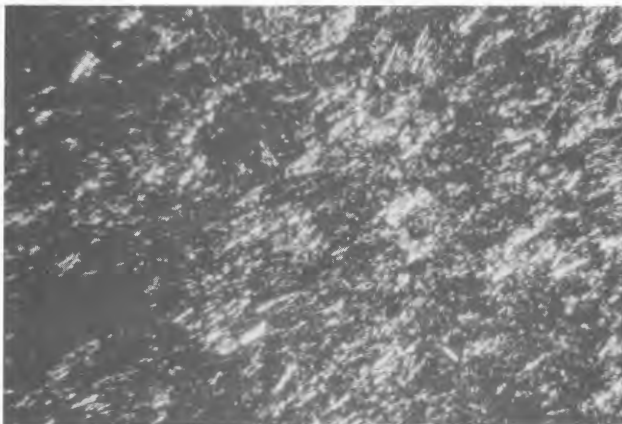


Figure 3.9b
Matching thin-section from site 7702, Kahalu'u.

tics in differentiating sources rather than just one or two features, and greater accuracy is also possible when characteristics such as flow structure can be identified in addition to aspects of mineral composition or texture (Weisler 1989). In this study, both of these principles were followed in matching artifacts to their sources. Fortunately, source materials

from the island of Hawai'i have proven to be quite distinctive, particularly with respect to material from the major Mauna Kea source.

SOURCES OF STONE FOR ADZES

Of the 155 artifacts subjected to petrographic analysis, more than half (66 percent) matched thin-sections of raw material from the Mauna Kea adze quarry (table 3.2). This quarry, located on the south slope of Mauna Kea (fig. 3.3), is the largest known adze quarry in the Hawaiian Islands; it is a complex of extraction areas, workshops, chipping stations, rock shelters, habitation sites, and shrines that extends over a total area of at least 12 km² (figs. 3.5, 3.6; McCoy 1990:92). Extensive archaeological research has been conducted at the Mauna Kea quarry (Allen 1981; Cleghorn 1982, 1986; McCoy 1976, 1977, 1982, 1986, 1990, 1991; McCoy and Gould 1977; Williams 1989), and large amounts of manufacturing debitage from the site are curated at the Bishop Museum.

Nineteen artifacts from the Mauna Kea quarry had previously been thin-sectioned and described petrographically (Cleghorn et al. 1985). In 1987, six additional artifacts were selected for thin-sectioning from collections at the Bishop Museum. They were from two areas, areas 7 and 11 on the outwash plain, where raw material from the quarry had not yet been analyzed.

Mauna Kea material is hawai'ite, an andesitic rock composed largely of plagioclase feldspar and pyroxene (Cleghorn 1982:62–63; Cleghorn et al. 1985; MacDonald, Abbott, and Peterson 1986:127–128). Typically, thin-sections of Mauna Kea stone have a texture of more than 130 g/mm and contain lath-shaped phenocrysts of plagioclase feldspar (fig.

3.7a,b); stone from Mauna Kea is generally finer-grained than stone from other Hawaiian sources (table 3.3; also Cleghorn et al. 1985 and Withrow 1991:268–287).

A second source of adze stone on the island of Hawai'i is located in the Pololū Valley (fig. 3.7) of North Kohala (figs. 3.3, 3.4). What is commonly referred to as the Pololū quarry site consists of a small but dense concentration of adze-making debris located along the main stream in the floor of the Pololū Valley. The site was excavated in 1974 by the Department of Anthropology, University of Hawai'i at Manoa (Olson and Nakama 1974; Tuggle 1976, 1987; Tuggle and Tomanari-Tuggle 1980); artifacts from the site are curated at the University of Hawai'i. Prior to this research, four of the curated artifacts had already been subjected to petrographic analysis and the stone described as a mugearite (Cleghorn et al. 1985), which is an andesitic rock similar to hawai'ite (MacDonald, Abbott, and Peterson 1986:127–128). In 1987, five additional artifacts from four different excavation units within the site were also submitted for petrographic analysis.

The actual source of the stone used to manufacture adzes at the site has not been identified. There is exposed stone in the valley wall near the Pololū site but no evidence of actual quarrying activity. Analysis of adze-making debris from the Pololū site shows that at least many of the adzes made here were manufactured from large flakes that had been removed from cortex-covered cores (chapter 4). It is possible that these cores were collected from loose stone found on the ground between the stream and the valley wall; this loose stone has been referred to as talus (Olson and Nakama 1974) although it may actually be, at least in large part, water-carried debris deposited outside the stream during flash floods. It is also likely that cores were collected from in the stream itself. The debris in and outside of the streambed must have originated at a source farther upstream and/or higher on the valley walls.

In 1987, nine samples of raw material were collected at the Pololū site from the rock outcrop in the valley wall, from natural debris found at the base of the valley wall, and from natural debris in the stream bank. Petrographic analysis indicates that stone found in all three of these locations as well as the actual Pololū artifacts curated at the University of Hawai'i at Manoa were all of the same type of raw material. In addition, petrographic analysis indicated that nine (6 percent) of the artifacts from the island of Hawai'i sites that were sourced for this study are

apparently made from the same Pololū material (table 3.2). In general, this raw material is coarser-grained than stone from Mauna Kea; most samples have a texture of approximately 100 g/mm. Characteristic features include the fairly common occurrence of biotite in the groundmass and in the form of small phenocrysts and flow structure seen in the parallel alignment of small lath-shaped phenocrysts of plagioclase feldspar (fig. 3.9a,b; table 3.3; Cleghorn et al. 1985; Withrow 1991:287–291).

Recently, however, X-ray fluorescence analysis of some of the raw material samples collected from Pololū has shown that the loose stone from the base of the valley wall and that from the stream bank are indeed chemically the same, but the stone from the valley wall itself is not. Stone from the valley wall is very similar to the stone from the other two locations because it most probably originated from the same volcano, but it probably represents a different lava flow within the Pololū Valley (Sinton 1993a, 1993b). These findings suggest that petrographic analysis may have been inadequate in identifying the raw material from wherever the Pololū source is. On the other hand, none of the actual adze-making debris from the Pololū site nor any of the artifacts from other sites on the island of Hawai'i that have been tentatively traced to the Pololū source have been subjected to geochemical analysis. It is still possible that these artifacts do in fact come from the same source somewhere in the Pololū Valley and also possible that they come from more than one similar source within the valley. In either case, the immediate source of stone for adze-makers was apparently at the Pololū site where cores were collected from naturally deposited debris.

A third source of adze stone is believed to have existed near Kīlauea Volcano (fig. 3.3), perhaps in Keanākako'i Crater, but it was apparently destroyed by volcanic activity in the late nineteenth century (Cleghorn et al. 1985; Kamakau 1976:122). Examination in 1987 of the floor and lower walls of Keanākako'i Crater as well as areas on and near the rim of the crater in 1987 was not successful in locating any evidence of the possible quarry site. However, a previously reported habitation cave site near Kīlauea, the Big 'Ōhi'a Shelter, was relocated, and several polished adze fragments as well as pieces of unpolished stone debris were collected from the surface of this site.

Three of the artifacts from the Big 'Ōhi'a Shelter were subjected to petrographic analysis. The thin-sections generally have a texture of less than 100 g/

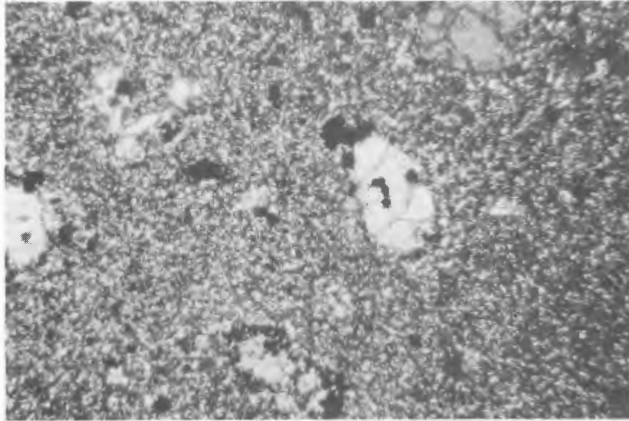


Figure 3.10a
Raw material from Big 'Ōhi'a site, Kīlauea.

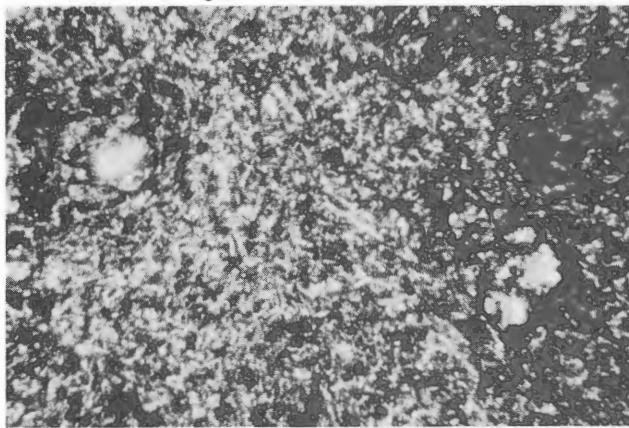


Figure 3.10b
Matching thin-section from site 355, Kalāhuipua'a.

mm and contain large olivine phenocrysts (fig. 3.10a,b; table 3.3; Withrow 1991:291–293). They represent olivine basalt, a relatively fine-grained, dark rock composed of plagioclase feldspar, pyroxene, and olivine which is typically produced by Kīlauea lavas (MacDonald, Abbott, and Peterson 1986:127–128, 373). It is impossible to determine whether the stone from the Big 'Ōhi'a Shelter is from the particular source referred to in ethnohistoric accounts, but the existence of a source of adze stone in the Kīlauea area seems likely. In addition to the three artifacts collected from the Big 'Ōhi'a Shelter, five of the partial adzes and adze fragments from other habitation sites on the island of Hawai'i were apparently made of material from the same source (table 3.2).

There are also previously unknown sources of adze stone represented in the artifacts submitted for petrographic analysis. Five (3 percent) of the artifacts seem to represent material labeled type A; two of the artifacts were recovered from the same archaeological site and could very well represent two pieces broken from the same original adze. Type A thin-sections are characterized by pyroxene phenocrysts and a comparatively coarse texture of 35–55 g/mm

(table 3.3; Withrow 1991:293–294). Seven additional artifacts (5 percent) were identified as type B material. They were recovered from three sites, and it is most likely that three adzes are represented. Type B thin-sections contain phenocrysts of plagioclase feldspar and olivine, and olivine phenocrysts are often hopper or funnel shaped. Texture ranges from 60 to 120 g/mm (Withrow 1991:294–296). Four artifacts (3 percent) represent material from a source referred to as type C. Two of the four artifacts are from the same site and could have come from the same original tool. Like type B material, this stone contains phenocrysts of olivine and plagioclase feldspar, but type C material is quite coarse-grained (50–80 g/mm) and shows some alteration of olivine phenocrysts (Withrow 1991:296–297). The remaining twenty artifact thin-sections (13 percent of the total) seem to represent individually unique and unknown sources of adze stone. Most are quite coarse-grained with more than half having textures less than 60 g/mm (Withrow 1991:297–300).

None of the unidentified material types has been compared to actual thin-sections of stone from known quarries on other islands. Published petrographic descriptions of material from off-island sources (Cleghorn et al. 1985) indicate no obvious correlations with any of the thin-sections made for this analysis, and most of the unknown materials identified in this study are much coarser-grained than the stone from known sources elsewhere with textures that are less than 100 g/mm, commonly 50–60 g/mm, and sometimes as coarse as 35 g/mm.

Given the large amounts of stone available at the Mauna Kea quarry, it is interesting that so many other sources of stone also seem to have been used. This suggests the existence of at least several other, probably small, sources on the island of Hawai'i. They need not have been actual quarries where stone was extracted from outcrops but like Pololū could have been procurement areas where stone was simply collected from concentrated talus or streambed deposits. Single, isolated pieces of suitable stone could also have been utilized.

The fact that there were apparently a number of types of local stone used for adze manufacture calls into question one of the assumptions underlying this study: that adze stone was a differentially available resource not found within every ahupua'a. Suitable stone may have been found in or near almost every community, but stone from such sources was coarser-grained and somewhat less desirable for adze manufacture than stone from larger quarry sites such

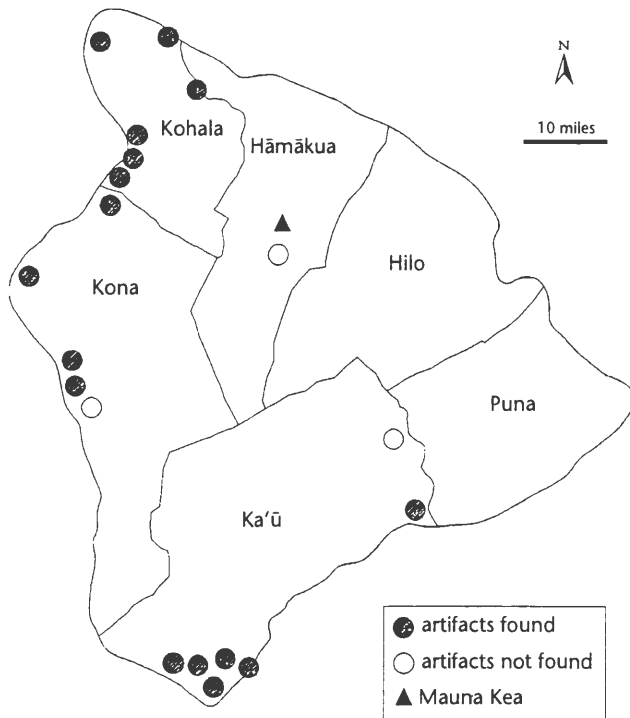


Figure 3.11
Localities with Mauna Kea material. Base map source: *Hawai'i County Department of Land and Natural Resources 1987*

as the Mauna Kea quarry.

DISTRIBUTION OF RAW MATERIAL

Mauna Kea material is widely distributed (fig. 3.11). It is found at all but three of the nineteen localities from which artifacts were analyzed; in each of these three areas only one artifact from one archaeological site was subjected to petrographic analysis; small sample size may, therefore, account for the absence of Mauna Kea stone at these locations. If the distribution of Mauna Kea material is examined at specific sites within each time period (fig. 3.12; table 3.4), it seems to be widely distributed in the same manner for every period.

Although occurring less frequently than Mauna Kea material, other material types also seem to be widely distributed with no evidence of any local concentrations (fig. 3.13). Type A, type B, and type C materials tend to be found in the southern part of the island but are not restricted solely to this area, and it is difficult to draw conclusions from such small samples. When the distribution of the non-Mauna Kea materials is examined for each time period, there appears to be little if any change in the basic pattern of widespread distribution (fig. 3.14; table 3.4). Type C material is lacking from sites which date to more recent time periods, but since there are only four artifacts of type C material this apparent trend may be the result of small sample size.

Distance from Sources

It is clear that the Hawaiian artifacts considered here are not necessarily found at the sites closest to their sources (figs. 3.11, 3.13), and this may suggest that the occurrence of adzes does not decline with increased distance from the source. If we follow the premises of regional distribution models, we conclude that adzes were apparently not acquired through direct access and/or down-the-line exchange but rather through centralized redistribution, which is characterized spatially by concentrations of materials at some sites located far from the source.

However, the apparent failure of adzes to decrease in occurrence with distance from their sources does not necessarily indicate redistribution. Specifically, there are several geographical factors that make it unlikely that adzes would decline in occurrence with distance from the source even if they had been acquired through direct access or informal, hand-to-hand exchange. In the Near East, where distance decay models were first applied, the obsidian sources were located in the north, and amounts of obsidian

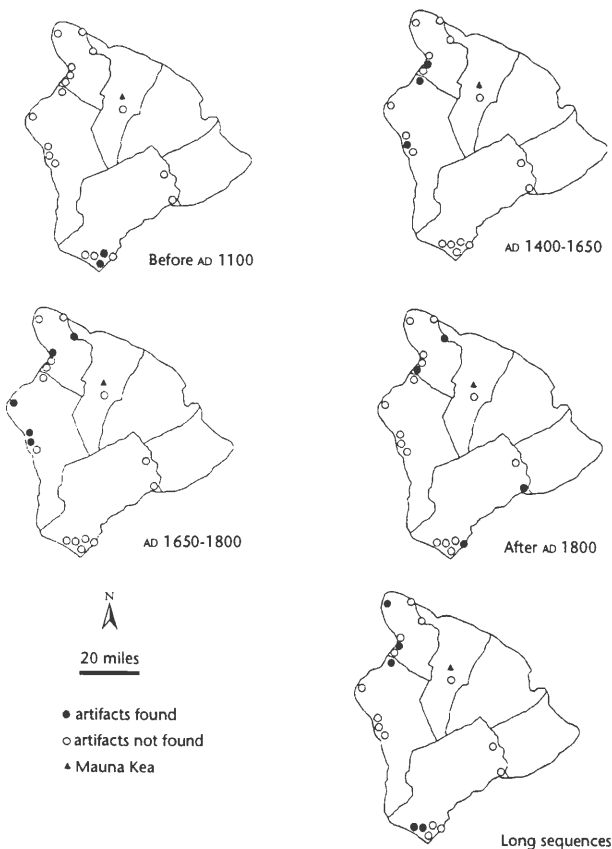


Figure 3.12
Distribution of Mauna Kea material by time period. Base map source: *Hawai'i County Department of Land and Natural Resources 1987*

Table 3.4
Presence of raw material types at sites by time period

Site	No. on fig. 3.4	Qty	MK	PO	KL	A	B	C	Unidentified
Before AD 1100									
H8	2	15	x	x	x	x	x	x	x
H1	1	5	x	x			x		
AD 1400–1650									
324	3	7		x		x			
368	3	8		x					x
701A	4	4		x					
5004	5	1							x
D4-48	6	1							x
D4-51	6	1		x					
7702	6	4		x					x
AD 1650–1800									
2727	7	3		x					x
5998	7	2		x	x				
8825	7	2		x					
5625	8	1		x					
5627	8	2			x				x
8010	8	1		x					
8018	8	3	x						
4-16-6	9	1		x					
D6-21	10			x					
D6-41	10	3		x					
D7-27	10	3		x					
D8-52	10	1		x					
5611	6	3		x					
7702	6	27		x	x	x		x	x
T-1	11	1			x				
H2	12	2		x			x		
After AD 1800									
2732	7	8		x		x			x
2776	7	9		x					
8824	7	2		x					
303	13	1		x					
73	14	1		x					
Long sequences									
6941	15	5		x					x
355	3	7		x		x			
1349	4	1		x					
H65	16	3		x					
22-64	17	6		x			x		x x
22-248	17	3		x					

found at habitation sites decreased to the south, but other areas, including the island of Hawai'i, are more geographically complex. In particular, a central source from which stone can be transported with almost equal ease in any direction can disrupt distance-dependent patterning (Ammerman, Matessi, and Cavalli-Sforza 1978:191–192), and the fact that the source of the largest number of the Hawaiian artifacts, Mauna Kea, is nearly centrally located on the island of Hawai'i could account for some of the

lack of distance decay in the occurrence of adzes.

It is uncertain though whether access to Mauna Kea would have been equally possible from all parts of the island of Hawai'i. Factors including local topography and the presence of trails (Ericson 1977, 1981), as well as sociopolitical boundaries (Ericson 1977, 1981; McBryde 1978, 1979, 1984; McBryde and Watchman 1976) could have affected access. The shortest, most direct route to the Mauna Kea quarry would have originated in the Hāmākua District on the east or windward coast of the island of Hawai'i, and established trails from Hāmākua to Mauna Kea are known to have existed. Botanical and faunal remains from Mauna Kea rock shelters are of windward origin suggesting that adze makers came from or at least traveled through the east coastal regions of the island of Hawai'i (Allen 1981:109–111). The Mauna Kea adze quarry is within the ahupua'a of Kā'ohe in Hāmākua District, but it is unclear to what extent this may have affected access to the site. Use of the quarry may not have been restricted to residents of Kā'ohe (Allen 1981:13–15) although access to the quarry could have been controlled by this ahupua'a (McCoy 1990:111–112).

Sea travel is another factor which may prevent or disrupt a regular falloff pattern in material occurrence. At the very least, the measure of distance from a site to a material source is complicated by the possibility of sea travel. In addition, sea travel makes transport easier and effectively shortens distances in terms of energy expenditure so that the decline in abundance of a material over distance may be less pronounced (Ammerman 1979; Hodder 1978:162–163; Hodder and Orton 1976:113, 117–118; Sidrys 1977). Land travel distances in Hawai'i are also comparatively short. There could have been direct access and/or informal down-the-line exchange without an obvious distance decay effect. Direct, informal access to sources may tend to occur when transport costs are low, regardless of the level of sociopolitical complexity (Findlow and Bolognese 1982:78–80), and this may have been the case in Hawai'i.

The artifacts sourced in this study represent finished tools that were no doubt carried from one place to another; they could have been used, discarded, and eventually recovered at sites far from their place of original acquisition. In this respect, adzes are unlike the materials studied in many other distributional analyses, which dealt with raw materials brought to workshops or households for subsequent manufacture into tools which would leave recover-

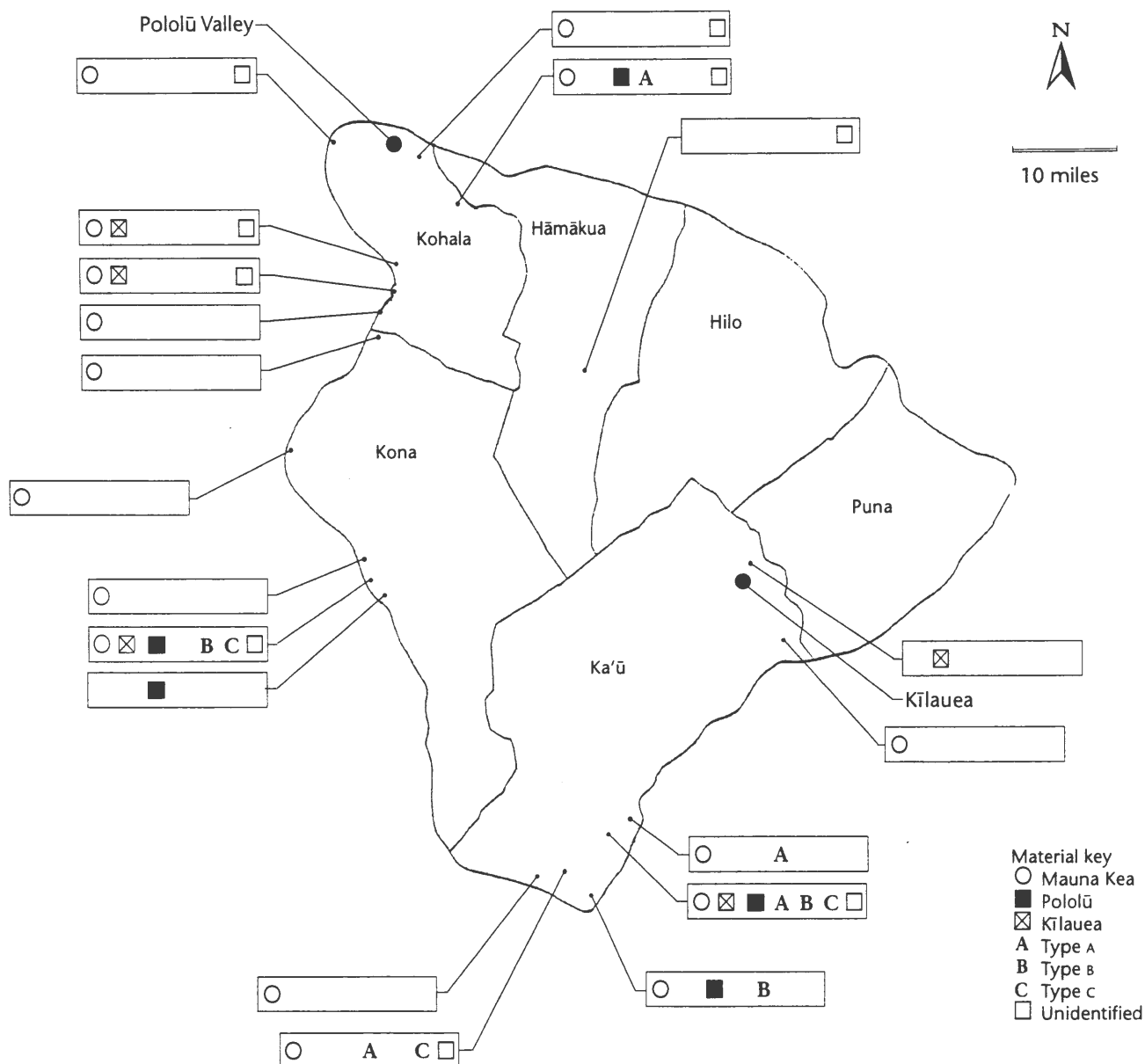


Figure 3.13
Distribution of adze stone materials by locality. Base map source:
Hawai'i County Department of Land and Natural Resources 1987

able debitage at habitation sites.

Material Types Found at Sites

More than one material type is commonly found among the artifacts of a single site and/or locality, showing that a variety of raw materials were available to specific local areas on the island of Hawai'i. In general, the same range of materials seems to be found at all sites, and this seems to be true for all time periods. Although it has been suggested that the occurrence of the same types of materials at a

number of sites indicates a regional system of redistribution, the equitable distribution of materials between sites could also indicate more informal types of acquisition. One description of New Guinea stone-axe distribution indicates that when axes are acquired through unsystematic, informal means, archaeological distribution patterns are characterized by "lines of diffusion crossing in a bewildering manner and the products of two or more factories converging on particular sites at the same time" (Clark 1965:27). This description also seems to apply to the

Redistribution in the Development of Hawaiian Chiefdoms

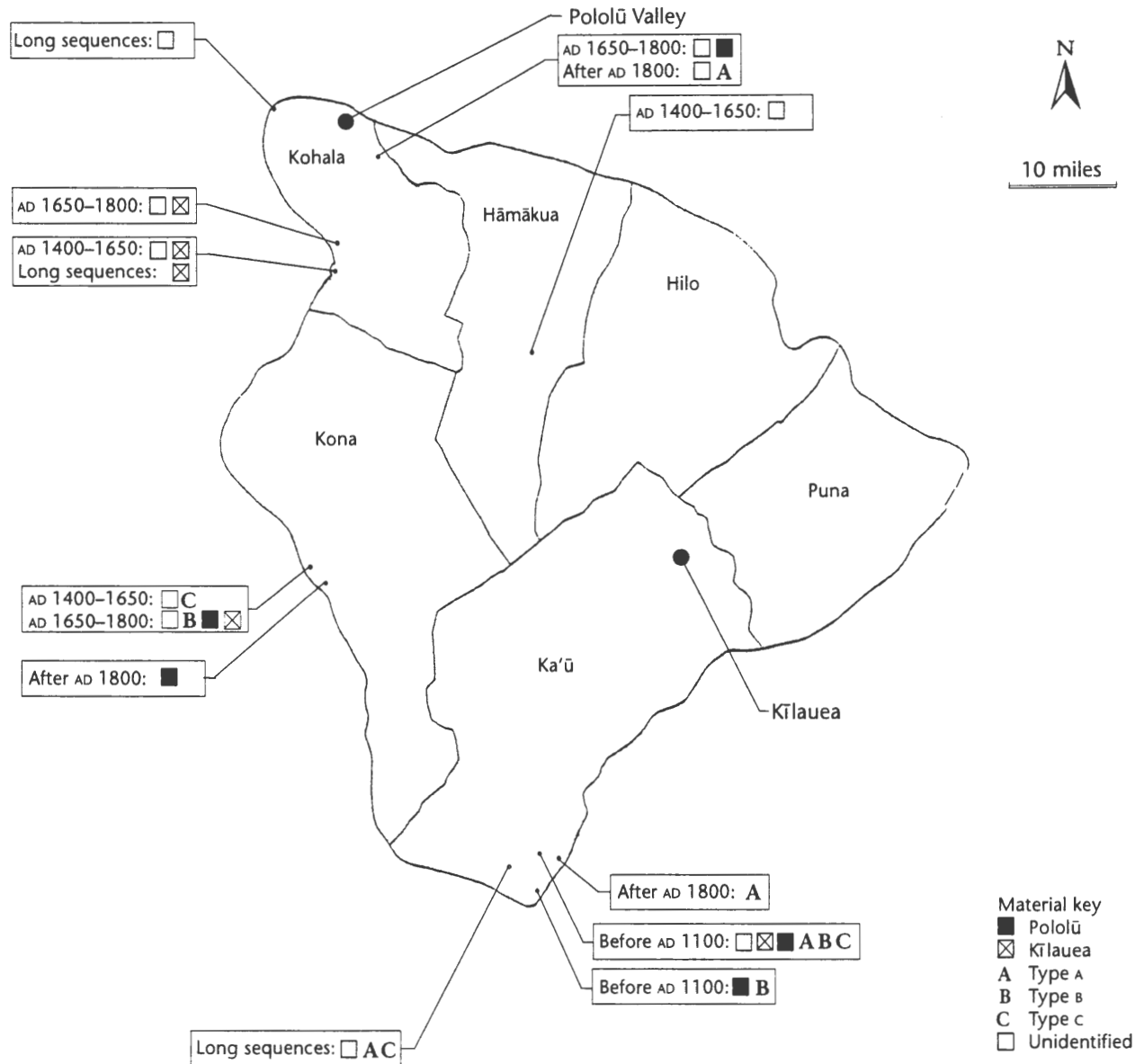


Figure 3.14
Distribution of adze stone materials by time period. *Base map source:*
Hawai'i County Department of Land and Natural Resources 1987

Hawaiian data considered here. In addition, centralized redistribution is probably not indicated because so many apparently small, local sources are represented among the raw materials found at sites. It is unlikely that a formal system of redistribution would incorporate these small sources in addition to the major Mauna Kea quarry.

It is possible that some—particularly high quality or preferred—materials may be subject to centralized control at the same time that other sources are not (Ericson 1984:7), but this does not seem to have been the case on the island of Hawai'i. The

regional distribution of Mauna Kea material does not differ significantly over time from that of other materials, which would probably be expected if it alone had been subject to centralized control. Specifically, one might expect Mauna Kea material to be widely distributed and other materials to have more localized distributions, but this is not evident in any time period.

Increasing Reliance on One Source

It has been suggested that with formal redistribution fewer lithic sources are used, and, in particular,

there is a tendency to rely on one major source of raw material (Clark and Lee 1984; Winter and Pires-Ferreira 1976). A shift from the use of many sources to an almost complete reliance on Mauna Kea material would probably be expected if centralized distribution had developed over time, but there is no evidence that this occurred. Mauna Kea material clearly dominates the assemblages of all time periods, but other sources are used throughout as well.

OVERALL TEMPORAL CHANGE

There seems to be no apparent change in either the materials used or the spatial distribution of various materials over time. This fact suggests that centralized redistribution of adze stone probably did not take place. Some sort of change in distribution patterns would be expected if centralized control of stone resources had accompanied or developed with the other trends toward cultural complexity which have been documented in Hawaiian chiefdoms.

If conventional models are applied to the Hawaiian data considered here, direct access and down-the-line exchange do not seem to be indicated. Instead, some sort of centralized exchange system is suggested. However, traditional models are not well suited for interpreting the Hawaiian data presented here. In particular, there are several geographical factors that could have prevented an obvious decline in the occurrence of adzes with distance from their sources even if direct access and down-the-line exchange had occurred. These include the probability

of sea travel, relatively short distances involved in traveling from any given source to any other location on the island of Hawai'i, and the central location of the largest and most commonly used source, the Mauna Kea quarry. Some have suggested that when materials are equitably distributed between sites, as they apparently are on the island of Hawai'i, this indicates centralized redistribution, but this is not necessarily true, especially when materials can be acquired relatively easily, directly, and locally, as in Hawai'i.

Additional lines of archaeological evidence argue against the centralized redistribution of Hawaiian adze stone. Specifically, this evidence includes the use of many stone sources including what may have been numerous small sources in addition to the Mauna Kea quarry and an apparent lack of any change in distribution patterns over time. In particular, the distribution of Mauna Kea material does not at any time differ from that of other materials which would probably be expected if centralized redistribution had developed.

Adzes were probably acquired by direct access and/or informal exchange among commoners within the subsistence economy and not collected and distributed by Hawaiian chiefs. Service's hypothesis that the control and redistribution of differentially available necessities contributed to the development of Hawaiian chiefdoms is not supported by archaeological data on the acquisition and distribution of stone adzes.

Chapter 4

Specialization in Hawaiian Adze Production

Control over the acquisition of such utilitarian items as adzes was probably not what enabled Hawaiian chiefs to achieve or maintain power. However, tools like adzes could still have been involved in activities such as canoe building, house construction, and the construction of temples (*heiau*) that chiefs did use to gain power and maintain control. Ethnohistoric sources indicate that these activities were sometimes carried out by specialists who were supported by the chiefs.

Malo says that adze manufacture was an "art" which was "handed down from remote ages" and that "ax-makers were a greatly esteemed class." Thus, he implies that adze-making was carried out by only some individuals, but it is not clear whether they were independent or attached specialists. Adze-makers (*po'e ka ko'i*) prospected for suitable stone to make adzes. Once finished, an adze "now became an object of barter with this one and that one, and thus came into the hands of the canoe-maker" (Malo 1951:51).

Of canoe-making, Kamakau says this was "an important profession for which one had to first be trained and become an expert before he could engage in the work or go to the mountains to hew a canoe" (1976:119); the canoe-maker (*kahuna ka lai wa'a*) was "an expert in his profession" (Kamakau 1976:121). More than in the case of adze-makers, it seems clear that canoe-makers were craft specialists. However, again, it is unclear whether they were independent specialists or attached specialists. Kamakau says that such goods as pigs, dogs, bark cloth, nets, and other articles were given to the canoe-maker in exchange for his labor, but it is not

clear who provided this support. Canoe-makers used adzes in all stages of work, and Kamakau refers to adze-makers as "expert stoneworkers" (1976:118–122).

Some canoe builders may have been attached to high-ranking households, whereas others were not. Among the attached specialists there may have been further specialization by task; for example, some canoe-makers apparently focused only on hafting adzes for use in making canoes (Pukui 1939:27–37; Sahlins 1958:115). From Malo (1951:51), Sahlins infers that there were specialist house builders or "men called upon to supervise house construction—especially the chiefs' houses" (1958:115;) and that there were possibly specialist adze-makers as well. However, Sahlins says that it is unclear to him whether adze-making may have been a profession that was combined with canoe-making so that adze-makers were also canoe-makers or perhaps subspecialists within the canoe-making industry (1958:115–116).

Some craft production in Hawai'i was clearly sponsored by the chiefs. For example, attached specialists, apparently retainers within chiefly households, manufactured the feather cloaks that chiefs wore on public ceremonial occasions and also presented to other high-ranking individuals (Beckwith 1932:134; Earle 1987a:70–71; Kaeppler 1985; Linnekin 1988). Feathers were collected by the chief in tribute or taxation (Earle 1987a:70–71; Linnekin 1988:271; Malo 1951:77; Menzies 1920:82) after having been obtained by specialist bird catchers (Earle 1987a:70; Emerson 1895; Kamakau 1961:38–40; Malo 1951:82). It is unclear whether bird catchers "were residents of the ahupua'a land section or mobile retainers in the

immediate train of the chief," but Linnekin suggests that "bird-catching was not always a full-time specialisation, but may have been practised by certain men, evidently commoners, who lived in a land section belonging to their chief" (Linnekin 1988:271).

Items like feather cloaks provide an articulation between staple finance and wealth finance systems (Earle 1987a). Such items are produced by specialists who must be supported through staple finance. In turn, they enable chiefs to maintain their power including the ability to collect more staple goods. Adzes may also represent an articulation between staple and wealth finance but in a somewhat different and less direct way than wealth items. Unlike cloaks, adzes were probably not significant as valuable objects or symbols of power, but they were used to carry out important tasks such as construction of canoes for the chiefs, construction of chiefs' houses, and construction of temples. Like cloaks, these projects symbolized the chiefs' power and influence, and like feathers, adzes were resources needed by specialists who performed important labor and provided visible markers of status.

Even if adzes were used in activities that were directed by the chiefs, it is certain that some were also used solely within the subsistence economy. Adzes were used to fell trees for a variety of purposes, to build canoes and houses for everyday use, to manufacture smaller items of wood, and to clear land for agriculture (Handy and Handy 1972:28; Malo 1951: 78, 118–126, 126–135, 165). Thus, adzes could have been involved in both the subsistence and political sectors of the Hawaiian economy. This idea is often implied when comparing large adze quarries like the Mauna Kea quarry with smaller adze-manufacturing sites. It is often assumed that larger sites like Mauna Kea were probably used by attached specialists who were directed by the chiefs and that smaller manufacturing sites were used locally by independent specialists or even nonspecialists (Cleghorn 1989; McCoy 1990:110). This chapter assesses the existence and nature of craft specialization in Hawaiian adze manufacture, and it does so by comparing archaeological evidence for adze manufacture at the Mauna Kea quarry site with evidence from the small Pololū adze-manufacturing site.

CRAFT SPECIALIZATION

Craft specialization is the production of particular manufactured items carried out by a relatively small number of individuals who regularly produce certain durable, portable goods in quantities above and

beyond the needs of their own households. Craft specialists are withdrawn at least part-time from subsistence activities and obtain at least part of their support by exchanging their products with others (Arnold 1985:38; Costin 1991:3–4; Evans 1978).

Craft specialization varies in degree; it is not simply present or absent in any given society (Costin 1991:4). It also includes a broad range of activities and institutions, and many different types of craft specialization have been defined. One of the most common distinctions is that made between attached specialists who are controlled, directed, or sponsored by leaders and independent specialists who are not directed in any way (Brumfiel and Earle 1987; Earle 1981, 1987a).

Independent specialists manufacture goods in response to consumer demand. Independent specialization tends to take place when the raw materials needed to manufacture particular goods are not universally available, although differential ability on the part of individuals to produce certain goods can also be a consideration. Such specialization usually involves the production of essentials. It does not necessarily play a role in increasing cultural complexity (Brumfiel and Earle 1987; Earle 1981, 1987a), and, in fact, is found in societies with varying degrees of cultural complexity. For example, independent specialists may have manufactured stone tools that were used 22,000 years ago during the Upper Paleolithic (Gibson 1984).

Attached specialists have also been described as administered specialists (Sinopoli 1988) and patronized specialists (Clark and Parry 1990). Such specialists are created and supported by leaders for the purpose of producing goods, often wealth items, for elite use. The political use of attached craft specialists and the goods they produce has the potential to contribute to increases in cultural complexity (Brumfiel and Earle 1987; Clark and Parry 1990; Earle 1981, 1987a).

The concept of specialization was an integral part of Service's original adaptationist hypothesis concerning redistribution and chiefdom development. In Service's scenario, communities were required to specialize in the production of certain goods, particularly food and other necessities, because only particular resources were available to them. It was specialization that led to the centralized redistribution of the products from various communities which, in turn, contributed to the development of increasingly complex societies. Further specialization was then encouraged by the existence of an

efficient, centralized means of distributing products. Craft specialization also increased as leaders extended their influence to the sponsorship of some types of production (Service 1962:135–139; 1975:75–76,78).

Specialization plays a similar role in other adaptationist approaches which followed Service's work. In particular, some researchers incorporated the fundamental idea that regional specialization and the redistribution which follows it are advantageous in areas with a high degree of ecological diversity. Specialization and redistribution can contribute to more efficient production, greater overall productivity, a more diversified regional subsistence base, and possible insurance against crop failures or failures in other kinds of production (Gall and Saxe 1977; Halstead and O'Shea 1982; Peebles 1971).

In political approaches to cultural complexity, a significant distinction is made between regional specialization in the production of necessities such as food and the specialized production of other items by specific individuals. Thus, two classes of goods—subsistence goods and wealth—can be the focus of specialized production.

Subsistence goods are food and other items required for basic household needs. Local or regional specialization in the production of certain basic necessities may be brought about by environmental differences, but this specialization is not directed or administered by elite leaders. It takes place only within the subsistence economy (Brumfiel and Earle 1987:4–5).

It is in a leader's best interest to encourage overall productivity in subsistence goods because in many cases they collect such goods for their own support and the support of others who carry out activities for them. However, leaders are generally not concerned with actually supervising or directing the production of subsistence goods.

Leaders can, however, have a vested interest in the production of wealth items, that is, valuables or rare goods used in display, ritual, and/or exchange. Through the sponsorship of craft specialization leaders control the production of wealth. The essence of craft specialization in this view is control of production of wealth items so that particular items cannot fall into the wrong hands (Arnold 1987:251; Clark 1992b). Wealth items can be used to extend or maintain political power because they are sacred symbols, are associated with an already established elite power (Flannery 1968), can be used to attract allies (Stephen Shennan 1982; Susan Shennan 1982), and/

or can be given to political leaders to integrate various levels of an administrative hierarchy (D'Altroy and Earle 1985). Staple goods can be used to support the production of wealth items by attached craft specialists (Brumfiel and Earle 1987:4–5).

In political approaches to specialization, the control over the production of wealth by craft specialists is the key to increasing cultural complexity. This sort of specialization follows the redistribution or mobilization of resources by the elite. It is quite different from regionally focused specialization in subsistence goods which precedes the appearance of both redistribution and any kind of leadership. In political approaches to cultural complexity, specialization is a political tool that can contribute to and maintain hereditary inequality and social stratification. It is not an economic or ecological requirement that in itself leads to the emergence of leaders (Brumfiel and Earle 1987; Clark 1991; Clark and Parry 1990).

ARCHAEOLOGICAL INDICATORS OF CRAFT SPECIALIZATION

The following are commonly cited as archaeological indicators of craft specialization (Arnold 1985, 1986, 1987:30–33, 56–61; Costin 1991: 18–40; Torrence 1979, 1984, 1986):

- Manufacturing debris at distinct locations within habitation sites where production beyond the needs of a single household clearly took place
- Standardized production methods
- Uniformity in artifacts produced
- High rate of efficiency in use of time and raw materials
- Low rate of errors and other evidence of skill in manufacturing
- High volume of production

There are several difficulties involved in applying these indicators. First, and most simply, some are not applicable to all manufacturing industries. For example, Hawaiian adze manufacture was a quarry-based industry, and so evidence for production beyond household needs cannot be recovered from habitation sites. In addition, measures of such things as efficiency and production rate mean little in absolute terms but must be compared to known standards from comparable industries. Also, the commonly used archaeological indicators of specialization are largely designed to detect the presence or

absence of a generic type of craft specialization. They are not particularly useful in distinguishing between important types of craft specialization such as independent specialization and attached specialization. This is at least partially owing to the fact that independent craft specialization and attached craft specialization are ideal types which are difficult to identify empirically.

There are other problems of logic with specific indicators associated with craft specialization. For instance, standardization or uniformity in methods of manufacture is often assumed to be a logical consequence of craft specialization because production is restricted to relatively few individuals who share a set of norms and expectations regarding the manufacturing process (Ericson 1984:6). Ethnographic evidence from New Guinea does support the idea that stone tool production by nonspecialists is characterized by a variety of manufacturing techniques and heterogeneous lithic debris (White, Modjeska, and Hipuya 1977:390). However, factors unrelated to specialization may also result in what appears to be a highly standardized industry. These factors include cultural norms not limited to any group of specialists, constraints imposed by the type of raw material used, and the fact that there may be only one basic way of making a particular item.

It is often implied that standardized manufacture which can be a way of increasing the speed and efficiency of production is particularly indicative of attached specialization (Rathje 1975:414–415). However, speed and efficiency may or may not be one of the aims of attached specialists. If craft specialists are sponsored to produce luxury goods for elite use, they may take the time to produce relatively few items which are highly variable or even individually unique in form and appearance (Clark 1986:276; Clark and Parry 1990:293–297; Costin 1991:37–39). Thus, there is no necessary relationship between specialization and standardization in either methods used or items produced (Adams 1981; Costin 1991:33–36; Hodder 1981).

Relatively efficient use of raw material, comparatively high volume of production, high success or completion rate, and indications of skill in manufacture are also often assumed to reflect craft specialization. These indicators are usually expected to covary and in particular to increase in direct proportion with increases in the degree of craft specialization (Clark 1992a:4) and/or a move from independent specialization toward attached specialization (Sheets 1978:40; Sinopoli 1988; Torrence 1986).

While it is often implied that particularly high degrees of these factors are indicative of a well-organized, centrally directed craft industry (Sheets 1978:40; Torrence 1986), this is not necessarily true. It is logical that a more highly skilled craftsman will make fewer errors and have a higher rate of success or completion than a less skilled individual. It is unclear, however, whether a more highly skilled craftsman will necessarily apply his or her skill toward high productivity or making highly efficient use of raw material. Furthermore, there is no reason why attached craft specialists should necessarily be more able than independent specialists or even nonspecialists. Attached specialists, independent specialists, and nonspecialists may all include individuals with outstanding skills who can execute difficult manufacturing techniques and produce elaborate items (Arnold 1987:2–3). It is not degree of skill that separates attached specialists from other producers but rather the goals toward which attached specialists apply their skill and ultimately the social and political context within which the specialists manufacture their goods.

Archaeological evidence from the Pololū adze-manufacturing site is examined to describe the nature of the adze production at this location. And, evidence from Pololū is used to assess the usefulness of particular indicators of craft specialization for the Hawaiian adze industry and for craft production in general. When or why specialization and standardization co-occur and the extent to which efficient use of material, productivity, and skill is associated with craft specialization will be considered.

PRODUCTION AT THE POLOLŪ SITE

Data on various aspects of adze manufacture at the Pololū site on the island of Hawai'i are compared to the results of similar analyses carried out by Cleghorn (1982, 1986) for the Mauna Kea adze quarry. The objective is to determine whether there were significant differences in adze production between the two quarries and, if so, whether these reflect differences in craft specialization. Evidence for the form of raw material used and the stages of manufacture which were carried out at the Pololū site is also summarized since these factors rather than variation in type or degree of craft specialization may have caused some apparent differences between the lithic assemblages at Pololū and Mauna Kea.

Site Description

The Pololū site (50-10-03-4981) is located approxi-

Specialization in Hawaiian Adze Production

mately two miles from the mouth of the intermittent stream located on the floor of the Pololū Valley (fig. 4.1) and extends 25 to 30 m along the east side of the streambed. It consists of lithic artifacts exposed in the streambed as well as surface scatters of artifacts between the stream and the east valley wall, a distance of 10 to 15 m (fig. 4.2). The site was found during archaeological investigation of several valleys in the district of North Kohala conducted from 1972 to 1974 by the Department of Anthropology at the University of Hawai'i at Manoa (Olson and Nakama 1974; Tuggle 1976, 1987; Tuggle and Tomanari-Tuggle 1980).

The site was excavated by the University of Hawai'i in 1974. In the excavations, the area along the streambed at the Pololū site was divided into several 3-m sections; these were labeled A through G (fig. 4.2). A trench 50 cm wide and extending 85 to 100 cm into the stream bank was excavated in section D; approximately one and a half meters below the surface was an extensive deposit of lithic debitage up to 30 cm deep. Most of the artifacts recovered from the site are from section D. Additional trenches were excavated in sections A, B, and G, and artifacts were also collected from an area of four square meters located away from the stream bank (Olson and Nakama 1974; Tuggle 1987).

Artifacts recovered from the Pololū site consist of unfinished adzes, hammerstones, cores, and debitage associated with adze manufacture. They are curated in the Department of Anthropology at the University of Hawai'i and were used for this research. The Pololū site was revisited in 1987 when some pieces of stone were collected for petrographic analysis, but no further excavation or collection was conducted at the site.

One radiocarbon date from cultural deposits found beneath the lithic artifacts at the Pololū site dates the first use of the site to approximately AD 1400±100 years; this is the earliest date obtained for the Pololū Valley (Tuggle 1987). Volcanic glass hydration dates for the site are somewhat more recent (Tuggle and Tomanari-Tuggle 1980:307). Petrographic analysis of adze fragments from habitation sites on the island of Hawai'i (chapter 3) shows that adzes made of Pololū material have been recovered from sites dating to AD 1650–1800. This suggests that the Pololū site could have been used for adze manufacture into the late 1700s.

The Pololū site was apparently used for at least some of the same period of time that the Mauna Kea adze quarry was utilized. A series of twenty-three

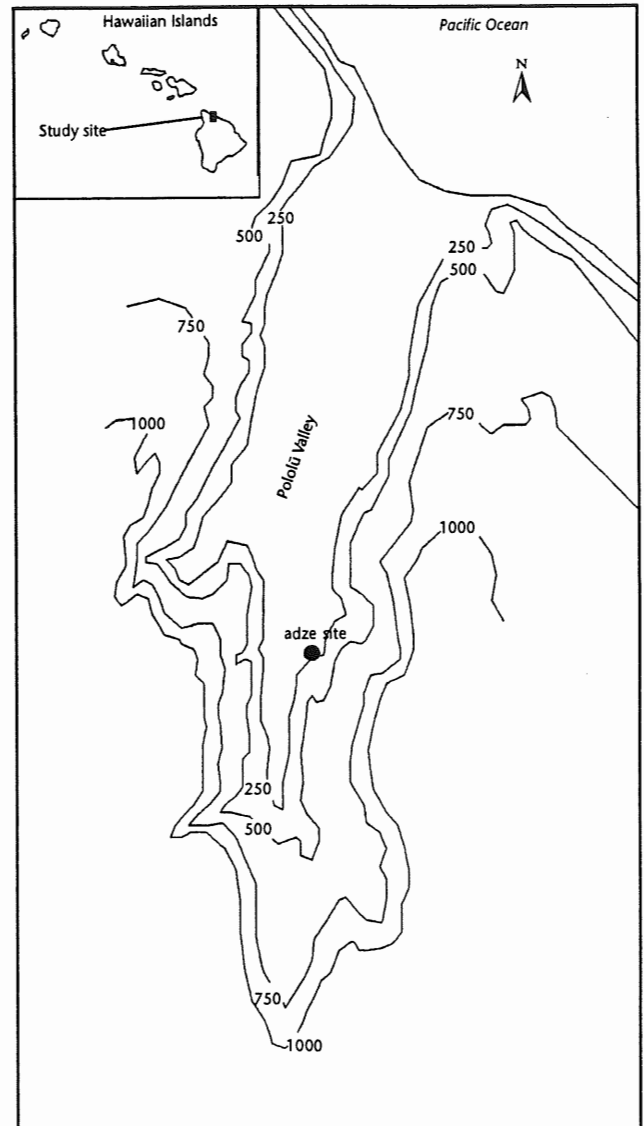


Figure 4.1
Pololū adze-manufacturing site.

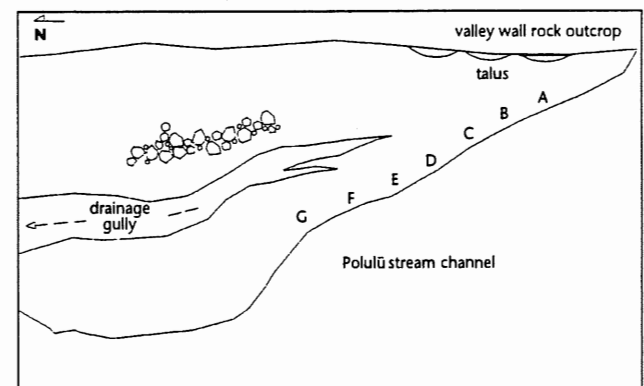


Figure 4.2
Pololū adze-manufacturing site. After Olson and Nakama 1974

radiocarbon dates from Mauna Kea shows that the use of the quarry probably extended from at least AD 1100 to AD 1800 (McCoy 1990:92–93). Petrographic

Table 4.1
Recorded attributes and aspects of adze manufacturing

	Raw material form & quality	Manufacturing techniques including skill	Stage of manufacture carried out at site
Flakes			
Presence/location of cortex	x		x
Bulb type		x	
No. of dorsal ridges			x
Flake shape	x	x	
Termination type		x	x
Size	x		
Length to striking platform thickness ratio		x	
Unfinished adzes			
Presence/location of cortex	x		
Size	x		
Reasons for rejection		x	x
Presence/location of bidirectional flaking		x	x
Flakes removed from intended bevel		x	x
Presence or absence of tangling			x

analysis of adze fragments conducted for this study (chapter 3) indicates that some adzes apparently manufactured at Mauna Kea are associated with sites dated before AD 1100. Chronological change in adze manufacture at the Mauna Kea quarry can be examined by studying materials recovered from rock shelters where there are relatively deep, stratified archaeological deposits (Williams 1989). Unfortunately, much of the Mauna Kea quarry and all of the Pololū site consist of surface artifact scatters and/or a single relatively shallow artifact deposit. The question of chronological change cannot be addressed from studying the evidence at these two locations. Thus, this analysis is restricted to comparing, as a whole, the Pololū site with the Mauna Kea quarry over a broadly defined period of site use.

Sampling

For this analysis, all unfinished adzes (twenty-nine), hammerstones (two), and cores (four) from the Pololū site were studied. Hammerstones are battered, roughly disc-shaped rocks used to remove flakes from cores or unfinished adzes (Cleghorn 1982:106–109; Leach 1981:174,179; Leach and Leach 1980:133–135). Cores are pieces of stone from which flakes have been removed for subsequent manufacture into tools (Bradley 1975:6).

A random 10 percent sample of each lot of curated debitage was also analyzed. A lot consisted of a box or bag of artifacts previously excavated from a particular section of the Pololū site. Most lots contained one hundred or more artifacts. There were approximately 3,500 pieces of debitage originally recovered from the site in the excavations conducted by the

University of Hawai'i. After selecting 10 percent of each lot of artifacts from the site, artifacts without identifiable striking platforms or bulbs of percussion were removed. The remainder of the debitage (142 flakes) was analyzed. Appendix B contains more detailed information on the sampling procedures used.

Methodology

A variety of both quantitative (metric) and descriptive (non-metric) attributes were recorded for flakes and for unfinished adzes. These attributes provide information about three aspects of adze manufacturing:

- Raw material form
- Manufacturing techniques including skill and efficiency
- Stage of manufacture carried out at the site

As will be discussed shortly, many of the adze attributes must be evaluated in combination with each other to provide insights into production. While there is not a simple correlation between attributes and adze manufacturing aspects, some general associations are present. Table 4.1 sets forth these expected relationships as an overview of analyses undertaken. A more detailed description of the recorded attributes follows to provide background for the results of the investigation.

Attributes of Flakes

Presence and location of cortex. Presence and location of cortex can provide information on the reduction stages carried out at a particular location

and whether cortex was removed there. This attribute can also provide information on the form of raw material used. When tabular pieces of stone with cortex on several surfaces are used, flakes removed from them more often have cortex on two or more adjacent surfaces. On the other hand, flakes removed from other large flakes or flake blanks tend to have no cortex and to lack, in particular, flakes with cortex on adjacent surfaces (Cleghorn 1982:114, 257).

Bulb type. When the bulb of percussion (fig. 4.3) is obvious or highly visible, it is termed salient. When poorly defined, it is termed diffuse (Crabtree 1972:59). It is commonly assumed that bulb type is determined by the hardness of the hammer used to remove the flake and/or the size of the contact area between the hammer and raw material (Cleghorn 1982:116; Crabtree 1972:59,62). However, the type of bulb may be influenced by factors such as the angle of impact, roughness of the striking platform, and/or amount of force applied (Speth 1972:38–39).

For Mauna Kea flakes, Cleghorn also recorded another type of bulb, positive-negative bulbs (1982:116,153). Since these were not recorded for the Pololū flakes, comparisons are made only with Mauna Kea flakes that had either diffuse or salient bulbs. Mauna Kea percentages were recalculated to exclude flakes with positive-negative bulbs.

Number of dorsal ridges. Dorsal ridges are found on the outer or dorsal surface of a flake and indicate where other flakes have been removed from a piece of raw material prior to the removal of the flake in question (fig. 4.3). The presence and number of dorsal ridges may provide information on the stage of tool manufacture during which a flake was removed (Williams 1989).

Flake shape. Flake shape refers to the outline form of a flake. Flake shape was recorded as parallel, subparallel, divergent, convergent, or irregular (fig. 4.4). Analysis of flakes from the Mauna Kea adze quarry and from experimental adze manufacture do not support the idea that flake shape varies with stage of manufacture, and Cleghorn concluded that it is unclear if shape is actually a result of deliberate planning (Cleghorn 1982:116–117, 142–145, 267–268). However, analysis of the Pololū artifacts seems to show that when combined with data on other attributes, flake shape can sometimes provide information on manufacturing techniques.

Termination type. The flake termination is at the opposite end from the striking platform (fig. 4.3).

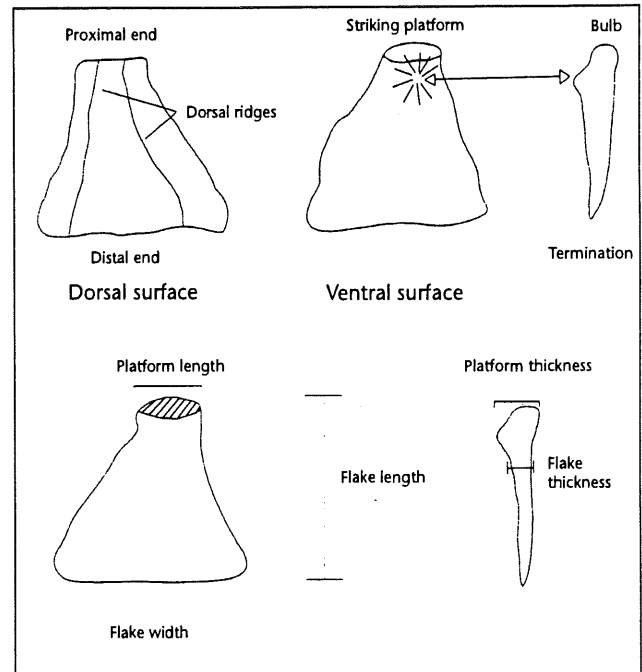


Figure 4.3
Flake dimensions and characteristics. After Cleghorn 1982

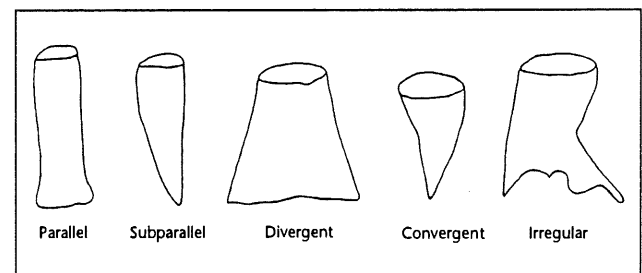


Figure 4.4
Flake shapes.

Terminations can be described as either feather or abrupt. A feather termination is thin and tapering, and it is formed by an ideally placed blow that creates a complete cone of percussion. When flakes break away from a parent mass before the cone of percussion is complete, an abrupt termination occurs. Abrupt terminations can take several forms such as step fractures and hinge fractures (Crabtree 1972:63). For this analysis, specific types of abrupt terminations were not identified or labeled.

Consistency in termination type may indicate that a particular type of termination was being deliberately created for some purpose. Adze-makers might deliberately have removed flakes with abrupt terminations to create straight edges and 90 degree angles on intended adzes (Cleghorn 1982:116, 159). As discussed below, analysis of the Pololū artifacts suggests that termination type may also reflect qualities of raw material and/or degree of skill applied in removing flakes.

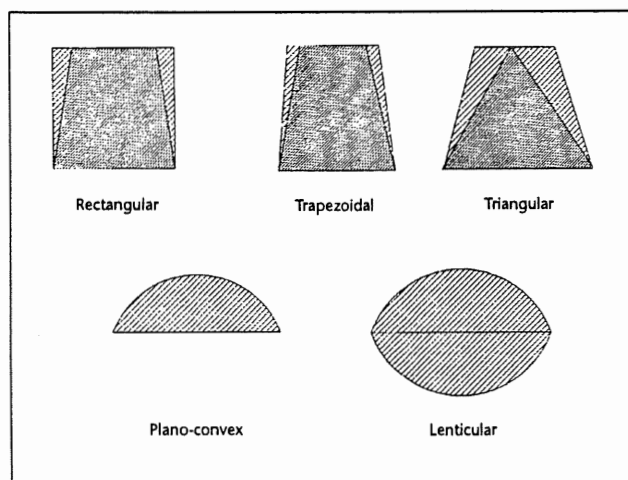


Figure 4.5
Adze cross-section forms (front of adze is up). After Emory 1968,
Cleghorn 1982

Attributes of Unfinished Adzes

In analyzing the unfinished adzes from the Pololū site, no effort was made to distinguish between blanks and preforms. In most lithic technologies, blanks are defined as modified pieces of raw material that have the potential to be made into a variety of tools. Preforms are blanks that have been further worked so that they more clearly represent unfinished tools of an intended type (Bradley 1975:5–6). Unlike many other lithic industries, in adze manufacture the intent is to produce only one type of tool. Thus, blanks are often defined as adzes that were abandoned early in the manufacturing sequence, so that the shape of the adze in cross section (fig. 4.5) is not determinable, while preforms are defined as unfinished adzes in which the form or type of intended adze is apparent (Cleghorn 1982:170,173,328).

In this research, however, all unfinished adzes were simply grouped together. Using a two-part classification of unfinished tools obscures the fact that there is considerable if not continuous variation in tools which were rejected and abandoned at many different points in the manufacturing sequence. There are particular problems in assigning unfinished tools to stages of manufacture based on whether or how closely the cross section resembles a form recognized in finished adzes (Dye, Weisler, and Riford 1985:11; McCoy 1991:82–87; Weisler 1990:34). Determining whether the cross-section form is recognizable is somewhat, if not highly, subjective. Furthermore, the extent to which the cross section appears to resemble a finished form is not necessarily indicative of the stage of manufacture. A piece of tabular raw material could be made into

an artifact with a reasonably well-defined rectangular cross section early in the manufacturing process. If another form of raw material such as a flake blank was used, definition of the cross section could have taken longer and not been defined to the same degree until later stages of manufacture.

Apparent reason(s) for rejection of the adze.

Unfinished adzes found at Pololū and other adze-manufacturing sites are assumed to have been rejected and abandoned without being finished and removed from the site because of errors in manufacture and/or flaws in the raw material being used. If specific errors or flaws can be identified in unfinished adzes, the stage of manufacture at which they were rejected can sometimes be determined.

Presence and location of cortex. The presence and location of cortex on an unfinished adze can provide information on the form of raw material used to manufacture the adze. As with flakes, unfinished adzes with cortex on two opposing or nonadjacent surfaces were most probably made from tabular pieces of raw material (Cleghorn 1982:171–172, 189, 191–192).

Presence and location of bidirectional flaking.

Bidirectional flaking or removal of flakes from two opposing margins of the front, back, or side surfaces of an adze tends to be found on adzes abandoned relatively late in the manufacturing sequence. This is especially true of bidirectional flaking on more than two adze surfaces (Cleghorn 1982:192–196, 237–243).

Flakes removed from the intended bevel. Consistency in the way in which bevel flakes were removed may indicate a preferred adze-making strategy (Cleghorn 1982:196–197). Furthermore, removal of flakes with the intention of creating a bevel is thought to be an intermediate step in adze manufacture (Cleghorn 1982:196–197, 241). The presence or absence of bevel flaking may provide information about the stage of manufacture during which an unfinished adze was rejected.

Presence/absence of tanging. Tanged adzes have a clear separation between the butt portion and the remainder of the adze; untanged adzes do not. When tanging is done, it is one of the last steps in adze manufacture (Cleghorn 1982:200, 202–208).

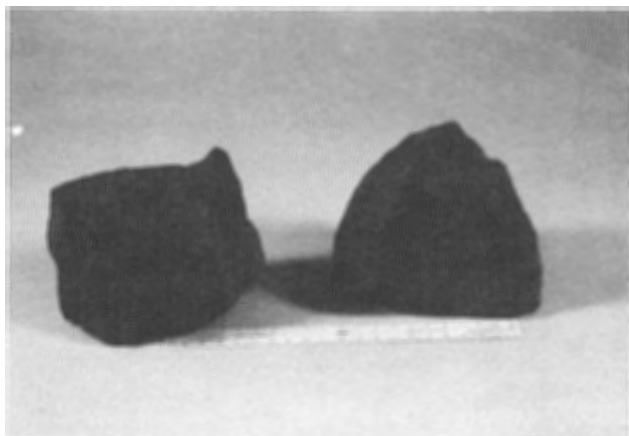


Figure 4.6
Pololū cores. Ruler shown is 12 inches long.

Form of Raw Material Used at the Pololū Site

Raw material is present at Pololū in rock outcrops in the valley wall from which stone could have been quarried as flake blanks and/or as nodules from which to remove flake blanks. Stone also could have been collected from the stream in the form of water-carried debris in the streambed and along the stream banks. Geochemical analysis shows that the stone from the outcrop in the valley wall is not the same as that from the streambed or the stream bank (chapter 3; Sinton 1993a, 1993b). This, along with a lack of evidence of quarrying activity, supports the hypothesis that adze-makers at Pololū used stone acquired from the stream.

Adzes could have been manufactured from stream cobbles, but most were probably made from flake blanks which had been removed from cobbles. Evidence includes cores which show that large flakes were removed from nodular pieces of stone (fig. 4.6). In addition, larger flakes from Pololū tend to be parallel or subparallel in shape and to have cortex. These flakes probably represent rejected flake blanks or other flakes removed from cores in the process of creating flake blanks. In some cases, it is clear from examination that unfinished adzes were in the process of being manufactured from a large flake; the lack of cortex on unfinished adzes and their relatively small size may also indicate that flake blanks were used (Withrow 1991:106–114).

Stages of Manufacture at Pololū

Flake size distribution. Experimental manufacture of stone tools including adzes has shown that most small flakes are produced late in manufacture (Stahle and Dunn 1982:86–87; Cleghorn 1982: 259–261, 269–277). As a result, a flake assemblage can be expected to have a certain percentage of small flakes,

and the cumulative percentages of flakes in various size classes form a characteristic curve when plotted on a graph (Stahle and Dunn 1982). When deviations exist between the curves for experimental data and those for data from archaeological assemblages, this suggests that flakes of a particular size class are missing from the archaeological assemblage. If small flakes are missing this may mean that late stages of manufacture did not take place at the site in question.

Before examining the cumulative percentage curves of flake size categories recorded for Pololū, it is necessary to verify that the characteristic curves developed for other stone tools are appropriate for application to adze manufacture. To do this two tabulations were made using data from Cleghorn's adze-making experiments. In the first, the cumulative percentage of flakes are plotted for each step in one of his adze-making experiments (1982:269–272). The last step in that experiment, which Cleghorn described as steepening the bevel angle, has been omitted because it is apparently not a usual part of the manufacturing sequence. The results are shown in figure 4.7.

The second tabulation was made by using all flakes from two of Cleghorn's experiments, divided into initial width reduction (stage 1) and post-initial width reduction (stage 2) categories (fig. 4.8). The curves produced by these tabulations resemble those expected from the experimental manufacture of other stone tools (Stahle and Dunn 1982:86). It is clear that, as predicted, successive steps or stages in manufacture are associated with progressively larger percentages of small flakes. When the data from figure 4.8 are plotted in logarithmic form (fig. 4.9), an approximately straight line is formed which again conforms to ideal expectations. However, the curves and straight lines formed by Cleghorn's experimental data are shorter and steeper than those for other stone tools. Relatively large flakes are lacking in Cleghorn's experimental assemblage, which may be attributable to the size of the raw material used (Cleghorn 1982:261).

Flakes in different length classes from four Mauna Kea chipping stations were plotted in the same manner. At one of these chipping stations (F10) flake blanks were apparently used to manufacture adzes. At the other three stations (F1, F18, F26) tabular material was used. Figure 4.10 shows curves for the four chipping stations as well as for F10 and for F1, F18, and F26 combined. In these plots, flakes less than 1 cm in size have been omitted. The Pololū

assemblage has no flakes less than 1 cm in length, but Mauna Kea does. It is possible that the difference relates to the fact that screening was not done at Pololū (Tuggle 1992), while it was at Mauna Kea (Cleghorn 1982:131). To control for this factor, these very small flakes have been excluded from the Mauna Kea data used for comparison in this discussion of flake size. The question of whether differential recovery techniques may have affected the frequency of flakes in other size classes at Pololū will be addressed further below.

The curves for the site where quarried flake blanks were used and the three other sites where tabular material was used are very similar, but sites with tabular material have a somewhat lower percentage of small flakes and/or higher percentage of large flakes. When the curve representing all four of the Mauna Kea sites is converted to logarithmic form a straight line is formed (fig. 4.11).

Figures 4.12 and 4.13 compare the cumulative percentages of flakes in different length categories between Cleghorn's experiments, Mauna Kea, and Pololū. The Pololū curve most closely resembles that for tabular material at Mauna Kea, but there is clearly a lower percentage of small flakes and/or higher percentage of large flakes at Pololū than at Mauna Kea. The apparent scarcity of small flakes larger than 1 cm in length at Pololū is not attributable to differential recovery techniques. If relatively small size flakes were absent because of recovery techniques, the lower portion of the curve would be very steep and then rapidly catch up to the curves for other sites, but this is not the case. Instead, it seems likely that the Pololū site has somewhat fewer small flakes than expected because later stages of manufacture, which produce larger numbers of small flakes, were not carried out at the site. Larger flakes may be somewhat overrepresented because some large flakes were created by core preparation and the formation of flake blanks and not by adze manufacture itself.

The use of tabular material at Mauna Kea may also have involved initial trimming or reduction which also caused an overrepresentation of large flakes, possibly explaining why the Pololū flake size curve is most similar to that for tabular material at Mauna Kea.

In sum, it appears as if the general distribution of flake sizes is the same for adzes as for the manufacture of other stone tools. However, existing experimental data for adzes is probably not a good model of what to expect at all adze-manufacturing sites. Little reduction of raw material was required in

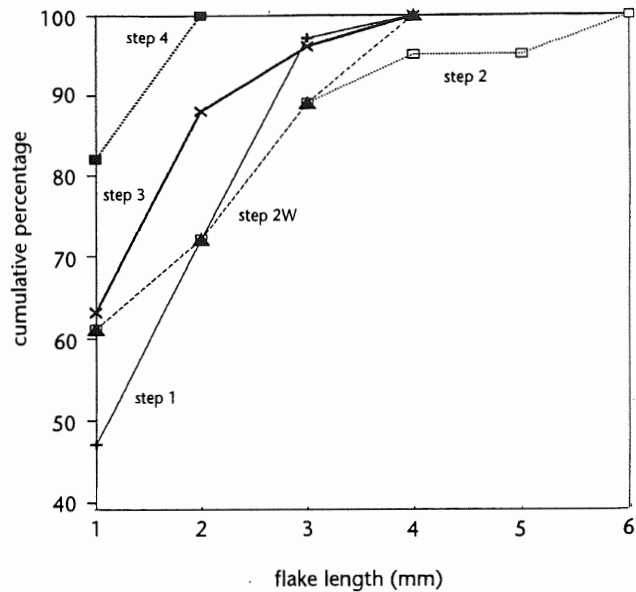


Figure 4.7
Flake length distribution for four steps in Cleghorn's experiment 12: step 1, initial width reduction (n=60); step 2, bevel creation (n=18); step 2W, bevel creation including one extremely large flake (n=19); step 3, tanging (n=48); step 4, side straightening (n=22).

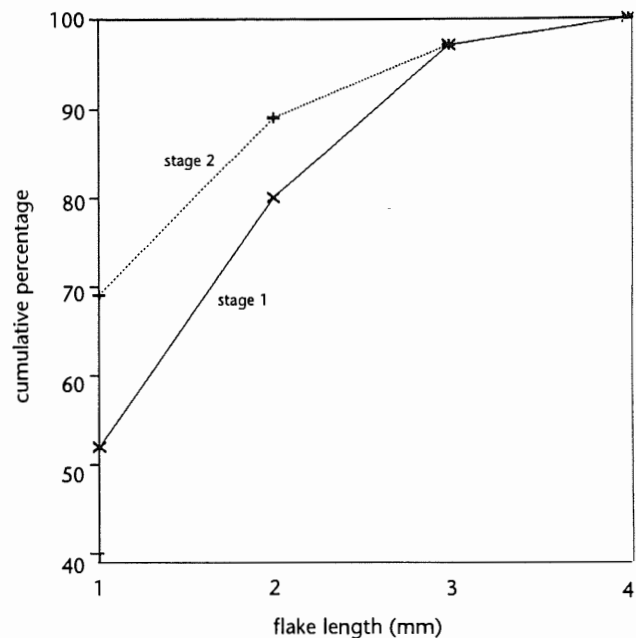


Figure 4.8
Flake length distribution for Cleghorn's experiments 12 and 13: stage 1, initial width reduction (n=901); stage 2, after initial width reduction (n=128).

Cleghorn's adze-making experiments so large flakes are lacking from the experimental data. Differences between flake size distributions at Pololū and Mauna Kea are probably caused by differences in the stages of manufacture carried out and the form of raw material used at the two sites. Specifically, small flakes are underrepresented at Pololū because later

Specialization in Hawaiian Adze Production

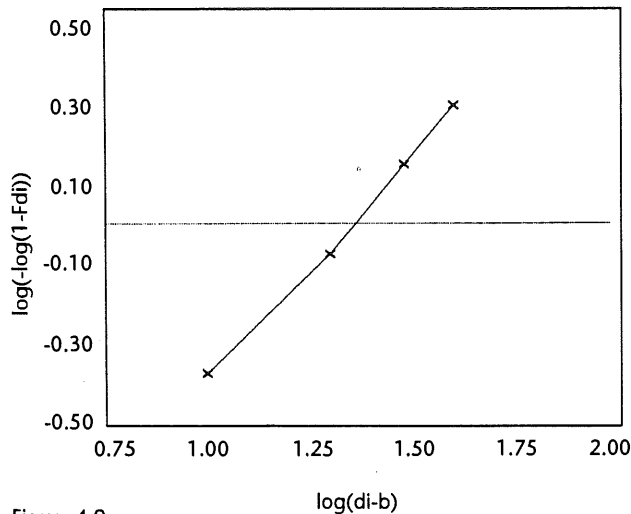


Figure 4.9
Logarithmic form, flake length distribution for Cleghorn's experiments 12 and 13.

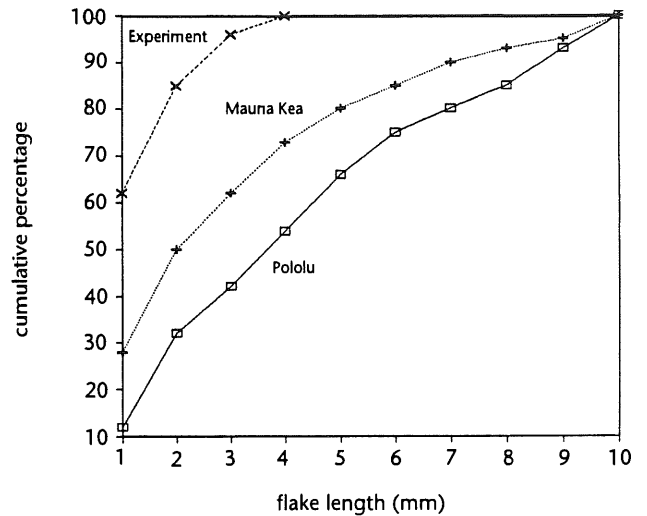


Figure 4.12
Comparison of flake length distributions for Cleghorn's experiments 12 and 13, Mauna Kea, and Pololū. Experiment: $n=218$; Mauna Kea: $n=1,574$; Pololū: $n=142$.

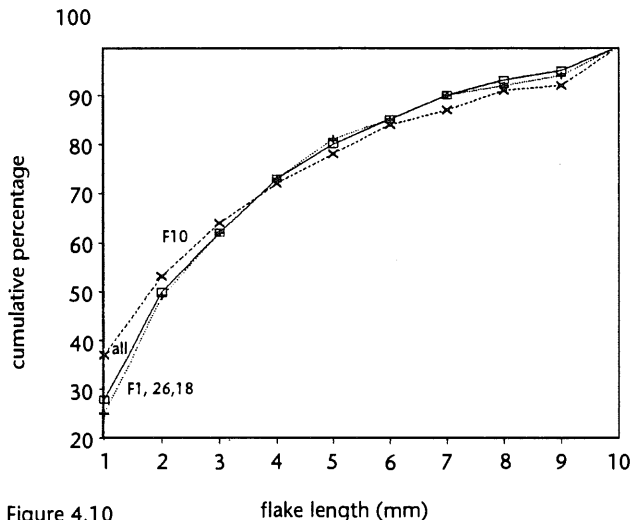


Figure 4.10
Flake length distribution for flakes from Mauna Kea adze quarry: chipping stations F1, F26 and F18: $n=1203$; chipping station F10: $n=371$; all chipping stations: $n=1,574$.

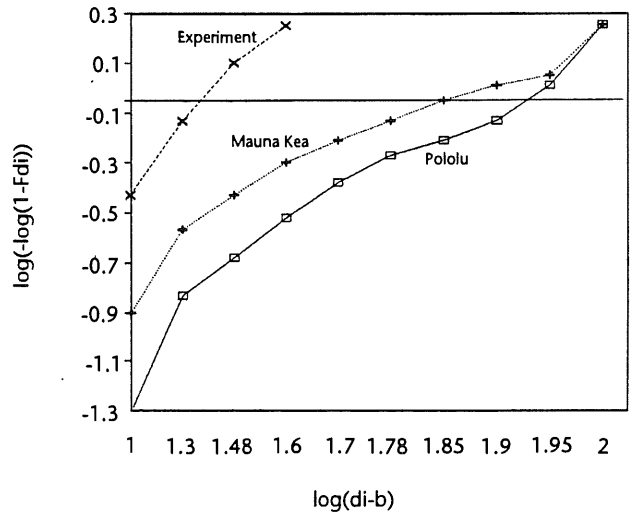


Figure 4.13
Logarithmic form, flake length distributions for Cleghorn's experiments 12 and 13, Mauna Kea, and Pololū.

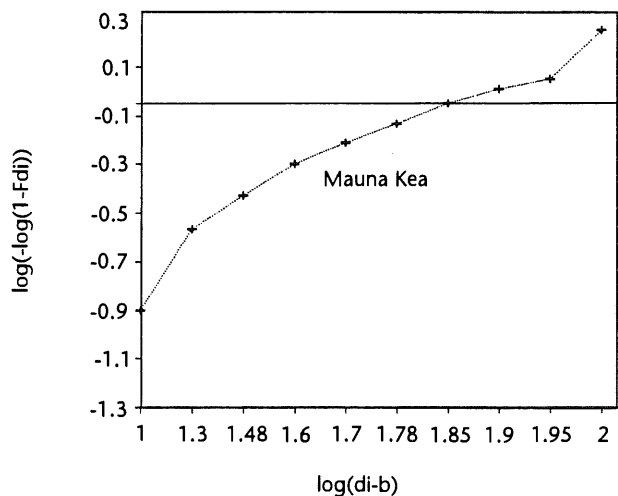


Figure 4.11
Logarithmic form, flake length distributions for all chipping stations, Mauna Kea adze quarry.

stages of manufacture were not done there. At the same time, large flakes are somewhat overrepresented because some were produced during the creation of flake blanks.

Percentage of secondary reduction flakes.
Cleghorn defined five steps in the adze-making process:

1. Initial width reduction: front, back, and two sides are relatively well defined
2. Bevel creation
3. Poll straightening (optional)
4. Tang formation (optional)
5. Side straightening (optional)

However, in his analysis of Mauna Kea artifacts, the attributes that he recorded for flakes were not diagnostic of the manufacturing steps he defined. This may have occurred, at least in part, because Cleghorn's manufacturing steps represent only cognitive changes in the goals of manufacture and are not technological stages marked by actual changes in manufacturing techniques (Williams 1989:17-19).

Williams (1989) reanalyzed the flakes from Cleghorn's adze-making experiments and classified them as either primary flakes or secondary flakes. Primary flakes are generally associated with Cleghorn's initial width-reduction step. Their characteristics include only one or no dorsal ridge; flat, natural platforms; acute striking platform angles; and pronounced curvature near the distal end. When present, dorsal ridges are pronounced. Primary flakes are also thick in relation to their length and have relatively wide striking platforms.

Secondary flakes are produced after raw material has been reduced to a regular shape but before final grinding and polishing of the finished adzes. These flakes have steep platform angles, uncurved profiles, several dorsal ridges, and diffuse bulbs of percussion; they are also thin relative to their length (Williams 1989:53-56).

Williams (1989) compared the percentage of secondary flakes at the Ko'oko'olau rock shelter at the Mauna Kea quarry with the percentages of flakes produced after initial width reduction in Cleghorn's experimental assemblage. He suggested that primary reduction was not generally carried out at the rock shelter because primary flakes were less plentiful there than expected from the adze-making experiments.

The opposite seems to be true at Pololū; there are fewer secondary flakes in the Pololū assemblage than expected from experimental data. This supports the conclusion drawn from flake size data that later stages of adze manufacture did not take place at the Pololū site.

According to Williams' criteria, secondary flakes should have diffuse bulbs of percussion, have more than one dorsal ridge, and be relatively thin relative to their length. At Pololū, 30 percent of the flakes have two or more dorsal ridges (table 4.2). Because flakes with diffuse bulbs of percussion make up over 90 percent of the assemblage (table 4.3) there is no meaningful correlation between bulb type and number of dorsal ridges. However, flakes with diffuse bulbs that have two or three dorsal ridges are concentrated in the thickness/length ratio category of

less than 0.4/1, (table 4.4). Most of them (35/42) also have diffuse bulbs of percussion. These thirty-five can be classified as secondary flakes with this combination of attributes. However, this classification is not conclusive since only some of the flake attributes listed by Williams are considered. Furthermore, it is unclear why diffuse bulbs are not a particularly diagnostic attribute at Pololū. Nevertheless, if thirty-five flakes is accepted as an estimate of the number of secondary flakes in the Pololū sample, then this category makes up 25 percent of the assemblage. In Cleghorn's experiments an average of 37 percent of the flakes were secondary flakes with a range of variation in ten experiments of 28 percent to 55 percent (Williams 1989:68). Thus, the percentage of secondary flakes for Pololū is slightly below the lower end of this range.

Reasons for rejection of unfinished adzes. In the case of broken artifacts, it is assumed that breakage itself was probably the most common reason for rejection (Cleghorn 1982:176,178; Leach and Leach 1980). For complete artifacts, other reasons must have played a role. In some cases, probable reasons for rejection are visible in unfinished artifacts: a relatively large lump that was not or could not be removed, an almost irreparable depression or flake scar in the intended adze, curvature or twisting of the long axis of the intended adze (Cleghorn 1982:176, 178-179, 243-246; Leach and Leach 1980:116), an extremely obtuse angle at the intended bevel, and extremely disproportionate cutting edge, midsection, and butt widths.

Among the nineteen complete, unfinished adzes from Pololū, nine (approximately half) have no obvious defects. The defects of the other ten are shown in table 4.5.

The types of apparent flaws in unfinished Pololū adzes indicate that most were rejected rather early in the manufacturing sequence, probably during initial width reduction when the basic form of the intended adze was being established. Some with defective cutting edges may have been abandoned at the beginning of the bevel creation step. Cleghorn suggests that at Mauna Kea most unfinished adzes were also abandoned relatively early, usually during initial width reduction when any difficulties in manufacture were first encountered. The next most likely time for rejection was after the bevel had been created but before tanging and final finishing (Cleghorn 1982:218-219). The fact that none of the unfinished adzes from Pololū were abandoned at a

Table 4.2
Number of dorsal ridges for Pololū flakes

	Frequency	Percent
None	51	35.9
One	49	34.5
Two	39	27.5
Three	3	2.1

Table 4.3
Bulb type for Pololū flakes

	Frequency	Percent
Diffuse	128	90.8
Salient	13	9.2

Table 4.4
Dorsal ridges and thickness/length ratios for flakes with diffuse bulbs at Pololū

	Less than 0.4 to 1	0.4 or more to 1	Total
0 or 1	76 (68.5%)	17 (100%)	93
2 or 3	35 (31.5%)	0	35
Total	111	17	128

Table 4.5
Characteristics of rejected unfinished adzes at Pololū

No obvious defect	9
Visible defect	
twisted or curved	10
nearly vertical cutting-edge angle	3
disproportionate width measurements	1
disproportionate width measurements, twisted axis	3
steep cutting angle and twisted axis	1
steep cutting angle, disproportionate width and irreparable flake scars	1

point any later than preliminary bevel creation further suggests that later stages of manufacture may not have been carried out at the site.

Artifact proportions. Data on the size of blanks and preforms from Mauna Kea (Cleghorn 1982:176,180–183) show that the length of the intended artifact was established early in manufacture, during initial width reduction. Later steps established appropriate width and thickness measurements so that midsection width, cutting-edge width, butt width, and thickness measurements of artifacts defined as preforms are very similar. The mean length to width to thickness ratio for preforms at Mauna Kea was 3:1:1 ranging from 0:1:1 to 6:1:1. Thus, preforms tended to have a width approximately equal to their thickness, which is near the ratio found in

finished adzes.

For Pololū, mean midsection width, edge width, butt width, and thickness measurements are not as similar to each other as are those for Mauna Kea preforms (table 4.6). The mean length to width to thickness ratio for unfinished adzes is 4:2:1, ranging from 2:1:1 to 6:2:1. This indicates that, in general, ideal width and thickness ratios had not been established when the artifacts were abandoned. On that basis, the unfinished adzes at Pololū represent early manufacturing steps and not later ones.

Bidirectional flaking. At Pololū, most of the unfinished adzes (59 percent) do not have bidirectional flaking on any surface, and few (17 percent) have two or more bidirectionally flaked surfaces (table 4.7). When compared with Mauna Kea blanks and preforms or unfinished adzes from the Kapohaku adze quarry on Lānaʻi, Pololū unfinished adzes have less bidirectional flaking. At Mauna Kea, only 15 percent of the unfinished adzes lacked bidirectional flaking, and 56 percent had bidirectional flaking on two or more surfaces (Cleghorn 1982:194). Sixty percent of the unfinished adzes made from flake blanks at the Kapohaku adze quarry on Lānaʻi had bidirectional flaking (Weisler 1990:38). Since bidirectional flaking is not extensively used in early stages of manufacturing, it would appear that the unfinished adzes from Pololū were abandoned during early stages of manufacture.

Bevel flaking. The intended cutting edge can be identified on twelve (41 percent) of the unfinished adzes from Pololū (table 4.8a). On only seven (25 percent) have flakes apparently been removed from the cutting-edge portion with the intention of creating the bevel (table 4.8a). At Mauna Kea, somewhat more (36 percent) of the blanks and preforms had bevel flakes removed (Cleghorn 1982:196). The lack of bevels among unfinished adzes from Pololū suggests that many if not most of the artifacts were abandoned before or at the beginning of the bevel creation step. Some artifacts may have been removed to other locations for bevel creation; intended adzes for which successful bevels were completed could have been taken elsewhere for finishing.

Among the seven Pololū artifacts with bevel flakes removed, most have three or four bevel flake scars (table 4.8b). This is consistent with data on artifacts from Mauna Kea as well as adze-making experiments that show that most artifacts with a bevel have three to five flake scars (Cleghorn 1982:196, 198, 312–313).

Table 4.6
Descriptive statistics for unfinished adze measurements

	Length, cm	Width, cm	Thickness, cm	Cut width, cm	Butt width, cm	Weight, g
n	19	19	19	9	9	19
Mean	12.37	5.58	4.23	4.61	3.99	429.12
Range	8.22	4.90	4.12	4.60	4.55	1,176.7
Minimum	9	3	2	2	2	103
Maximum	17	8	6	7	7	1,280
Std dev	2.44	1.40	1.34	1.43	1.43	283.86
Skewness	0.15	0.19	0.20	0.09	1.22	1.61
Kurtosis	-0.68	-0.83	-1.33	-0.23	1.27	3.34

Table 4.7
Bidirectional flaking on unfinished adzes at Pololū

	Frequency	Percent
None	17	58.6
One	7	24.1
Two	4	13.8
Three	1	3.4
Four	-	-

Table 4.8
Identification of cutting edge, presence, and directionality of bevel flakes at Pololū

a. Identification of cutting edge

	Frequency	Percent
Cutting edge cannot be identified	17	59
Cutting edge can be identified	12	41
no bevel flaking	5	16
bevel flaking	7	25

* * *

b. Presence of bevel flakes when cutting edge identified

	Frequency	Percent
No bevel flaking	5	41.7
Bevel flaking	7	58.3
one	1	8.3
two	1	8.3
three	3	25.0
four	2	16.7

c. Directionality of bevel flakes

	Frequency	Percent
Parallel	7	100
Perpendicular	0	
Both	0	

For all of the Pololū artifacts with bevel flakes, the flakes had been removed parallel to the long axis of the intended adze (table 4.8c). Mauna Kea artifacts with bevels were more variable in terms of the orientation of the removed flakes (Cleghorn 1982:197, 199). It is not clear why a particular strategy of removing bevel flakes may have been chosen. The dominance of parallel flaking at Pololū could simply be a consequence of small sample size.

Tangling. At Mauna Kea, 19 percent of preforms were tangled. Unfinished tangled adzes were much less common than expected given the known frequencies of tangled adzes among finished tools. This was explained by the fact that since tangling was the last major step in manufacture, adzes that were successfully tangled were completed and removed from the quarry so that they were not well represented among unfinished artifacts (Cleghorn 1982:200, 202–208). None of the unfinished adzes from Pololū were tangled. Here, too, unfinished adzes may have been removed from the site before any had reached the tangling step.

To summarize, data from both flakes and unfinished adzes indicate that the final steps in adze manufacture were not carried out at Pololū. There are fewer small flakes in the artifact assemblage than would be expected if all manufacturing steps had been conducted at the site. There also are fewer than expected secondary flakes or flakes produced after initial reduction. Data on unfinished adzes also support the conclusion that only initial manufacturing was done at Pololū and suggest that most unfinished adzes were removed from the site before or during bevel creation to be finished elsewhere. The evidence consists of the types of errors or flaws in unfinished tools, the fact that unfinished artifacts are not well proportioned, and a lack of bidirectional flaking, bevel flaking, and tangling in unfinished adzes.

Assessing Skill and Efficiency at Pololū

Several possible indicators of skill in adze-making have been used by Cleghorn in his analyses of Mauna Kea adzes. These include flake length to platform thickness ratios, termination type, and bidirectional flaking.

Flake length to striking platform thickness ratios. In his analysis of Mauna Kea flakes, Cleghorn suggested that flakes in which the striking platform is thin relative to overall flake length are the result of greater control or skill in removing flakes. Flakes from his four chipping stations had mean length/platform thickness ratios ranging from 5:1 to 7:1; the maximum ratio ranged from 52:1 to 8:1. Cleghorn compared flake length to striking platform thickness ratios among his four sites and concluded that skill was significantly greater at one of the sites (F10) than at the others (1982:160–164). He proposed that workers at the other three sites were apprentices rather than expert craftspersons (Cleghorn 1982:322; 1986:383–386).

The mean ratio of flake length to striking platform thickness at Pololū is 6:1 with a range of 1:1 to 22:1. This is comparable to ratios from Mauna Kea, but Pololū mean and maximum ratio values seem closer to the three Mauna Kea sites where comparatively less skill was supposedly applied. This suggests that adze-makers at Pololū were equivalent only to apprentices at Mauna Kea and implies that, as commonly assumed, specialists worked at Mauna Kea but not at smaller quarries like Pololū.

However, there are difficulties in assuming that flake length to platform thickness ratios reflect skill in adze manufacture and in proposing that apparent skill in removing flakes indicates craft specialization and, in particular, attached craft specialization. First, the results of experiments in which Cleghorn manufactured adzes cast some doubt on how well flake length to platform thickness ratios actually indicate degree of adze-making skill. The mean flake length to platform thickness ratio for flakes produced by Cleghorn in his adze-making experiments was 7:1 ranging from 1:1 to 39:1 (1982:294, 302–303). There were statistically significant differences in the ratios produced by different experiments, which he attributed to differences in raw material and raw material size and not to differences in his skill or workmanship. Thus, differences in length to platform thickness ratios can be caused by factors other than differential skill.

Furthermore, Cleghorn suggested that his ratios indicate a “fair amount of skill” in detaching flakes (1982:302), and they are, in fact, equivalent to the ratios for the Mauna Kea site (F10) where he claimed that most skill was exhibited. Cleghorn concluded that since even his own relatively inexperienced skill level was apparently the same as at the site where most skill was exhibited, people working at the other sites

must have been “particularly inept” (1982:322–323; 1986:383–386). This implies that adze-makers at Pololū were particularly inept as well, but it is difficult to accept that so many adze-makers at both Pololū and Mauna Kea would have had skills equivalent only to beginners or apprentices as suggested by Cleghorn.

It is also problematic to assume that the removal of long, thin flakes indicates attached craft specialization. In most lithic industries, the removal of flakes which are long or have more cutting edge in relation to weight, thickness, or some other dimension shows efficient use of raw material (Sheets 1978). Some degree of skill or at least care is required to remove such flakes, but the main reason that such flakes may indicate organized craft specialization is that they reflect efficiency in the use of raw material. In adze manufacture, however, there is no particular advantage in removing long, thin flakes because those flakes are not made into tools or used for other purposes. Thus, there is no compelling reason for a craftsman to work to remove long, thin flakes.

Termination type. At Pololū, 37 percent of the flakes have feather terminations (table 4.9); at Mauna Kea, flakes with feather terminations ranged from 36 percent to 71 percent of all flakes at the four chipping stations (Cleghorn 1982:157–158). The frequency of feather terminations is relatively low for Pololū. It is possible that adze-makers deliberately made abrupt terminations in order to create straight edges for adzes (Cleghorn 1982:153, 156–159), but why this strategy would have been followed at Pololū and not at Mauna Kea is not clear. In the manufacture of other stone tools, abrupt terminations are usually avoided whenever possible because it is difficult to remove additional flakes after other flakes have been broken abruptly from a piece of raw material. The high frequency of abrupt terminations among Pololū flakes could indicate a relatively low skill level, but characteristics of the raw material could also have affected the ability to detach flakes.

Bidirectional flaking. When compared to unfin-

Table 4.9
Termination type for Pololū flakes

	Frequency	Percent
Feather	52	36.9
Abrupt	87	63.1
Total	139	100.0

ished adzes from Mauna Kea, unfinished adzes from Pololū are much less likely to have bidirectional flaking (85 percent for Mauna Kea and 41 percent for Pololū). It has already been suggested that this may be explained by the removal of adzes from the Pololū site during early stages of manufacture before bidirectional flaking was generally used. If, however, unfinished adzes from Pololū are compared only with Mauna Kea blanks, which presumably represent earlier manufacturing steps, the frequency of bidirectional flaking at Mauna Kea (72 percent) is still greater than that at Pololū (Cleghorn 1982:194). This could still be attributable, at least in part, to stage of manufacture, but other factors including low skill level could also be involved.

Adze-making experiments show that it is difficult to flake more than one adze surface bidirectionally because it is difficult to obtain appropriate striking platforms on all of the necessary edges (Cleghorn 1982:318). The contrast between the number of unfinished adzes with bidirectional flaking on all four surfaces is particularly marked for Pololū and Mauna Kea. At Mauna Kea, 15 percent of the unfinished adzes have bidirectional flaking on four surfaces (Cleghorn 1982:194), but at Pololū none do. Differential skill level could explain part of the lack of bidirectional flaking at Pololū when compared to Mauna Kea, but other factors to be considered include a simple preference for unidirectional flaking, characteristics of raw material, and small sample size.

* * *

In conclusion, when Pololū materials are evaluated on the same criteria, it is possible to infer that adze-makers at Mauna Kea were more skilled than those at Pololū. However, many factors other than differential skill appear to be involved. Characteristics of the raw material used and personal preference can affect how flaking is done. Perhaps more importantly, even if there were differences in creating relatively long flakes, removing flakes with feather terminations, and carrying out bidirectional flaking on unfinished adzes, this variability does not necessarily indicate attached craft specialization. Attached craft specialists are not distinguished primarily on the basis of superior ability but rather by the purposes to which their skill is directed. Skill may be directed toward making efficient use of raw material, successfully completing a high percentage of artifacts, or producing a high volume of items. Skill also could be directed toward producing a few

high quality items without making greatly efficient use of time or material. Thus, the proposed skill indicators do not necessarily relate to the potential aims of craft specialists.

Estimates of Productivity and Success Rate

Productivity refers to overall volume of production and often is expressed as a production rate such as the number of stone tools produced per year. The number of adzes that were apparently produced and removed from the Pololū site throughout its period of use is estimated at approximately 260 (table 4.10a). Using the same method as that presented in table 4.10a, Cleghorn calculated the number of adzes removed from each of four Mauna Kea chipping stations. However, he misinterpreted the number produced by the calculation to be the actual number of adzes removed rather than a proportion. If his results (Cleghorn 1982:339–340; 1986: 381–383) are reinterpreted (table 4.10c), there was apparently one adze produced and removed from one chipping station, three adzes from another, and one adze from a third. For the fourth site, F10, these calculations would indicate that 160 percent of the adzes worked on at the site were completed and removed, clearly an impossibility. The aberrant production figure for site F10 probably results from the fact that there is much more debitage per unfinished tool at this site than expected from adze-making experiments. This factor will be discussed in more detail shortly.

Success rate refers to the number of tools successfully completed out of the total number worked on at a site. For Pololū, the success rate is reconstructed as being 90 percent (table 4.10b). For Mauna Kea, success rates for Cleghorn's four chipping stations are calculated as being 14 percent, 21 percent, and 33 percent. A valid success rate cannot be determined for site F10 because of the mathematically impossible result of the productivity calculation.

Theoretically, production figures and success rates can be compared between sites. It is often assumed that at sites with higher production and success rates, tool makers were more skilled and more organized. Indeed, at Mauna Kea, Cleghorn suggested that the craftspersons who worked at site F10 were experts while adze-makers at the other chipping stations were only novices (Cleghorn 1982:343; 1986:383–386).

If Pololū is compared to the Mauna Kea sites, Pololū certainly appears to have been relatively productive in terms of absolute number of adzes produced although differences in the size or extent of Pololū and the chipping stations must be kept in

Specialization in Hawaiian Adze Production

Table 4.10
Calculation of production and success rates

a. Calculating production for Pololū site

1. Weight of 19 complete unfinished adzes = 8,153 g
Weight of 10 incomplete unfinished adzes = 3,341 g
Total weight of unfinished adzes = 11,494 g
2. Weight of 142 flakes analyzed = 11,674 g
Weight of 246 pieces of shatter analyzed = 10,802 g
Total weight of debitage in the 10% sample = 22,475 g
Approximate weight of debitage in entire assemblage = 22,475 x 10 or 224,750 g
This is assuming that most of the site assemblage was recovered during excavation.
3. Ratio of unfinished adze weight to debitage weight = 11,494/224,750 or 0.05/1
In other words, there is 0.05 g of unfinished adzes for every gram of debitage.
4. From Cleghorn's experiments, the expected ratio of unfinished adze weight to debitage weight is 0.50/1 or 0.5 g of unfinished tools for every gram of debitage.
Since the adze weight to debitage weight ratio at Pololū is 0.05 to 1 this means that there is ten times more debitage at Pololū than expected from adze-making experiments.
This implies that 90 percent of the expected number of adzes are missing and presumably finished and removed from the Pololū assemblage.
5. There were 29 unfinished adzes from the Pololū site.
29 is 10 percent of 290, and 90 percent of 290 is 261. Thus, 261 adzes were apparently removed.

b. Calculating success rate for Pololū site

1. Success rate = number of adzes removed from the site out of the total number of adzes worked on at the site
2. Number of adzes removed (see a) = 261
3. Number of adzes worked = 261 plus 29 unfinished = 290
4. Thus, success rate = 261/290 or 90 percent

c. Calculating production for Mauna Kea sites

	F1	F18	F26	F10
1. Unfinished tool/debitage ratio	0.3/1	0.17/1	0.2/1	0.03/1
2. Expected ratio of .50/1 divided by unfinished tool/debitage ratios	1.7	2.9	2.5	16.7
3. These figures -1 for proportion of adzes missing from each site	0.7	1.9	1.5	15.7
4. These figures rounded to nearest whole number	1	2	2	16
5. Proportion/percent of adzes missing	10%	20%	20%	160%
6. Number of unfinished adzes at each site	6	11	2	3
7. Number of adzes that must have been taken away (rounded to highest whole number)	1	3	1	-

d. Calculating success rates for Mauna Kea sites

1. Number of adzes taken away/total worked	1/7	3/14	1/3	-
2. Success rate	14%	21%	33%	-

mind. There is no way to calculate a production rate for any of the Mauna Kea sites because their duration of use is not known, but a tentative production rate can be calculated for Pololū. If it is assumed that the site was used continuously from approximately AD 1400 until AD 1800 this means that one adze was produced every one and a half years. This seems to indicate a fairly unambitious rate of production. With a success rate of 90 percent, Pololū does seem to have a higher success rate than the three Mauna Kea sites for which valid rates of less than 35 percent were calculated.

There are, however, several problems associated with using the estimates of productivity and success presented above. Such estimates are ultimately derived from an expected ratio of debitage weight to adze weight. But, this ratio, derived from Cleghorn's experiments, may not apply to localities like site F10 at Mauna Kea or even Pololū where adzes were manufactured from flake blanks and not tabular raw material. The weight of debitage produced at such sites would be increased by breaking up raw material, trimming cores, and making flake blanks, and as at site F10 at Mauna Kea, the amount of debitage may be much more than expected. This would explain the invalid production estimate for site F10. It also could mean that the relatively high estimates for Pololū may be inflated and that production was somewhat lower than the calculations indicate.

Another problem is the assumption that the adzes apparently removed from sites were necessarily completed successfully. Finally, the assumption that production and success rates are indicators of skill and/or the type of craft specialization is questionable. A high production rate could be related, for example, to the number of individuals working at a site, the amount of raw material available, or even characteristics of the raw material used.

Standardization in the Pololū Manufacturing Process

There was not significant variability within the manufacturing sequence nor was more than one basic adze-making strategy used at Pololū. The general method of adze manufacture carried out at Pololū seems to have been basically the same as that proposed for Mauna Kea (Cleghorn 1982:217–220). It is even more similar to the manufacturing sequence suggested for the Kapohaku quarry where flake blanks were used as they were at Pololū (Weisler 1990). This conclusion is based on general observa-

tions rather than from detailed, quantitative analysis of Pololū artifacts.

There is debate over how standardized Hawaiian adze manufacture was and what any degree of standardization might imply. At the Mauna Kea quarry, Cleghorn suggested that adze manufacture was highly standardized and thus specialized (1982:343), but McCoy maintains that there is "evidence for a multiplicity of reduction strategies and tool forms" at Mauna Kea and points out that standardization may not be indicative of craft specialization (1990:100–101, 1991:94).

Even though the degree of homogeneity in unfinished tools is often used to comment on standardization in manufacture, this approach is based on potentially faulty assumptions and was not applied to the Pololū artifacts. Unfinished and rejected adzes do not necessarily accurately reflect manufacturing techniques. Furthermore, homogeneity in tools, finished or unfinished, does not necessarily reflect uniformity in manufacturing techniques. Homogeneity in debitage rather than rejected tools has more potential to provide information on standardization in manufacture, but further analysis or reanalysis of Pololū artifacts is required before this can be verified.

NATURE OF HAWAIIAN ADZE PRODUCTION

If a dichotomy is made between subsistence goods and wealth items, Hawaiian stone adzes were clearly subsistence goods, necessities used to carry out everyday activities. However, leaders could have had a vested interest in the use of adzes in activities that they sponsored which, like wealth items, eventually came to symbolize or represent chiefly power and influence. They may have been interested in ensuring that adzes or particular types of adzes were available to other attached specialists such as canoe builders or house builders.

It is often suggested that some Hawaiian adze-manufacturing sites, particularly the large Mauna Kea adze quarry, were the focus of attached craft specialization and that smaller sites were not. Researchers have assumed that attached craft specialists probably worked at larger sites, at sites that are isolated or far from settlements, and at sites with associated shrines (Cleghorn 1989; McCoy 1990). However, previous research has not been directed at comparing the artifact assemblages at sites like these with assemblages from smaller sites to see if there may be specific indicators of attached craft specialization.

Analysis of flakes and unfinished adzes from Mauna Kea and Pololū indicates that there are some differences in the archaeological assemblages of these two sites, but these appear to reflect differences in the form of raw material available and the stages of manufacture carried out rather than the fact that attached craft specialists worked at Mauna Kea and did not work at Pololū. Admittedly, there are few, if any, ready indicators of attached craft specialization, and there are difficulties involved in obtaining valid data with which to calculate supposed indicators such as production rate or standardization in manufacture. This analysis has not provided conclusive evidence that attached craft specialization did not exist at Mauna Kea or Pololū, but it has pointed out that differences in efficiency of raw material use, productivity, success, standardization, and skill are not necessarily related to attached craft specialization in every industry and has described how factors such as form of raw material used can affect the interpretation of supposed indicators of craft specialization in adze manufacture.

The fact remains, however, that there are clearly differences between the Mauna Kea and Pololū sites in their size, their proximity to habitation areas, and the presence of shrines. While these considerations are most often cited in suggesting that sites like Mauna Kea must have been the focus of attached craft specialization (Cleghorn 1989), they are not necessarily indicative of that type of specialization.

Production at large and distant quarries like Mauna Kea would certainly have required a degree of planning and organization not necessary at sites like Pololū. Adze manufacture at Mauna Kea required a relatively long journey into a harsh, high-altitude environment. Adze-makers had to stay at the quarry at least overnight and had to bring food, fuel, and other necessities with them from lower elevations. Cold temperatures and snowfall during part of the year limited when and how often trips to the quarry could be made (McCoy 1990:90–92). Sites like Pololū, however, could have been used on a more casual, informal basis by individuals. Such differences in the manner in which the quarries were used are not insignificant, but they do not necessarily imply that attached craft specialists worked at Mauna Kea. The degree of organization required to travel to Mauna Kea and manufacture adzes there did not require any direction or sponsorship and, in particular, did not require sponsorship by chiefs.

It is highly possible, however, that adze-makers at Mauna Kea were independent specialists, individu-

als who spent at least part of their time manufacturing adzes for others. Such individuals could have specialized in adze-making because they were somewhat more skilled in stone working than the average person and/or familiar with sources of adze stone. They would have been more likely to have taken the time and made the effort to visit a site like Mauna Kea than would nonspecialists. Such an interpretation is consistent with ethnohistoric data which indicates that adze-makers were trained experts who deliberately prospected for sources of adze stone and that when they finished an adze it became "an object of barter with this and that one" (Malo 1951: 51). Ethnographic data from New Guinea indicates that in at least some areas of the world it was common for adze-making to be carried out sometimes by independent specialists and sometimes by nonspecialists. Furthermore,

the fact that there were specialist axe makers in the Wahgi Valley [in New Guinea] does not imply that there existed a guild of craftsmen set apart from the mainstream of society. The men were specialists by virtue of the fact that they were good with their hands and because other men could not do the same tasks as well. [Burton 1985:124]

In addition to differences in knowledge and ability, it is possible that some individuals in Hawai'i specialized in the production of adzes because they had preferential access to sources of adze stone. They may have lived near a stone source, on or near routes to a source, and/or within an ahupua'a within which a source was located. It is uncertain to what extent access to sources would actually have been restricted by virtue of the fact that they were located within the boundaries of a particular community.

McCoy (1990:111–112) points out that the Mauna Kea quarry was located within the boundaries of the ahupua'a of Kā'ohe. Unlike most of the ahupua'a, Kā'ohe extended far inland so that it included substantial upland areas within its boundaries. It contained little arable land but did have other valuable resources including Mauna Kea adze stone and forest resources. McCoy implies that Kā'ohe could have traded adzes for other resources that they were lacking, and the community may have tried to limit outsiders' access to the quarry. Many or most of the independent specialists who worked at Mauna Kea could have been inhabitants of Kā'ohe. If so, this implies that there may have been community spe-

cialization in adze production based on differential proximity to adze-manufacturing sites. There is no evidence with which to assess the likelihood of this suggestion, however, and it is highly possible that Mauna Kea was used by independent specialists from more than one community.

Sources of raw material like Pololū where no actual quarrying of stone occurred are often overlooked or dismissed as relatively insignificant (Leach 1990:380, 381), but ethnographic evidence (Hughes 1977:144,146; Vial 1940:159) and archaeological evidence (Jones 1984; Leach 1990: 374, 380, *passim*; Leach and Leach 1980:133–134; Leach and Witter 1987) indicate that such sources, particularly streambeds or beaches, were commonly exploited in other areas of Oceania. Some ethnographic accounts suggest that stream cobbles were used in areas where other stone was not available (Hughes 1977), but this does not imply that all nonquarry sources were inferior or were viewed as such. There were probably many sources of adze stone in Hawai'i similar to that at Pololū, only some of which have been found and investigated (Dye, Weisler, and Riford 1985:68; Weisler 1990). Petrographic analysis of polished flakes from Hawaiian habitation sites (chapter 3) confirms that adzes came from a number of unidentified sources.

If raw material for adze manufacture was apparently available at a number of locations, this raises the question of why adze-makers used Mauna Kea so extensively. It is often assumed that the raw material found at Mauna Kea was of particularly good quality and highly desired for adze manufacture. Stone from Mauna Kea is unusually fine-grained in comparison to other known types of adze stone (chapter 3). However, there is no real evidence that Mauna Kea material is clearly preferable for adze manufacture. McCoy suggests that the outstanding feature of the Mauna Kea quarry is the large volume of raw material available in one place so that the site could be used repeatedly over a long period of time. He goes on to suggest that this fact made Mauna Kea a likely location for attached specialization because

Mauna Kea is the only known source with the inherent potential to sustain over a period of more than perhaps a few centuries an institutional practice such as the legitimation of chiefly authority and power based on the production for exchange by a group of attached specialists. [McCoy 1990:110]

However, while the large amounts of material at Mauna Kea could very well have attracted adze-makers and provided the basis for a long-standing tradition of manufacturing adzes there, there is no reason why these adze-makers were necessarily attached specialists. In fact, because more easily acquired sources of stone were apparently available at a number of other locations there must have been an incentive to visit Mauna Kea beyond the fact that large amounts of material were available in one place. These incentives may have included the high quality of the material for adze making, the fact that the material often occurred in tabular form amenable to the manufacture of rectangular adzes, or, perhaps more importantly, that Mauna Kea was regarded as a special, significant, or even sacred place.

Another fact often cited in proposing that Mauna Kea was the focus of attached craft specialization is that shrines are found at the site (Cleghorn 1989). These consist of one or more upright stones; lithic debris found near and at the base of the stones was apparently placed at the shrines as offerings (McCoy 1981; 1990:97; McCoy and Gould 1977). Such shrines may be unique to Mauna Kea although possible shrines may be associated with the Kaho'olawe adze quarry on Kaho'olawe and the adze quarry on Haleakalā on Maui (Cleghorn 1989).

McCoy (1990:113–114) suggests that the vicinity of the Mauna Kea quarry was originally the focus of religious or ritual activities associated perhaps with the fact that snow is often found near the summit of Mauna Kea. He believes that after the source of adze stone was discovered the area retained sacred connotations. Because it was a sacred place, its use may have been restricted to adze-makers who were affiliated with the chiefs. Again though, the presence of shrines is significant but not necessarily indicative of attached craft specialization. While the summit area of Mauna Kea could have been a sacred or meaningful place to Hawaiian people, access was not necessarily controlled or restricted by the chiefs. Shrines consisting of upright stones are associated with everyday households, and various offerings to the gods were made regularly (Kirch 1985:260–261; Weisler and Kirch 1985). Shrines were also erected by fishermen along coastlines where they made offerings to ensure success in fishing (Kirch 1985:261). Even when a shrine was not erected, offerings or sacrifices were made on many occasions; Malo (1951:127), for example, describes how offerings of food were made before felling the tree to be used in construction of a canoe. Shrines at Mauna

Specialization in Hawaiian Adze Production

Kea certainly could have been used to make offerings before commencing adze manufacture. This practice could have been restricted to Mauna Kea because this location did have particularly sacred connotations, as suggested by McCoy.

There were no doubt differences between Hawaiian adze-manufacturing sites, but differences in the size of sites, their potential to maintain a long-standing industry, and their sacred associations do not

necessarily reflect the fact that some quarries were the focus of attached craft specialization while others were not. Independent specialists may very well have produced some adzes and they, more than nonspecialists, would have been more likely to have used sites like the Mauna Kea adze quarry which required more effort to exploit. Currently there is no good evidence that Hawaiian chiefs sponsored or directed adze-makers to manufacture stone tools.

Chapter 5

Craft Specialization and Homogeneity in Finished Adzes

Homogeneity or uniformity in the size, shape, and/or other characteristics of finished craft items is often assumed to be an indicator of craft specialization (Arnold 1987:56–61, 241, 244; Rice 1981; Torrence 1986:157–162). Uniform products presumably reflect a set of norms shared by a relatively small group of specialists. In addition, specialists who are manufacturing items for others and not for their own use may be more likely to provide generic or uniform products (Ericson 1984:6–7). However, homogeneity in finished artifacts is not an unambiguous indicator of attached craft specialization, and it is important to try to determine if and when standardized products are an expectable consequence of a particular craft industry (Costin 1991:34–35). In this chapter, the degree of uniformity in finished Hawaiian adzes is assessed, and the extent to which homogeneity in finished adzes seems to provide information about the type and degree of specialization in adze manufacture is discussed.

DATA AND METHODOLOGY

One hundred and thirty-five complete or partial adzes were analyzed for this research. Complete adzes are artifacts containing at least portions of the butt, mid, and bevel sections of the original artifact. Most of the adzes analyzed here (38 percent) are only bevel portions of the original adze, but more than 20 percent are complete (table 5.1).

The adzes used for this analysis are located in collections from previously excavated archaeological sites on the island of Hawai'i. No sampling was involved in selecting the 135 adzes for analysis. Complete or nearly complete adzes are recovered com-

paratively rarely from archaeological sites, and so all complete or partial adzes from dated sites that could be located were analyzed for this study. Table 5.2 lists the collections from which adzes were obtained for analysis.

The adzes used for this analysis were originally recovered from thirty-two different archaeological sites. Most of these are located on the west or leeward coast of the island of Hawai'i where most of the archaeological fieldwork on the island of Hawai'i has been carried out. Over half of the adzes are from only seven of these sites: sites H1 and H8, site 7702 at Kahalu'u, and four sites within Pu'u'honua o Hōnaunau, a large ceremonial complex.

Only 120 of the 135 adzes analyzed are from dated contexts (table 5.2). Some undated adzes from site 7702 at Kahalu'u were analyzed simply because some portions of the site were dated, but others were not. In addition, some artifacts from two undated sites were analyzed in order to compare adzes from these particularly distinctive sites with adzes from other sites. One of these undated sites is the *pu'u'honua* (place of refuge) at Hōnaunau on the Kona Coast of the island of Hawai'i. The *pu'u'honua* was a sanctu-

Table 5.1
Portion of adzes analyzed

Artifact	Frequency	Percent
Bevel portion	51	37.8
Complete adze	30	22.2
Midportion	27	20.0
Butt portion	24	17.8
Unidentified	3	2.2
Total	135	100.0

Chapter Five

Table 5.2
Sites from which adzes obtained for analysis

District, area	Site	No. Analyzed	Period	Collection	References
Puna, Volcanoes Park	911	1	1100–1400	Natl. Park Service	Ladd 1969b
Kona, Kahalu'u	D4-48	1	1400–1650	Bishop Museum	Kirch 1973
	D4-51	1	1400–1650	Bishop Museum	Kirch 1973
	7702	3	1400–1650	Paul H. Rosendahl Inc.	Hay et al. 1986
Kona, Hōlualoa	7976	1	1400–1650	H. Hammatt	Hammatt, Barthwick, Schideler 1986
Kohala, Kalāhuipua'a	324	3	1400–1650	Bishop Museum	Kirch 1979
	343	1	1400–1650	Bishop Museum	Kirch 1979
	368	1	1400–1650	Bishop Museum	Kirch 1979
Kohala, 'Anaeho'omalū	197	4	1400–1650	Bishop Museum	Barrera 1971
	298	1	1400–1650	Bishop Museum	Barrera 1971
Kona, Kahalu'u	7702	17	1650–1800	Paul H. Rosendahl Inc.	Hay et al. 1986
Kona, Kēahole	262	3	1650–1800	Historic Sites Division	Hammatt and Folk 1986
Kona, Kuakini	D7-27	1	1650–1800	Bishop Museum	Schilt 1984
	D8-33	1	1650–1800	Bishop Museum	Schilt 1984
Kona, Hōlualoa	7967	1	1650–1800	H. Hammatt	Hammatt, Barthwick, Schideler 1986
Ka'ū, site H2	H2	7	1650–1800	Bishop Museum	Emory and Sinoto 1969
Kohala, Mudlane-Waimea	2727	3	1650–1800	Bishop Museum	Clark and Kirch 1983
	5998	1	1650–1800	Bishop Museum	Clark and Kirch 1983
	8825	1	1650–1800	Bishop Museum	Clark and Kirch 1983
	2732	1	after 1800	Bishop Museum	Clark and Kirch 1983
	8824	1	after 1800	Bishop Museum	Clark and Kirch 1983
Kona, Pu'uhonua o Hōnaunau	A-27	13	long sequence	Natl. Park Service	Ladd 1987
Kona, Kamehameha Rd.	D4-27	2	long sequence	Bishop Museum	Crozier 1971
Kona, Kailua-Kawaihae	1349	1	long sequence	Bishop Museum	Rosendahl 1973
Ka'ū, site H1	H1	21	long sequence	Bishop Museum	Emory and Sinoto 1969, Goto 1986, Green 1971, Kirch 1985
Ka'ū, site H8	H8	18	long sequence	Bishop Museum	Emory and Sinoto 1969, Emory, Bonk, and Sinoto 1969, Goto 1986, Green 1971, Kirch 1985
Ka'ū, Wai'ahukini	22-64	8	long sequence	Bishop Museum	Sinoto and Kelly 1975
Kohala, Kalāhuipuaa	342	1	long sequence	Bishop Museum	Kirch 1979, Hommon 1983
Kohala, Lapakahi	6941	2	long sequence	Historic Sites Division	Tuggle and Griffin 1973
Kona, Pu'uhonua o Hōnaunau	A-26	4	no date	Natl. Park Service	Ladd 1969a
	A-1/A-2	5	no date	Natl. Park Service	Ladd 1969c
	B-105	3	no date	Natl. Park Service	Ladd 1986
Kona, Kahalu'u	7702	1	no date	Paul H. Rosendahl Inc.	Hay et al. 1986
Kohala, Pololū	4838	2	no date	U of Hawaii	Tuggle 1976, 1987

ary for breakers of taboos (*kapu*) and includes several large temples. Pu'uhonua o Hōnaunau was apparently used occasionally as a seat of government by paramount chiefs, and historic accounts indicate that one of the heiau at the site housed the bones of prominent chiefs (Kirch 1985:161). The other undated site from which adzes were analyzed is site 4838. This site is potentially interesting because it is located adjacent to the Pololū adze-manufacturing site, and adze manufacturing and/or maintenance activities may have taken place here.

Adzes from dated contexts were placed in one of the following time periods:

- Before AD 1100
- AD 1100–1400
- AD 1400–1650
- AD 1650–1800
- After AD 1800

Chronological placement was based on published (or otherwise recorded) radiocarbon and/or hydra-

Table 5.3
Frequency of adzes by time period

Period	Frequency	Percent
Before AD 1100	0	-
AD 1100-1400	1	1.0
AD 1400-1650	16	13.3
AD 1650-1800	35	29.2
After AD 1800	2	2.0
Long sequences	66	55.0
Total	120	100.00

tion rind dates. Some adzes were placed in a category labeled "long sequence" because dates for the sites from which they had been excavated spanned two or more time periods. The chronological categories used for this analysis and the specific procedure by which sites and adzes from them were placed in a category were the same as that used for the analyses discussed in chapter 3. Appendix A explains how chronological placement was carried out. Table 5.2 lists the chronological classification of each site from which the adzes discussed in this chapter were obtained. Most of the adzes used for this analysis (55 percent) are from sites with long sequences of dates; an additional 29 percent are from sites dated to AD 1650–1800, but there are few adzes from any other time periods (table 5.3). Because of the small sample sizes for some periods, the periods have been collapsed to "before AD 1650" and "after AD 1650" for the analyses discussed in this chapter; the original category for long sequences has been retained (table 5.3).

Only four partial adzes were sourced using petrographic analysis (chapter 3) because most curators did not want complete or nearly complete adzes subjected to thin-sectioning. Because only four are sourced, no analyses designed to examine possible relationships between adze size or form and type of raw material could be carried out.

The following measurements were recorded for each of the complete and partial adzes: length, thickness, weight, cutting edge width, midsection width, butt width, and bevel angle. Bevel angle refers to the angle at which the front and back surfaces of an edge meet at the cutting edge (fig. 3.1). If an adze was broken so that a particular measurement did not reflect the actual dimensions of the original artifact, that measurement is not included in the statistical analyses of adze dimensions presented in this chapter.

Profile type and cross-section form were also recorded when determinable. Profile type refers to

whether an adze is tanged or untanged. A tanged adze has a well-defined boundary between the butt or portion of the adze that is lashed when the tool is hafted and the remainder of the tool or blade. This boundary or shoulder is created during adze manufacture by reducing the thickness and/or width of the butt. In untanged adzes there is no clear division between the butt and the blade (fig. 3.1; Buck et al. 1930:175–176; Cleghorn 1982:16, 171; Emory 1968:153). Cross-section form refers to the shape of the adze body in cross section; for this analysis cross-section forms were described as rectangular, trapezoidal, triangular, or lenticular (fig. 4.5; Cleghorn 1982:25; Emory 1968:152–153).

Much previous research on Hawaiian and Polynesian adzes has focused on using data on adze characteristics to define various types of adzes that may represent particular cultural groups and/or historical periods, adzes used in particular activities, and/or adzes produced by certain manufacturing techniques (Cleghorn 1982:12–39). The purpose of this analysis, however, is not to define types of adzes but rather to assess the degree of homogeneity or uniformity in Hawaiian adzes in general and within particular time periods. Degree of homogeneity is assessed by examining four characteristics: profile form, cross-section form, various dimensions of size, and bevel angle. These are considered independent variables that may or may not covary to produce distinctive types of adzes.

ADZE PROFILE AND CROSS SECTION

Among the adzes for which the profile form was determinable, approximately 75 percent are tanged. Tanged adzes are clearly dominant in all three temporal categories (table 5.4). Over 90 percent of the adzes in all of the temporal categories have rectangular cross sections (table 5.5). Only nine (8 percent) adzes have cross sections that are trapezoidal, triangular, or lenticular.

The nonrectangular adzes are from only four sites, including sites H1 and H8 (table 5.6). Even though sites H1 and H8 have long sequences of dates, some of the dates are quite early, and they may be among the earliest occupied sites in the Hawaiian Islands (Emory and Sinoto 1969; Emory, Bonk and Sinoto 1969; Goto 1986; Green 1971; Kirch 1985:81–86; appendix A). This lends possible support to the longstanding notion that Hawaiian adzes were more variable in cross-section form during early times and later became more standardized (Emory 1968:162–164; Kirch 1972, 1985:184–185). However, adzes with

Table 5.4
Adze profile frequencies

	Frequency				Percent			
	All*	-1650	+1650	Long sequence	All*	-1650	+1650	Long sequence
Tanged	35	5	9	17	76.1	71.4	69.2	85.0
Untanged	11	2	4	3	23.9	28.6	30.8	15.0
Total	46	7	13	20	100.0	100.0	100.0	100.0

*Includes undated adzes.

Table 5.5
Adze cross-section frequencies

	Frequency				Percent			
	All*	-1650	+1650	Long sequence	All*	-1650	+1650	Long sequence
Rectangular	106	14	31	49	92.2	93.3	91.2	90.7
Nonrectangular	9	1	3	5	7.8	6.7	8.8	9.4
Total	115	15	34	54	100.0	100.0	100.0	100.0

*Includes undated adzes.

Table 5.6
Sites with nonrectangular adzes

Site	Trapezoidal	Triangular	Lenticular
H1	2	1	0
H2	0	1	0
H8	1	0	1
7702	2	1	0
Total	5	3	1

nonrectangular cross sections were also found at sites H2 and 7702, which are apparently more recent sites. Site H2 dates to AD 1650–1800 (Emory and Sinoto 1969; appendix A); for site 7702 two of the nonrectangular adzes date to AD 1650–1800, and one is from a portion of the site dated somewhat earlier at AD 1400–1650 (Hay et al. 1986; appendix A). It is possible that nonrectangular adzes occurred in small percentages throughout the precontact sequence but that they tend to be recovered more often from relatively large, well-excavated, long-term habitation sites with large artifact assemblages such as the four sites considered here.

Degree of Homogeneity and Craft Specialization

There seems to be a high degree of homogeneity in adze profile as well as cross-section form. However, this homogeneity is not necessarily indicative of attached craft specialization in adze manufacture. If such specialization developed with or as a part of other trends toward cultural complexity which have

been documented in the Hawaiian archaeological record, evidence of increasing specialization over time should be apparent. At this time there is no evidence that adzes became any more homogeneous from one time period to the next in terms of profile and cross section. There are factors other than craft specialization that could explain the high degree of similarity in adze profile and cross section throughout the precontact sequence: cultural norms unrelated to craft specialization, the intended use or function of adzes, and effects of the type of raw material on the final adze form.

Cultural norms. Highly standardized products can be produced by craftspersons who share rather strictly defined goals and standards regarding their finished products without being directed or sponsored by others in attached craft specialization (White, Modjeska, and Hipuya 1977) or indeed without necessarily being craft specialists of any kind. Some researchers have noted regional standardization in stone-axe forms in New Guinea where axe manufacture was apparently not carried out by craft specialists, and they have attributed this uniformity to cultural or traditional standards (Hughes 1977:154, 174–176; Strathern 1969:314–315). However, the possible effects of other factors such as the intended functions of the finished tools and characteristics of the raw materials used to make axes are often dif-

ficult to separate from the effects of stylistic norms (Hughes 1977:145, 171–176; Phillips 1979:112).

Adze use and function. It is possible that there were functional requirements of finished adzes which made tangling and rectangular cross sections preferred adze characteristics. This may be particularly applicable in the case of tangling, which could have facilitated hafting or at least enabled certain types of hafting. In a study of New Guinea axes, Hughes (1977:174) mentions that shouldered tangs were probably “aids to gripping” in the axe haft.

There is little information in the archaeological, experimental, and ethnographic literature on adzes regarding the possible functional significance of various cross-section forms. For New Guinea axes, Hughes recorded a number of measurements intended to describe stone-axe shape, including the cross-section form; he concluded that axe shape was probably not related to any aspects of adze use or function, given that a variety of axe types seem to have been used for the same general purposes throughout New Guinea (1977:151–154, 160, 174–175). The same argument would seem to apply to the variety of adze cross-section forms found throughout the Pacific (Leach 1981:168).

Effects of raw material. The form of the raw material used to manufacture adzes may have influenced the cross-section types adze-makers were able or inclined to produce. A number of researchers have noted that tabular or blocky raw material is particularly amenable to the manufacture of adzes with rectangular cross sections (Burton 1985:90,123; Cleghorn 1982:211; Hughes 1977:171; Jones 1984; Leach 1981:169). Tabular material is found in part of the Mauna Kea adze quarry where a large percentage of Hawaiian adzes were apparently produced (chapter 3). In discussing this fact, Leach suggested that the dominance of rectangular cross sections in Hawai'i “may be attributed to the form in which the raw material occurs” (1981:169). Cleghorn proposed that adze-makers deliberately sought out tabular material at Mauna Kea because it was relatively easy to use such stone to produce rectangular adzes (1982:211–212).

The presence of tabular material may have encouraged or facilitated the production of rectangular adzes at at least some locations in Hawai'i, but it is unlikely that raw material form was the sole or even main determinant of cross-section type. Rectangular adzes were apparently produced from

nontabular, quarried flake blanks in other parts of the Mauna Kea adze quarry (Cleghorn 1982), and rectangular adzes were apparently made from various forms of raw material at other quarries in the Hawaiian Islands as well (Dye, Weisler, and Riford 1985). For New Guinea axes, Hughes noted that, when desired, particular axe shapes could be imposed on a variety of raw material forms, and he concluded that difference in raw material was probably not a significant factor in explaining differences in adze shape (1977:171–174).

ADZE SIZE

Descriptive statistics including the mean, standard deviation, skewness, kurtosis, range, and minimum and maximum values were computed for the measurements of adze length, thickness, weight, cutting edge width, midsection width, and butt width (table 5.7). Computations were made by using the program Condescriptive in the *Statistical package for the Social Sciences* (Nie et al. 1975:181–193).

In the case of length, thickness, and weight, standard deviations are quite large in relation to the mean (table 5.7); standard deviations for length and thickness are approximately half the size of the mean and in the case of adze weight, the standard deviation is larger than the mean. This indicates that there is a wide dispersion of values for length, thickness, and weight. The range in values for length, width, and thickness is also quite large (table 5.7); this is particularly true for length, which ranges from a minimum of 3 cm to a maximum of 17 cm, and for weight, which ranges from 4 to 335 g.

Thus there seems to be a great deal of heterogeneity in adze length, thickness, and weight. However, positive values for skewness and kurtosis (table 5.7) indicate that measurements are not normally distributed. Instead, most of the length, thickness, and weight measurements are less than the mean and concentrated within a fairly narrow range of values; in each case, there are a few extreme values that are much larger than the mean.

The three width measurements include midsection, cutting edge, and butt width. Here standard deviations are not as large in comparison to the mean as they are for length, thickness, and weight; they are approximately one-third the size of the mean. This indicates somewhat less heterogeneity or dispersion of values than for measurements of adze length, thickness, and weight. Values for skewness and kurtosis indicate more normal distributions than those for length, thickness, and weight (table 5.7).

Table 5.7
Descriptive statistics for adze measurements

Variable	n	Mean	Std dev	Skewness	Kurtosis	Range	Min	Max
Length, cm	30	6.98	3.24	1.63	2.41	13.66	3	17
Thickness, cm	101	1.50	0.74	1.09	1.86	4.05	0	4
Weight, g	25	79.64	100.15	1.69	1.70	330.50	4	335
Midsection width, cm	27	2.43	0.81	0.93	-0.10	2.86	1	4
Cutting-edge width, cm	42	2.58	0.89	0.32	-0.13	4.27	1	5
Butt width, cm	48	2.11	0.76	0.61	0.12	3.38	1	4
Bevel angle, degrees	64	52.66	8.91	0.03	0.06	45.00	30	75

Table 5.8
Descriptive statistics by time period

	n	Mean	Std dev	Skewness	Kurtosis	Range	Min	Max
Length, cm								
before AD 1650	8	7.89	4.32	1.54	2.02	12.86	4	17
after AD 1650	8	5.55	2.07	1.50	3.28	6.80	3	10
Long sequence	13	7.18	3.12	1.60	1.89	10.59	4	14
All*	30	6.98	3.24	1.63	2.41	13.66	3	17
Thickness, cm								
before AD 1650	15	1.29	0.72	1.33	0.64	2.33	1	3
after AD 1650	24	1.61	0.76	0.88	1.32	3.40	0	4
Long sequence	55	1.52	0.76	1.15	2.53	4.05	0	4
All*	101	1.50	0.74	1.09	1.86	4.05	0	4
Weight, g								
before AD 1650	7	111.09	130.61	1.13	-0.35	323.80	11	335
after AD 1650	8	41.85	51.83	2.56	6.89	162.90	4	167
Long sequence	10	87.85	105.70	1.76	2.32	313.00	16	329
All*	25	79.64	100.15	1.69	1.70	330.50	4	335
Midsection width, cm								
before AD 1650	7	2.79	0.96	0.62	-1.66	2.38	2	4
after AD 1650	6	1.95	0.35	-0.06	-0.55	0.97	1	2
Long sequence	13	2.42	0.83	0.84	-0.08	2.55	1	4
All*	27	2.43	0.81	0.93	-0.10	2.86	1	4
Cutting edge, cm								
before AD 1650	12	2.68	0.74	-0.39	0.29	2.58	2	4
after AD 1650	7	2.08	0.49	0.43	-0.54	1.37	2	3
Long sequence	20	2.50	0.93	-0.01	-0.61	3.45	1	4
All*	42	2.58	0.89	0.32	-0.13	4.27	1	5
Butt width, cm								
before AD 1650	8	2.39	0.92	1.25	-0.22	2.26	2	4
after AD 1650	14	2.22	0.72	0.33	-0.84	2.28	1	3
Long sequence	23	1.90	0.75	0.72	0.88	3.10	1	4
All*	48	2.11	0.76	0.61	0.12	3.38	1	4
Bevel angle, degrees								
before AD 1650	14	54.64	11.51	0.37	-0.88	35.00	40	75
after AD 1650	13	50.00	10.00	-0.37	-0.31	35.00	30	65
Long sequence	33	52.73	7.41	-0.19	0.20	35.00	35	70
All*	64	52.66	8.91	0.03	0.06	45.00	30	75

*Includes undated adzes

Table 5.8 presents descriptive statistics for adzes from sites dated to before AD 1650, after AD 1650, and for those with long sequences of dates. In all three temporal categories, the general characteristics of the descriptive statistics are the same as those described above for the entire population of adzes analyzed. In all categories, standard deviations for length, thickness, and weight are large in comparison to the mean, and the range in length and weight is quite large as well, indicating heterogeneity or dispersion of measurements. Positive values for skewness and kurtosis indicate nonnormal distributions in which most measurements are less than the mean, and a few are relatively large. For width measurements in each category, standard deviations are not as large in comparison to the mean; measurements are more normally distributed than those for length, thickness, and weight.

Descriptive statistics do not show differences in the degree of homogeneity between adzes dated to before AD 1650 and those dated to after AD 1650; there is also no apparent difference in the degree of homogeneity for adzes from sites with long sequences of dates. This suggests that there was no change in degree of homogeneity between these broadly defined time periods.

Frequency Distributions

The number of adzes in various length, thickness, weight, and width categories was determined using the program Frequencies in the *Statistical package for the Social Sciences* (Nie et al. 1975:194–202). For length, thickness, and weight, frequency distributions clearly illustrate (table 5.9) that most adzes are restricted to a fairly narrow size range and are relatively small. For example, among the thirty complete adzes for which length could be measured, the average length is approximately 7 cm, but most adzes (63 percent) are less than 7 cm long. In the case of weight, the mean is 80 g; however, most (68 percent) adzes weigh less than 50 g. There are, however, a few extremely large artifacts, including one adze that is more than 15 cm long and two adzes that weigh more than 300 g each.

For cutting edge, midsection, and butt width, measurements are distributed somewhat more evenly around the mean, and frequency distributions are lacking the extremely large values found in the case of length and weight (table 5.9). This is particularly true for midsection width, where there are really no extremely large measurements that are clearly distinct from the rest of the values in the

Table 5.9
Frequency distributions for adze measurements

	Frequency	Percent	Cumulative %
Length, cm			
< 5	6	20.0	20.0
5–6.99	13	43.3	63.3
7–8.99	6	20.0	83.3
9–10.99	1	3.3	86.7
11–12.99	2	6.7	93.3
13–14.99	1	3.3	96.7
> 15	1	3.3	100.0
Total	30		
Thickness, cm			
< 1	29	28.7	28.7
1–1.99	51	50.5	79.2
2–2.99	8	17.8	97.0
> 3	3	3.0	100.0
Total	101		
Weight, g			
< 50	17	68.0	68.0
50–99.99	2	8.0	76.0
100–149.99	1	4.0	80.0
150–199.99	1	4.0	84.0
200–249.99	1	4.0	88.0
250–299.99	1	4.0	92.0
> 300	2	8.0	100.0
Total	25		
Midsection width, cm			
< 2	8	29.6	29.6
2–2.99	12	44.4	74.1
> 3	7	25.9	100.0
Total	27		
Cutting edge, cm			
< 2	11	26.2	26.2
2–2.99	17	40.5	66.7
3–3.99	11	26.2	92.9
> 4	3	7.1	100.0
Total	42		
Butt width, cm			
< 2	25	52.1	52.1
2–2.99	17	35.4	87.5
> 3	6	12.5	100.0
Total	48		
Bevel angle, degrees			
< 40	2	3.1	3.1
40–49.99	13	20.3	23.4
50–59.99	26	40.7	64.1
> 60	23	35.9	100.0
Total	64		

distribution. There are a few adzes with a cutting-edge width greater than 4 cm or butt width greater than 3 cm, but the discontinuity between these large values and the remainder of the measurements in the distributions is not as marked as in the case of

Table 5.10
Identification of extreme values in adze measurements

Site	Condition	Length, cm	Thickness, cm	Weight, g	Cutting edge, cm	Butt width, cm
197	Complete	16.86*	2.95	334.60*	3.31	3.98*
1349	Complete	14.38*	3.10*	328.70*	4.00*	3.48*
H8	Complete	12.94*	2.46	224.20*	3.95	3.70*
197	Complete	11.56*	2.95	250.00*	4.08*	3.68*
262	Complete	10.00*	2.50	167.00*	--	2.50
D4-51	Complete	7.37	2.27	111.50*	3.50	2.44
H1	Complete	8.10	2.80	99.88*	3.10	2.22
H1	Complete	7.86	1.82	72.30*	2.85	2.15
H1	Bevel	--	4.40*	--	--	--
B-105	Bevel	--	1.90	--	4.82*	--
7702	Midsection	--	3.80*	--	--	--
7702	Butt	--	2.40	--	--	3.43*
7702	Butt	--	--	--	--	3.41*

*Denotes unusually large measurement.

length, thickness, or weight.

Table 5.10 lists the specific artifacts with comparatively large measurements for length (more than 9 cm), thickness (more than 3 cm), weight (more than 50 g), cutting-edge width (more than 4 cm), and butt width (more than 3 cm). Only thirteen adzes, or approximately 10 percent of those analyzed, account for all the very large values in the frequency distributions. All of the adze dimensions as well as adze weight are interrelated variables that should tend to covary; it can be assumed that the larger an adze is in one dimension the larger it is likely to be in others and the more it will weigh.

Frequency distributions were constructed for the adzes from sites dated to AD 1650, after AD 1650, and for those which had long sequences of dates (table 5.11). Because of the small sample sizes for some time periods and/or size categories, the number of size categories is less for most measurements than in the frequency distributions for the entire population of adzes discussed above. However, sample sizes are still quite small; a difference of even one adze can cause visible differences in the percentage of adzes within a particular size category. In spite of this, however, the frequency distributions for adzes from sites dated to before AD 1650, after AD 1650, and for those with long sequences are very similar to each other and to the overall distribution of adze measurements. In terms of length and weight, most adzes in each temporal category are less than 7 cm long and weigh less than 50 g, but a few are comparatively large. For width measurements, values are distributed somewhat more evenly around the mean.

Degree of Homogeneity and Craft Specialization
 It is difficult to characterize the adzes analyzed here

as either homogeneous or heterogeneous in size. There are a few adzes with extremely large dimensions; this is particularly applicable in the case of length and weight but true to some extent for thickness, cutting-edge width, and butt width as well. Most adzes are comparatively small and fall within a fairly narrow size range; it could be argued that there is at least a moderate degree of homogeneity in adze size.

However, there is no evidence to suggest that adzes became any more homogeneous in size over time, which would be expected if specialization with standardization in adze production had developed as a part of increasing cultural complexity in Hawai'i. Descriptive statistics and frequency distributions for adzes dated to before AD 1650, after AD 1650, and for those from sites with long date sequences show that adze measurements were distributed in basically the same way throughout. There is currently no evidence that Hawaiian adzes were the product of attached craft specialization.

Factors other than craft specialization are probably more important in explaining the degree of homogeneity in adze size that does exist, the presence of some extremely large adzes, and the fact that adze length and weight measurements are less normally distributed than other measurements. These factors include possible functional differences between adzes of different sizes, bias in the context of adze finds, and resharpening of adzes, which affected the measurements used in this analysis.

Adze size and function. Adzes of various sizes may have been deliberately manufactured because tools of a particular size were required or at least preferred for certain activities. Ethnographic and experimen-

Craft Specialization and Homogeneity in Finished Adzes

Table 5.11
Frequency distributions by time period

	Frequency				Percentage			
	All*	-1650	+1650	Long sequence	All*	-1650	+1650	Long sequence
Length, cm								
< 7	19	4	7	8	63.3	50.0	87.5	61.5
7-8.99	6	2	0	3	20.0	25.0	0.0	23.1
> 9	5	2	1	2	16.6	25.0	12.5	15.4
Total	30	8	8	13	100.0	100.0	100.0	100.0
Thickness, cm								
< 2	80	12	18	43	79.2	80.0	75.0	78.2
2-2.99	18	3	5	10	17.8	20.0	20.8	18.2
>3	3	0	1	2	3.0	0.0	4.2	3.6
Total	101	15	24	55	100.0	100.0	100.0	100.0
Weight, g								
< 50	17	4	7	6	68.0	57.1	87.5	60.0
>50	8	3	1	4	32.0	42.9	12.5	40.0
Total	25	7	8	10	100.0	100.0	100.0	100.0
Midsection width, cm								
<2	8	1	3	4	29.6	14.3	50.0	30.8
2-2.99	12	3	3	6	44.4	42.9	50.0	46.2
>3	7	3	0	3	25.9	42.9	0.0	23.1
Total	27	7	6	13	100.0	100.0	100.0	100.0
Cutting edge, cm								
< 2	11	2	3	6	26.2	16.7	42.9	30.0
2-2.99	17	6	4	7	40.5	50.0	57.1	65.0
3-3.99	11	3	0	6	26.2	25.0	0.0	30.0
>4	3	1	0	1	7.1	8.3	0.0	5.0
Total	42	12	7	20	100.0	100.0	100.0	100.0
Butt width, cm								
< 2	25	5	6	14	52.1	62.5	42.9	60.9
2-2.99	17	1	6	7	35.4	12.5	42.9	30.4
>3	6	2	2	2	12.5	25.0	14.3	8.7
Total	48	8	14	23	100.0	100.0	100.0	100.0
Bevel angle, degrees								
< 50	15	3	5	6	23.4	21.4	38.5	18.2
50-59.99	26	5	4	16	40.6	35.7	30.8	48.5
>60	23	6	4	11	35.9	42.9	30.8	33.3
Total	64	14	13	33	100.0	100.0	100.0	100.0

*Includes undated adzes

tal data indicate that this was true in at least some cases although the actual dimensions of the tools used for certain tasks are rarely specified. In part of New Guinea, for example, stone axes of three different sizes were apparently used. Large tools were used in clearing land for settlements and gardens and in

felling trees for house timbers and other construction projects; medium and small axes were used in the manufacture of canoes, shields, drums, and other items of wood (Townsend 1969:200). In the Trobriand Islands, axes of different sizes were deliberately intended for particular tasks. Larger, heavier axes were

used to fell trees for canoes, and several types of smaller tools were used in house and canoe construction; another type of axe was used for garden clearing (Clark 1965:18–19; Malinowski 1934). Experimental studies on the use of stone axes indicate that small tools are not particularly efficient in felling trees but are suitable for general carpentry (Harding and Young 1979:105).

Ethnohistoric accounts provide some information on the various uses of stone adzes in Hawai'i. In their description of Hawaiian agriculture, Handy and Handy (1972:28) say that "large stone adzes" (*ko'i lipi*) were used to cut timber for houses and canoes; they were also used to remove large trees when clearing land for agriculture although fire was also used in land clearance. Kamakau (1976:23) names several different types of "axes," "adzes," and "planes," including the *ko'i lipi* mentioned by Handy and Handy, but he does not specify the particular uses of each type. He says that, in general, these tools were used in obtaining wood for canoes, houses, fences, and other purposes. It is unclear to what extent adzes were used in agricultural clearance. In one account, Kamakau implies that adzes were probably not used for clearing; he says, "Fire was a man's plow and his clearing implement. With his hands he softened the earth, weeded, raked, and spaded with only the help of a wooden digging stick" (1976:23). In another account, however, Kamakau says, "With their hands alone, assisted by tools made of hard wood from the mountains and by stone adzes, they tilled large fields" (1961:237). Malo describes in some detail the use of adzes in felling trees and in the construction of canoes, houses, and temples (1951:78, 118–126, 126–135, 165). He does not indicate that adzes were used in agricultural clearance.

Clearing land was a primary function of stone axes in New Guinea (Steensburg 1980) and other areas (Clark 1945, 1947), but they may not have been used as extensively for this purpose in Hawai'i (McCoy 1990:112). The various forms of Hawaiian agriculture may not have required as much actual clearing of land as the shifting cultivation systems of New Guinea and elsewhere; if land was cleared, the use of fire may have been preferred. If most Hawaiian adzes were not intended for use in agricultural clearing or other heavy work, this could explain why most of the adzes analyzed are relatively small; most may have been used in the construction of canoes and other items of wood.

Bias in the context of adze finds. The distribu-

tion of adze sizes discussed in this analysis is skewed so that most adzes are relatively small and a few are extremely large; as discussed above, this may be explained by the fact that only a few Hawaiian adzes were made for heavy work such as clearing land. However, the types of sites from which the adzes for this study were originally obtained may also have influenced the adze sizes and uses represented. Most of the sites from which the adzes were recovered are coastal habitation sites where such activities as canoe manufacture, which required smaller tools, would probably have been carried out; such activities as agricultural clearing and felling of trees, which required larger tools, would have taken place away from the coast in garden and forest areas. Ethnographic evidence from New Guinea indicates that when tools came loose from the haft or were otherwise broken during agricultural clearing they were usually lost or abandoned in the forest away from settlements (White and Modjeska 1978). In short, larger Hawaiian adzes used in felling trees and agricultural clearing may be underrepresented in the archaeological collection used for this study simply because they did not tend to be lost or discarded at coastal habitation sites.

Adzes as valuables. It is possible that the comparatively rare large adzes were used as ceremonial items and/or as valuables in transactions of various kinds. In New Guinea, ceremonial axes were often distinguished from work axes. They were larger than work tools and were sometimes highly polished and elaborated in form. Ceremonial axes were considered valuables that could be used in bride price and other payments, as offerings in formal exchange ceremonies, and as gifts in a variety of situations; men also wore or displayed the axes in battle, at ceremonies, and on other occasions. Some ceremonial axes were so large and elaborate and/or hafted in such a way that they were useful only for display, but others were sometimes used as weapons (Burton 1985:137–161, 200–202; Hughes 1977:132–183; Phillips 1979; Strathern 1965, 1969; Vial 1940).

Ethnohistoric accounts do not seem to indicate that Hawaiian adzes were explicitly used as valuables or ceremonial items. Malo refers to adzes as "possessions of value," but in at least some cases he seems to use this expression to refer to items that were simply useful or essential in a practical sense. In the same passage, for example, he also lists such utilitarian items as houses, fishing lines, fish nets, and rope among the valued possessions of the Ha-

waiian people. He describes the uses of adzes in canoe-making, house construction, and other tasks, but does not refer to their use in any nonutilitarian contexts (1951:76–81). Other information is somewhat more suggestive regarding the possible ceremonial significance of adzes. Malo indicates that the adzes used to obtain timber for the construction of idols were consecrated by the priests or *kahuna* (1951:165); he also describes the use of adzes by *kahuna* in felling trees for canoes (1951:127) and in ceremonies associated with house building (1951:124). However, he does not indicate that the adzes consecrated or used by the *kahuna* were considered distinctive in any way from those ordinarily used for similar tasks. It is also unclear whether the *kahuna* Malo describes in every case were actually religious specialists or other specialists such as canoe builders; the term *kahuna* is somewhat ambiguous and can be used to refer to a variety of specialists or experts (Hommon 1976:208–209; Pukui and Elbert 1973:106; Sahlins 1958:115–116).

Archaeological evidence for ceremonial adzes is lacking or inconclusive. Some of the adzes in the sample analyzed here are relatively large, but none are so large that they are not functional; the large adzes are not distinctive in terms of their degree of polish or their shape or form. It is unclear whether adzes used as valuables or ceremonial items would necessarily be recovered from different archaeological contexts than adzes used for everyday tasks, but the sites from which the comparatively large adzes in this study were recovered are not unusual.

There are some very large adzes in the collections of the Bishop Museum; further research on adze size and the possible nonutilitarian uses of adzes should be conducted. The largest complete adze analyzed for the research described in this chapter is 17 cm long, and most of the adzes analyzed are only 5 to 7 cm in length. At the Bishop Museum, however, there are well over one hundred adzes that exceed 20 cm in length, and some of these are more than 30 cm long. All of these large adzes were donated to the Museum; some are known to have been collected from archaeological sites, but many were simply purchased or otherwise acquired by the donors, and their original context is unknown. None of these large adzes are unusual or ornate in appearance or obviously nonfunctional, and at least some were apparently used because they show signs of use, wear, and breakage.

Such large adzes may simply represent tools that are missing from the archaeological assemblages

examined in this research because they were used for agricultural clearing and are not recovered from coastal habitation sites. On the other hand, they may be missing from archaeological assemblages because they were valuables or family heirlooms that were kept, passed on from one generation to the next, and eventually lost, given away, sold, and/or donated to the Bishop Museum. It should also be kept in mind that the donated adzes in the Bishop Museum are a skewed sample of their own kind. Unusually large and impressive adzes are precisely the kinds of artifacts that, whatever their original use, would be noticed and acquired by various kinds of artifact collectors and eventually given to the Museum. Thus, it is impossible to say how common these large adzes would ever really be in archaeological assemblages.

Effects of resharpening. After manufacture, all adzes were subject to modification in size and shape through continual resharpening. Ethnographic evidence indicates that New Guinea axes had a use-life of about one and one-half years (Salisbury 1962:149); over this time resharpening could reduce them to as little as one-third of their original weight (Townsend 1969:200). Used-up axes were found in settlements where lost or discarded tools were subject to continuous recovery and recycling by successive owners until they were too small or too damaged for further use. This suggests that artifacts which enter the archaeological record by being discarded at habitation sites may not accurately reflect the sizes of the original tools or the original range in tool size (White and Modjeska 1978; Hodder and Lane 1982:216).

Like New Guinea axes, the adzes considered in this analysis probably represent tools that were repeatedly resharpened and eventually discarded when they were too small. This could help to explain not only why most of the adzes are relatively small but also why size measurements for the small adzes tend to be restricted to a fairly narrow range. Before use and resharpening, adzes could still have been primarily small- to medium-sized tools intended for use in woodworking activities, but there may have been a larger range in size than that represented by the artifacts analyzed for this study. Continual resharpening could have ultimately resulted in a fair degree of homogeneity in adze dimensions as all tools eventually reached a critical size at which they were no longer useful or functional. Most adzes may have been discarded, for example, when they were

less than 7 cm in length and/or weighed less than 50 g. This could explain, at least in part, why most of the adzes in the sample considered here are less than 7 cm in length and less than 50 g in weight.

The tendency for adzes to measure less than the mean and to be concentrated within a narrow range of values is more marked in the case of length and weight than for width and thickness. This could also be explained by the incidence of resharpening. While no doubt reducing the overall size of an adze, resharpening at the bevel end would have altered primarily the length of the tool. Since length is the largest adze dimension, adze weight is highly dependent on length. Resharpening would also have had a major effect on bevel angle, and this is discussed below.

BEVEL ANGLE

Descriptive statistics including the mean, standard deviation, skewness, kurtosis, range, minimum, and maximum were computed for bevel angles on sixty-four complete and partial adzes (table 5.7). These statistics were computed using the program Condescriptive in the *Statistical package for the Social Sciences* (Nie et al. 1975:181–193).

Bevel or cutting-edge angle ranges from 30 to 75 degrees with a mean of approximately 53 degrees. The standard deviation of approximately nine is not large in comparison to the mean. Values for skewness and kurtosis are near zero, indicating that there is a nearly normal distribution of values for bevel angle. Thus, descriptive statistics do not seem to indicate an unusually high amount of homogeneity or heterogeneity in bevel angle.

This is basically true for each temporal category as well. Standard deviations are not large in comparison to the mean, and skewness and kurtosis values indicate near-normal distribution of measurements around the mean (table 5.8). There seems to be no change in the degree of homogeneity in bevel angle over time; again, however, some sample sizes are quite small, and only broadly defined time periods were considered.

Frequency Distribution

A frequency distribution for bevel-angle measurements was constructed (table 5.9) using the program Frequencies in the *Statistical package for the Social Sciences* (Nie et al. 1975:194–202). The frequency distribution for bevel angle shows that most of the adzes (77 percent) have angles greater than 50 degrees. Frequency distributions were also constructed (table

5.11) for adzes from sites by time period. Because of the small sample sizes, the number of categories for bevel angle measurements was reduced. In all three temporal categories, most adzes (60 to 80 percent) have bevel angles larger than 50 degrees.

Degree of Homogeneity and Craft Specialization

In general, bevel-angle measurements are normally distributed suggesting that the adzes considered in this analysis are neither markedly homogeneous nor heterogeneous in terms of cutting-edge angle. This is true overall and for each of the three temporal categories discussed in this chapter. However, frequency distributions show that within a range of 30 to 75 degrees approximately 75 percent of the adzes have bevel angles larger than 50 degrees, and this suggests some degree of homogeneity in bevel angle.

Again, however, this apparent homogeneity is probably not indicative of craft specialization because there is no current evidence to suggest that adzes became any more homogeneous in terms of bevel angle over time. Perhaps more importantly, however, there are factors other than craft specialization that probably affected the bevel-angle measurements used in this analysis: possible functional differences between tools with different cutting-edge angles, and most significantly the resharpening of finished adzes.

Bevel angle and adze function. Adzes with different bevel angles may have been intentionally manufactured and perhaps even maintained through resharpening because particular cutting-edge angles were suitable for different tasks. In his study of New Guinea axes, Hughes (1977:175–176) indicates that different cutting-edge angles were preferred for different activities; other characteristics of the cutting edge such as its thickness and degree of symmetry were also important.

Effects of resharpening. Resharpening was specifically directed at reworking and modifying the cutting edge of an adze. In some cases, resharpening may have been carried out in an attempt to maintain as closely as possible the original cutting-edge angle of a particular tool; at other times, especially when adzes were repaired because of breakage, resharpening may have resulted in a very different bevel angle. In any case, bevel angles were undoubtedly altered by continuous resharpening. In New Guinea, Hughes (1977:162, 164) noted that, as distance from their source increased, axes tended to

become smaller and to have more obtuse bevel angles; he attributed these changes to intensive resharpening and reuse in areas where stone axes were scarce.

The tendency for adzes to become smaller and to have more obtuse bevel angles as the result of resharpening may also be apparent at Hawaiian habitation sites like those considered in this analysis. As discussed above, adzes were more likely to have been resharpened, reused, and ultimately discarded at coastal habitation sites. Discard may have occurred when they were no longer large enough for further use, but another factor in the decision to discard an adze may have been the cutting-edge angle. Most adzes may have been discarded when the cutting-edge angle exceeded 50 degrees, and it was difficult or impossible to resharpen the adze for continued use.

The fact that none of the complete adzes in the sample analyzed here had bevel angles less than 50 degrees (table 5.12) may be indicative of patterns of resharpening and discard. Approximately 25 percent of all artifacts for which the bevel angle could be measured had cutting-edge angles of less than 50 degrees, but these artifacts are all incomplete or broken adzes. They may have been discarded because they were broken beyond repair before they had been resharpened to the same extent that the complete adzes eventually were.

HOMOGENEITY AND CRAFT SPECIALIZATION

Most of the adzes analyzed for this study (75 percent) are tanged, and most (90 percent) are rectangular in cross section. Thus, there is a great deal of homogeneity in profile and cross-section form. Statistical analyses show that the distributions of measurements for adze length, weight, and thickness and to some extent cutting edge, midsection, and butt width are skewed; there are a few comparatively large adzes, but most adzes are relatively small and fall within a fairly narrow size range suggesting a degree of homogeneity in adze size as well.

However, this homogeneity in finished adzes is probably not indicative of attached craft specialization. There is no evidence that adzes became increasingly standardized in form or size over time, as would be expected if specialization had developed together with other aspects of cultural complexity in Hawai'i. Furthermore, homogeneity in finished artifacts is not always associated with attached craft specialization. It may accompany specialization in circumstances in which mass production is advan-

tageous but will probably not accompany the production of luxury or wealth items. The question of whether any Hawaiian adzes were produced as luxury or wealth items is a significant one. There is currently no ethnohistoric or archaeological evidence for the manufacture or use of adzes as valuables of any kind, but further research should be conducted.

The nature of the specific craft industry being investigated also determines whether homogeneity is an appropriate indicator of specialization because many factors other than type and degree of specialization can affect the degree of uniformity in finished goods. There are many such factors which probably cause Hawaiian adzes to be relatively homogeneous. For profile and cross-section form, these factors include stylistic norms unrelated to craft specialization, the functional requirements of finished tools, and characteristics of the raw material used to manufacture adzes. Specifically, cultural standards regarding the form of finished adzes could have resulted in the production of highly standardized tools. Furthermore, tanging may have been a preferred adze characteristic because it facilitated hafting of the finished tool, and rectangular cross sections may have been more easily manufactured from tabular raw material found at some adze-manufacturing sites and, specifically, the major Mauna Kea quarry.

For adze size, there are a number of factors other than craft specialization which could explain the distribution of adze size measurements found in this analysis. First, adzes of particular sizes may have been deliberately made for use in particular activities. Most Hawaiian adzes may have been used in tasks such as canoe-making that required relatively small woodworking tools. It is difficult to assess the validity of this suggestion, however, because of possible bias in the types of sites from which the adzes used in this study were originally obtained. Specifically, most of the adzes were excavated from coastal habitation sites where larger tools used in agricultural clearing or cutting timber were probably less likely

Table 5.12
Bevel angle frequencies for complete and incomplete adzes

	Complete adzes		Incomplete adzes	
	Frequency	%	Frequency	%
<40 degrees	0	0.0	2	4.5
40-49.99	0	0.0	13	29.5
50-59.99	13	65.0	13	29.5
>60	7	35.0	16	36.4
Total	20	100.0	44	100.0

to have been used, lost, or discarded.

Even if most Hawaiian adzes were originally small tools designed for particular tasks, they were reduced in size over time through reuse and resharpening. Perhaps more importantly, the range of variability in size was also reduced. Regardless of their original dimensions, adzes that reached a size beyond which they were no longer useful were discarded, leaving a fairly homogeneous sample of used-up adzes at habitation sites. The small number of comparatively large adzes found at these sites may represent tools used in such activities as agricultural clearing which were occasionally stored or cached at habitations.

The most important conclusion of this analysis is probably that homogeneity or standardization in finished tools is not necessarily an indicator of craft specialization. This is particularly true in the case of adzes, which can be designed for specific activities and have a long use-life during which they are subject to constant modification through reuse and resharpening. They also tend to be recovered from contexts of repair and discard rather than actual use. Analysis of adze fragments from Hawaiian sites verifies that repair and resharpening were commonly carried out and that adzes were often lost or discarded at habitation sites (Withrow 1991:189-237).

Chapter 6

Implications for the Development of Chiefdoms

Service's adaptationist hypothesis for the development of cultural complexity and Earle's politically oriented response represent important approaches to the development of cultural complexity. However, neither approach has been adequately tested with archaeological data, particularly for Hawaiian chiefdoms upon which their conclusions are based. This research has used archaeological evidence to examine the question of whether one differentially available item in Hawai'i, stone adzes, was the focus of centralized redistribution and/or specialized production during Hawaiian prehistory, as implied in Service's adaptationist hypothesis and rejected in Earle's political approach.

REDISTRIBUTION

According to standard spatial distribution models, the data on adze distribution from the island of Hawai'i seem to indicate centralized redistribution; adzes from various sources seem to be widely distributed and to show no clear falloff in abundance with increasing distance from their sources. In other words, direct access and down-the-line exchange are not indicated by the widespread unsystematic distribution of the various adze stone types, and some sort of centralized system that ensured distribution of all material types to all parts of the island of Hawai'i is suggested.

However, distance decay models cannot be uncritically applied to every situation and, for several reasons, are not well suited for interpreting the Hawaiian data presented here. First, because adzes are manufactured at sources of stone and not at habitation sites, the relative abundance of manufacturing debris from various sources within households

or communities cannot be measured as it is in most exchange studies. The regional occurrence of adzes from various sources can only be studied by sourcing finished adzes recovered at habitation sites, but adzes are portable tools with a long use-life and could have been lost, broken, or discarded at locations that do not closely reflect where or how they were originally acquired.

In addition, there are several geographical factors that make predictions involving distance decay inappropriate: the probability of sea travel along the coast of the island of Hawai'i, the relatively short land or sea distances involved in traveling from any adze quarry to any other location on the island, and the central location of the largest source, the Mauna Kea quarry.

Other data produced by this research can be used to argue against the existence of a centralized or redistributive system involving adzes or adze stone. First, the apparent use of many local sources in addition to the Mauna Kea quarry suggests that there was not a centralized, far-reaching system of distribution, or else a greater reliance on the large Mauna Kea source would probably be seen. Sometimes high-quality materials may be centrally distributed while others are not, but there is no evidence to suggest that the distribution of Mauna Kea material ever differed significantly from the distribution of other materials. Furthermore, there is no change over time in the distribution patterns of any of the materials, and such change would certainly be expected if centralized control of stone resources accompanied or developed with the increases in cultural complexity that have been documented for Hawaiian chiefdoms.

The distribution of adze stone, or more accurately adze preforms, on the island of Hawai'i was probably accomplished through informal, interpersonal exchange and/or direct trips to various quarries facilitated by easy sea travel, short travel distances, and also the typically dispersed Hawaiian settlement patterns that required or encouraged mobility on the part of individuals. The nature of the adze stone resource itself would have been well suited to informal and occasional acquisition. Unlike obsidian, adze stone was not acquired as a raw material that could be put to varied uses but rather as nearly finished, specific-purpose tools that had a relatively long use-life and were not highly portable or storable if amassed for some sort of more formal or regulated distribution. Occasional trips to quarries or exchange with other individuals was probably the most efficient and effective way to acquire adzes.

In conclusion, archaeological evidence from the island of Hawai'i does not support the idea that redistribution of necessary resources like adzes or adze stone was a key factor in the development of complex chiefdoms in Hawai'i. This is consistent with Earle's notion of a subsistence economy with reciprocal, informal exchange systems that was distinct from the political economy within which chiefs would mobilize resources for their own support. However, as tools used in such tasks as agricultural clearing, house construction, and canoe-making, adzes could have played an interesting role in both aspects of the Hawaiian economy. Certain aspects of their production or use may have occurred within the political sphere, and in particular they could have been produced and/or used by craft specialists involved in chiefly projects.

CRAFT SPECIALIZATION

Often, standardization in manufacturing techniques, high productivity, high success rate, and high degree of skill in manufacture are assumed to be indicators of craft specialization and, in particular, attached craft specialization. In this research, degree of adze-making skill, productivity, and standardization in manufacturing techniques were assessed for the Pololū adze-manufacturing site and comparisons made to similar analyses already conducted for the Mauna Kea quarry (Cleghorn 1982). It is commonly assumed that attached specialists or at least craft specialists of some kind worked at the large Mauna Kea quarry while somehow less specialized adze-makers worked at smaller sites like the Pololū adze-manufacturing site. There are no clear-cut differences,

however, between the Mauna Kea and Pololū sites in terms of apparent adze-making skill, adze production rate, successful adze completion rate, or degree of standardization in manufacturing techniques.

There are differences between the two sites in the form of raw material used because adzes at Mauna Kea were often made from tabular pieces of stone, whereas adzes at Pololū were manufactured from flake blanks. There are also differences in the stages of manufacture carried out at the two sites: at Mauna Kea adzes were apparently nearly finished before being taken away from the site, while adzes were removed from Pololū after only the early stages of manufacture. These differences are not attributable to differences in craft specialization but rather to availability of particular forms of raw material and logistical factors that made it easier to remove partially completed adzes from Pololū than from Mauna Kea. The differences in the form of raw material used and stages of manufacture carried out are relevant to the issue of craft specialization, though, because such differences can significantly affect how and how well adzes are manufactured and thus affect the calculation and interpretation of supposed indicators of craft specialization.

Another possible indicator of attached craft specialization is standardization in finished artifacts, and the degree of homogeneity in Hawaiian adzes was also assessed in this research. However, in this case artifact uniformity is probably not a reliable indicator of attached craft specialization because there are many factors other than attached craft specialization that can affect the degree of homogeneity in adze form and size. These include cultural norms not related to craft specialization, the intended use or function of adzes of various shapes and sizes, and postmanufacturing processes, such as resharpening, that modify the shape and size of finished adzes. It is important that standardization or other supposed indicators of craft specialization are expectable in the particular industry being studied, and many conventional indicators of specialization do not apply well to adze manufacture.

A significant difficulty in finding and applying reliable indicators of craft specialization in any industry is caused by the fact that the concept of attached craft specialization is not well defined in many archaeological studies, and there is no consensus on what the concept of attached specialization implies. As originally defined by Earle (1981), attached specialization was the sponsored produc-

tion of wealth items which were put to political purposes by elite leaders. Others have described this sort of specialization as administered (Sinopoli 1988) or patronized (Clark and Parry 1990). It is debatable whether standardization, efficiency, and even skill are diagnostic of this kind of specialization in which elite leaders sponsor the production of luxury or wealth items for their own use. Sometimes, however, the term *attached specialization* is used to describe any production that is sponsored or supported outside of the household, which could include commercially oriented industries in which mass production and standardization might be expected (Clark and Parry 1990). In addition, there is often a failure to recognize that attached specialization is or can be anything other than mass production, and it is often implied that if craft specialization is sponsored by the elite, then it simply must be characterized by standardization and efficiency.

Furthermore, even though the distinction between attached and independent specialization is a useful one, attached specialization and independent specialization are ultimately ideal concepts. Focusing on this distinction obscures the fact that there are not only differences between independent and attached specialists but also differences between the specialized production of subsistence goods and of wealth items, between full-time and occasional specialists, and between regional specialization by a large group of people and specialization on the part of individuals. It is often assumed that attached specialization is typical of the production of wealth items by individuals supported within the political economy and incorporated into high-ranking households or retinues; independent specialization involves the production of necessities, perhaps on a community level, within the subsistence economy. In actuality, however, the many dimensions of craft specialization may combine with and crosscut each other to provide a number of different types of specialization, which may or may not be associated with particular kinds of archaeological evidence. No one kind of specialist and no one set of archaeological evidence regarding these specialists may fit the model of either attached specialization or independent specialization.

In the case of Hawaiian craft specialists, bird catchers seem to have been attached specialists in the sense that they were directed by the chiefs to gather feathers and that they contributed the results of their labor to the chiefs for political use; however, these specialists were apparently commoners who resided

within their own ahupua'a and were dispatched only occasionally by the chiefs, and it is unclear how or to what extent they were supported by the chiefs (Emerson 1895:102; Linnekin 1988:271).

In conventional terms, Hawaiian adze-makers were probably independent specialists or even non-specialists. The manufacture of adzes involved the production of utilitarian, nonwealth goods which, as this research suggests, was apparently not controlled or supervised by the chiefs. If, however, as suggested in ethnohistoric accounts, adze-makers sometimes made adzes for use in significant activities sponsored by the chiefs, these adze-makers may have been selected individuals with reputations for good workmanship. Some adze-makers may have been similar to the bird catchers discussed above, or in other words, commoners living within local communities who were occasionally employed to provide special items. Neither Hawaiian bird catchers nor the adze-makers fit the ideal model of either attached specialists or independent specialists.

ADAPTATIONIST AND POLITICAL VIEWPOINTS

Archaeological data suggest that Hawaiian stone adzes were not collected and redistributed by the Hawaiian chiefs and that Hawaiian chiefs did not direct the production of adzes by craft specialists during the development of Hawaiian chiefdoms. Thus, Earle's rejection of Service's hypothesis regarding redistribution and specialization seems to be upheld with archaeological evidence. In general, Earle's conclusion that the development of Hawaiian chiefdoms was based on the deliberate use of certain resources by the chiefs rather than centralized management of subsistence activities is also supported. However, information on Hawaiian adze production and distribution can be used to critique and expand on such political approaches to cultural complexity.

Political ideas like those originally formulated by Earle were developed from testing, evaluation, and critique of adaptationist theories including that of Service. Such political approaches rejected the notion that cultural complexity develops from the centralized management of ecologically mandated activities such as redistribution or irrigation and pointed out the importance of the deliberate motives or goals of emerging leaders in a shift toward increased cultural complexity. However, similar to adaptationist approaches, they emphasize that political control by leaders is derived from the control of material resources and/or labor. Furthermore,

opportunities for this control are provided by environmental conditions (Earle 1987b; Johnson and Earle 1987).

Politically oriented researchers have considered the question of why groups accept political control, but their answers to this question are rooted in economic factors. For example, it is often proposed that populations accept control because they receive tangible benefits such as defense or irrigation from political leadership (Earle 1987b; Hastorf 1990; Johnson and Earle 1987). Control is also maintained because leaders use ideology and material symbols of ideology as a justification for their power (Earle 1987b). Although political approaches to cultural complexity have considered the political and economic relationships between the elite and the nonelite, commoners are generally portrayed as a basically passive population, which is interesting only in relation to elite leaders. For example, Earle says, "To understand the evolution of chiefdoms is thus to understand a balancing of interests between a dependent population and an emerging aristocracy"; peaceful control of the commoner population was accomplished "in part by an elaborate ideology to justify rule; however, it was also accomplished by the paternalism of the chiefs, which bound a population to them" (1987b:297,298).

Political approaches often distinguish between the political economy within which elite leaders mobilize resources for their support and investment in status-earning activities and the subsistence economy within which commoners are concerned with the day-to-day maintenance of their households (Earle 1978; Johnson and Earle 1987). In anthropological analyses, they have tended to focus on the political economy and the control strategies of the elite rather than the subsistence economy and the necessary relationship between the political and subsistence economies. Important distinctions are also drawn between subsistence goods and wealth items and between attached and independent craft specialization. Within the political economy, leaders mobilize resources to support attached craft specialists who manufacture wealth items that can be used for political purposes. On the other hand, subsistence goods are generally produced by independent specialists or nonspecialists within the subsistence economy.

Within this scheme, items like adzes appear to be uninteresting and insignificant and to have little potential role in the development or maintenance of cultural complexity since they were presumably

everyday tools that were simply made and used by commoners within the subsistence economy. However, in Hawai'i, stone adzes represent a link between subsistence goods and wealth items and between the subsistence economy and the political economy. They were clearly subsistence goods used regularly in ordinary activities, but adzes were also tools used by specialists to carry out activities for the chiefs such as the construction of canoes, houses, and temples.

It is unlikely that specialists employed by the chiefs to carry out construction projects were full-time specialists who were permanently retained. Sahlins (1958:115) interprets ethnohistoric information (Pukui 1939) as saying that some canoe-makers in Hawai'i were attached and that some were independent. However, it is possible that sometimes canoe builders were employed by the chiefs and that sometimes they were not, although certain builders may have been used more often than others because of exceptional skill or reputation. Canoe builders and other laborers who used adzes in work carried out for the chiefs may have been motivated to use tools which were manufactured for specific use in a particular project requested by the chief. They may have manufactured such adzes themselves from high-quality stone from special sources such as Mauna Kea, but it is also possible that they commissioned independent specialists to provide them with adzes. Thus, the distinction between attached and independent specialists need not have been definite or clear-cut. Some specialists could have been sponsored by the chiefs some of the time only, and they could have interacted with independent specialists.

The end result (canoes and houses) of specialists' labor were equivalent to wealth items like feather cloaks in that they served to symbolize a chief's status, influence, and power to command labor and resources. A chief's position and power to carry out projects was ultimately derived from the belief that he was descended from divine ancestors. Certain items such as feather cloaks were restricted to individuals of chiefly rank, certain foods were reserved only for chiefs, and an elaborate system of behavioral taboos were associated with being in the presence of the chief (Sahlins 1958, 1972, 1981, 1985). In short, nearly every activity involving the chiefs was imbued with a sense of sacredness or sanctity. Chiefs deliberately employed specialists to enhance or publicize the sense that their canoes, their houses, or public projects like temples were sacred, distinctive, and special. Craft specialists employed by the chiefs

may have been motivated to use special tools such as adzes made by particular individuals and/or acquired from certain places because they viewed and respected activities carried out for the chiefs as sacred. This idea is essentially one of the political explanations for chiefly control and is an ideological or religious justification for power. However, as the chiefs enhanced their status through the use of specialists, specialists employed by the chief may also have tried to enhance their own reputations by association with the chief. They could have publicized this association and the significance of their work by using carefully selected, special tools and materials. It is often assumed that the goals and motivations of participants in the political and subsistence economies are not congruent; specifically, it is usually assumed that only elite leaders have definite motives and aspirations. However, individuals within the subsistence economy can also take advantage of opportunities to enhance their influence or at least reputation. In Hawai'i, the completion of projects for the chief provided the chief with a material symbol of his influence but also provided a craft specialist with physical evidence of his skill and reputation.

Other recent approaches to the development of cultural complexity, and specifically to the emergence of political control, have recognized the active role that members of supposedly subordinate interest groups can play in the development and/or maintenance of political system. In short, power does not emanate only downward from leaders. The concept of power implies not only power over others but also the power to carry out actions and assert identities, and "All individuals and groups exercise power and are subject to its exercise" (Miller

and Tilley 1984a:6).

Groups and individuals use material objects as symbols to maintain or increase power (Miller and Tilley 1984a, 1984b), but it is not clear that Hawaiian adzes themselves were material objects that were explicitly used in this way. They were essentially necessary tools, but the production and use of adzes provided opportunities for commoners to seek status and prestige. Adzes represent, not in a symbolic sense but rather in the most material sense, a link between the political and subsistence economies defined in political approaches to cultural complexity.

Drawing a distinction between political and subsistence spheres of economic activity is useful, and this was particularly true in early evaluations of adaptationist approaches in which these potentially important distinctions were not made. However, by emphasizing dichotomies between the political and subsistence economies (as well as between wealth items and subsistence goods and between attached specialization and independent specialization), political approaches often neglect to consider subsistence items like adzes that can provide important insights on the question of political control and why and how leaders can impose and maintain such control. Examination of the precontact production, distribution, and use of Hawaiian adzes has suggested that the process of political control could have been a two-way process in which both chiefs and commoners actively participated. In the absence of any permanent, coercive force, the development and maintenance of Hawaiian chiefdoms depended solely on continuous, dynamic, and even fragile social, political, and economic relationships between chiefs and commoners.

Appendixes

Appendix A **Chronological Placement of Sites**

On the basis of published or otherwise recorded radiocarbon and/or volcanic glass hydration dates, sites were placed in one of the following periods:

- before AD 1100
- AD 1100–1400
- AD 1400–1650
- AD 1650–1800
- after AD–1800

RADIOCARBON DATING

In the case of radiocarbon dates, aberrant dates which did not conform to other dates obtained for a site and/or which had been rejected as inaccurate by other researchers were not used for chronological classification. Radiocarbon dates that were used were corrected using calibration tables (Stuiver and Pearson 1986) unless they had already been corrected by previous researchers. In a few cases, radiocarbon dates were not corrected because the dates were published or presented in such a way that they could not be accurately corrected (for example, with no standard deviation).

HYDRATION RIND DATING

Hydration rind dating is based on the principle that fresh, unweathered surfaces on volcanic glass absorb water at a constant, known rate. Such hydration alters the chemical composition of volcanic glass, and a hydration rind or layer forms on the outside of volcanic glass artifacts over time. The thickness of this layer can be measured and presumably reflects

the age of the artifact or how long ago it was manufactured (Barrera and Kirch 1973; Kirch 1985:50–51; Morgenstein and Riley 1974; Morgenstein and Rosendahl 1976).

However, recent research has shown that factors other than age can affect the thickness of the hydration rind. These factors include the original chemical composition of the glass, which varies according to the source from which the glass was obtained, and the physical environment, particularly temperature, within which hydration takes place (Kirch 1984:104–105, 1985:50–51; Olson 1983:328–330; Tuggle and Olson 1978:4–5). Kirch (1984:104–105) suggests that such factors are at least partially controlled when dating sites from the same region where it is likely that one source of volcanic glass was used and from the same environmental zone where it is likely that temperature and other conditions for hydration are fairly uniform. Both conditions are met for the sites considered in this study. Most of the sites are located in west Hawai'i where there is one large, well-known source of volcanic glass at Pu'uwa'awa'a (Kirch 1984:105; Olson 1983:336), and most sites are located in the coastal environmental zone.

Despite questions regarding the accuracy of hydration dates, such dates are usually consistent with dates based on stratigraphy and radiocarbon (Tuggle and Olson 1978:25). Hommon, for example, (1986:64) demonstrated that a site chronology for the island of Hawai'i based on hydration dating (1976) was essentially the same as that based solely on radiocarbon dates. It is probably safe to assume that hydration rind dating is at least adequate for placing sites in a relative chronological order (Kirch 1983; Olson

Table A.1
Chronological placement of sites for analyses in chapters 3 and 5

Locality	Site	Type of dating	Placement	References
H1	H1*	Radiocarbon	before AD 1100 for ch. 3; long sequences for ch. 5	Emory and Sinoto 1969, Goto 1986, Green 1971, Kirch 1985
H8	H8*	Radiocarbon	before AD 1100 for ch. 3; long sequences for ch. 5	Emory and Sinoto 1969, Emory, Bonk and Sinoto 1969, Goto 1986, Green 1971, Kirch 1985
Volcanoes	911	Radiocarbon	AD 1100–1400	Ladd 1969b
Kalāhuipua'a	324	Hydration	AD 1400–1650	Kirch 1979
	368	Hydration	AD 1400–1650	
	343	Hydration	AD 1400–1650	
Kailua-				
Kawaihae	701A	Hydration	AD 1400–1650	Rosendahl 1973
Bobcat Trail	5004	Hydration	AD 1400–1650	Haun 1986
Kahalu'u	D4-48	Hydration	AD 1400–1650	Kirch 1973
	D4-51	Hydration	AD 1400–1650 (portions)	Hay et al. 1986
Hōlualoa	7976	Radiocarbon	AD 1400–1650	Hammatt, Barthwick, Shideler 1986
'Anaeho'omalu	197	Hydration	AD 1400–1650	Barrera 1971
	298	Hydration	AD 1400–1650	
Mudlane-				
Waimea	2727	Both	AD 1650–1800	Clark and Kirch 1983
Mudlane-				
Waimea	5998	Hydration	AD 1650–1800	
	8825	Hydration	AD 1650–1800	
'Ōuli	5625	Hydration	AD 1650–1800	Rosendahl and Kaschko 1983
	5627	Both	AD 1650–1800	
	8010	Hydration	AD 1650–1800	
	8018	Hydration	AD 1650–1800	
Kalaoa	4-16-6	Hydration	AD 1650–1800	Cordy 1981
Kuakini	D6-21	Both	AD 1650–1800	Schilt 1984
	D6-41	Radiocarbon	AD 1650–1800	
	D7-27	Hydration	AD 1650–1800	
	D8-33	Both	AD 1650–1800	
	D8-52	Hydration	AD 1650–1800	
Kēahole	262	Hydration	AD 1650–1800	Hammatt and Folk 1980
Hōlualoa	7967	Radiocarbon	AD 1650–1800	Hammatt, Barthwick, Shideler 1986
Kahalu'u	5611	Hydration	AD 1650–1800	Hay et al. 1986
	7702	Both	after AD 1800 (portions)	
HelCo	T1	Radiocarbon	after AD 1800	Bath and Rosendahl 1984
H2	H2	Radiocarbon	after AD 1800	Emory and Sinoto 1969
Mudlane-				
Waimea	2732	Hydration	after AD 1800	Clark and Kirch 1983
	2776	Hydration	after AD 1800	
	8824	Hydration	after AD 1800	
'Anaeho'omalu	303	Hydration	after AD 1800	Barrera 1972
Pu'ueo	73	Hydration	after AD 1800	Spear 1987
Lapakahi	6941	Hydration	long sequence	Tuggle and Griffin 1973
Kalāhuipua'a	355	Hydration	long sequence	Kirch 1979
	342	Hydration	long sequence	Kirch 1979; Hommon 1983
Kailua-				
Kawaihae	1349	Hydration	long sequence	Rosendahl 1973
H65	H65	Radiocarbon	long sequence	Kirch 1985; Soehren 1966
Wai'ahukini	22-64	Both	long sequence	Sinoto and Kelly 1975
	22-248	Both	long sequence	
Hōnaunau	A-27	Hydration	long sequence	Ladd 1969a
Kamehameha	D4-27	Hydration	long sequence	Crozier 1971

1983). For this study, it is assumed that hydration dates were suitable for placing sites in one of several broad time periods and, when possible, radiocarbon dates were used for chronological placement (table A.1).

PROCEDURES FOLLOWED

Both radiocarbon and hydration dates have an associated standard deviation. Usually there is a series of several radiocarbon and/or hydration dates for a single site. The following rules were followed in using published dates to place a site within a time period:

- Mean or estimated dates were used for placement without consideration of the standard deviation associated with each date.
- When both radiocarbon and hydration dates existed for the same site the entire range covered by both sets of dates was used.
- When dates for a site included parts of two time periods the site was placed in the period within which most of the dates occurred.
- When dates for a site included parts of two time periods and the amount of time in each period was equal (± 20 years) the earliest period was consistently used.
- When dates for a site extended over parts of three or more time periods the sites were placed in the category labeled "long sequences."
- When portions of a site and/or stratigraphic layers within a site dated to different time periods, and published data was sufficient to do so, artifacts from different portions were placed in different periods.

Table A.1 lists the dated sites used in the analyses discussed in chapters 3 and 5 and indicates their chronological placement, whether radiocarbon and/or hydration rind dates were used, and in what references dates are published. In two cases, sites H8 and H1, chronological placement did not conform to the rules or procedures outlined above, and the rationale behind the chronological placement of these particular sites is explained below.

Site H8

Radiocarbon dates on varied materials have shown

some conflicting results, but dates from layer II at the site are quite consistently early (before AD 1100). Fifteen artifacts from this site were submitted for petrographic analysis as discussed in chapter 3; in this case a deliberate effort was made to identify specific artifacts which had been recovered from layer II, and, for the analyses discussed in chapter 3, site H8 has been placed in the category before AD 1100. For other analyses in chapter 5, no effort was made to identify artifacts from different strata at site H8, and the site was placed in the category "long sequences." None of the radiocarbon dates from site H8 were corrected.

Site H1

Results of excavations conducted at site H1 in 1953–1955 have not been published. Furthermore, "radiocarbon dating of the Pu'u Ali'i dune site [H1] has posed more problems than probably any other site in Polynesia" (Kirch 1985:82). Radiocarbon dates on varied materials have provided conflicting results, particularly a lack of consistency within and between stratigraphic levels. However, Kirch (1985:81–86), using unpublished information on the site H1 excavations, suggested that layer III, which was located beneath a layer of pavement at the site, does, in fact, represent occupation prior to AD 1100, and such a date is consistent with the types of artifacts recovered from layer III. Several artifacts from site H1 (5) were submitted for petrographic analysis (chapter 3); for this purpose, unpublished records on the site H1 excavations were used and an attempt was made to identify artifacts that were apparently recovered from within or beneath what was described as the coral pavement layer. In chapter 3, site H1 is placed in the category before AD 1100. For analyses in chapter 5, no attempt was made to identify from which strata artifacts had been recovered, and site H1 was simply placed in the category called long sequences. None of the radiocarbon dates from site H1 were corrected.

Appendix B Collections and Sampling Strategy

Each collection from which artifacts were analyzed is listed below. The sampling strategy for each collection is described.

DEPARTMENT OF ANTHROPOLOGY, BERNICE P. BISHOP MUSEUM

All dated sites yielding complete adzes, partial adzes, and/or adze fragments were identified, relevant ar-

tifacts from these sites were located at the museum, and the sites were classified chronologically (appendix A). Artifacts curated at the Bishop Museum were used for the petrographic analysis discussed in chapter 3 and for the analysis of finished, complete, or partial adzes discussed in chapter 5. The following sampling procedures were used.

Petrographic Analysis (chapter 3)

From the total artifacts twenty artifacts were selected dating to each of several time periods defined as before AD 1100, AD 1100–1400, AD 1400–1650, AD 1650–1800, after AD 1800, and long sequences. The decision to select twenty artifacts from each of the temporal categories was determined primarily by funds available for petrographic analysis.

For the period before AD 1100, there were only two sites with adze artifacts, H1 and H8. There were fifteen artifacts from site H8 which could be said with some certainty to have been recovered from layer II of the site, which represents the early (pre AD 1100) occupation of this site (appendix A), and all fifteen of these artifacts were selected for petrographic analysis. Five additional artifacts were selected from the site H1 assemblage. Using original field notes and some information written on the artifacts themselves during accessioning, five adze fragments were located which seemed likely to have been recovered from within or below the pavement layer at the site and thus to represent early (pre AD 1100) occupation (appendix A).

There were no sites and no artifacts that dated to the period AD 1100–1400; no sample was selected.

There were fifty-three artifacts from thirteen sites dating to AD 1400–1650 including twenty from Kalāhuipua'a 368, ten from Kalāhuipua'a 324, eight from Kailua-Kawaihae 701, three from 'Anaeho'omalū 197, two from Kahalu'u D4-51, two from Kalāhuipua'a 342, two from 'Anaeho'omalū 298, and one each from Kalāhuipua'a 350 and 343, Kahalu'u D4-48, 'Anaeho'omalū 297 and 103, and Kuakini D7-66. The assemblage was reduced to forty artifacts from only sites 324, 350, 268, 343, D4-51, D4-48, and 701 because assemblages from the other sites consisted primarily of complete adzes and/or very small fragments which were not well suited for thin-sectioning, contained mainly surface finds without good dating and other associations, had dates that original authors had questioned, and/or had ambiguities and inconsistencies in published site information. The accession numbers of the forty artifacts were written on slips of paper and twenty

randomly selected from a box containing the slips. Four of the seven sites were represented in the random sample; they included Kalāhuipua'a 368 (eight artifacts), Kalāhuipua'a 324 (seven artifacts), Kailua-Kawaihae 701 (four), and Kahalu'u D4-48 (one). One more artifact was arbitrarily added from Kahalu'u D4-51 to enlarge somewhat the number of different sites represented.

For the period AD 1650–1800, there were sixty artifacts from eleven sites including twenty-three from Mudlane 2727, seventeen from site H2, four from Kuakini D7-27, three from Kuakini D6-41, three from Mudlane 5998, two from Kuakini D6-21, two from Mudlane 8825, two from Kuakini D8-33, two from Mudlane 2728, and one each from Kuakini D8-52 and D7-83. Artifacts from sites D6-41, D6-21, D7-27, D8-52, 8825, and 5998 were most appropriate for thin-sectioning in terms of size, condition, and well-documented dates and associations. There was a total of fifteen artifacts from these sites, and all were submitted for petrographic analysis.

Five additional artifacts were then selected from the remaining sites. Artifacts from D7-83, D8-33, and 2728 were eliminated because they were not physically suitable for thin-sectioning. Three items were deliberately selected from site H2 which were suitable for petrographic analysis. For site 2727 two items were deliberately selected. Artifacts were recovered from both the surface and the subsurface of several different parts of this site. There was some difficulty in locating all artifacts from this site and reconciling published information on artifact provenience with information written on the artifacts at the time of accessioning, but two artifacts were chosen which were definitely subsurface finds with clear provenience information.

Later, four items were eliminated from the AD 1650–1800 sample. In one case museum curators did not want the artifact in question submitted for thin-sectioning because it was the only polished artifact that had been recovered from a particular site. In the three other cases, it was not clear that the artifacts were definitely polished adze fragments.

There were twenty-two artifacts from eleven sites that dated to after AD 1800 including eleven from Mudlane 2776, eight from Mudlane 2732, two from Mudlane 8824, and one from 'Anaeho'omalū 303. Site 2776 had actually yielded over 100 polished artifacts, but most were eliminated from consideration because they were clearly too small for thin-sectioning. Two additional artifacts from site 2776 were eliminated because they appeared to be surface finds

with less than certain dating associations. The remaining twenty artifacts from this period were submitted for petrographic analysis.

For sites with long sequences of dates that could not be placed within a single time period (appendix A), there were 106 artifacts from eight sites including forty-three from Wai'ahukini 22-64, twenty-six from Kalāhuipua'a 355, twenty-five from Wai'ahukini 22-248, three from Kailua-Kawaihae 1349, three from Wai'ahukini 21-20, two from 'Anaeho'omalu 148, two from Mudlane 8803, and two from Kamehameha D4-27. The number of artifacts was reduced to ninety-nine from five sites (355, 1349, 8803, 22-64, and 22-248) because the other assemblages were less desirable for petrographic analysis (artifacts not suitable for thin-sectioning and/or problematic dating and associations). The accession numbers of these ninety-nine artifacts were written on slips of paper and seventeen randomly selected from a box containing the slips; all sites except 8803 were represented in this sample. Two layers or strata at site H65 had yielded two quite disparate radiocarbon dates. From written records on the site and information written on artifacts from the site during accessioning nine artifacts were located which had clearly been recovered from either one strata or the other. Three of the nine were then randomly selected to complete the sample of twenty artifacts for the category "long sequences."

Analysis of Complete and Partial Finished Adzes (chapter 5)

All complete and partial adzes from dated sites on the island of Hawai'i were analyzed. No sampling was done.

DEPARTMENT OF ANTHROPOLOGY, UNIVERSITY OF HAWAII-MANOA

Artifacts curated at the University of Hawai'i were recovered during excavations conducted at several sites in the Pololū Valley in the 1970s (Tuggle 1976, 1987; Tuggle and Tomonari-Tuggle 1980; Olson and Nakama 1974). Pololū sites with artifacts relevant to this study are discussed below and sampling strategies described.

Site 4981 or Pololū Adze-Manufacturing Site (chapter 4)

All unfinished adzes, cores, and hammerstones were removed from the assemblage; all were analyzed. The next goal was to select a 10 percent sample of the remaining flakes for analysis. Flakes and pieces of

shatter from the site were curated in batches or lots; they consisted of artifacts recovered from a particular part of the site and stored together in a single box or bag. In some cases, other researchers had done some preliminary size sorting so that a bag or box might be labeled "small flakes" and another labeled "large flakes." The rationale behind the original batching of the artifacts was not always known or clear.

To obtain a representative sample from each of the batches the following method was used. With tape, 300 spaces were marked on a large table top and then each lot of debitage was laid out 300 pieces at a time on the table. Using a random numbers table in a statistics text, 10 percent or 30 items from each 300 artifacts were selected. If there were less than 300 artifacts in a batch, 10 percent was selected of whatever the total number was. If a particular section of the site had yielded relatively few total artifacts (less than 100), a sample was selected of somewhat more than 10 percent. Each lot and the sampling procedure and rationale for each is described below.

Box 1 was labeled trench 1, section D and contained 174 artifacts; 17 items were selected using random numbers table.

Box 2 was labeled trench 1, section D and contained 95 artifacts; 10 items were selected using random numbers table.

Box 3 contained 10 artifacts from trench 4, section B; 3 from section C; and 1 from trench 1, section D. All of these artifacts were analyzed.

Box 5 was labeled surface-gully and contained 100 artifacts; 10 were selected using random numbers table.

Box 6 was labeled surface-gully and contained 254 artifacts; 25 were selected using random numbers table.

Box 7 was labeled quarry 2 and contained 67 artifacts; 15 (15–20 percent) were selected using random numbers table. A sample larger than 10 percent was chosen because there were relatively few artifacts from this part of the site.

Box 8 contained 11 artifacts from trench 1, section D and 1 was selected using random numbers table. This box also contained 20 items in a bag labeled surface-gully, and 2 were selected using random numbers table. There also were 8 artifacts from section C, and all were analyzed since section C was not well represented. Also, 62 artifacts from section E, 15 randomly selected (more than 10 percent) because this section was not well represented. Also, 64

artifacts from section F13, 15 selected (more than 10 percent) because this area not well represented.

Box 32 was labeled trench 1, section D and contained a bag of 96 artifacts labeled medium in size; 10 were selected using random numbers table. A second bag of 67 artifacts was also labeled medium, and 7 were selected with random numbers table. A third bag of 12 artifacts was labeled cortical (presumably with cortex), and 2 (somewhat higher than 10 percent) were selected using random numbers table. A bag of 1,300 artifacts was labeled small. In this case the pile of flakes was first counted into 8 roughly equal parts, one of the 8 parts was randomly selected, and then 130 artifacts were chosen from this portion using the random numbers table. This box also contained another bag of 524 artifacts; this pile was counted into fifths, 3 of the 5 parts from which to draw the sample were randomly selected, and 52 items were selected using the random numbers table.

Box 33 was labeled trench 1, section D and contained a bag of 135 artifacts; 14 were randomly selected using table top chart and random numbers table. Another bag contained 27 artifacts labeled large, and 3 were randomly selected. Another bag contained 21 artifacts labeled medium and 2 were randomly selected. A final bag of 81 artifacts was labeled small, and 8 were randomly selected.

Box 34 was labeled trench 1, section D and contained a bag of 303 artifacts labeled small; 30 were selected using table top numbering system and random numbers table. This box also contained a bag of 60 artifacts labeled large, and 6 were randomly selected. Also a bag of 48 artifacts was labeled small; 5 were randomly selected.

Box 54 contained only 3 artifacts from trench 1, section D of site 4981; all 3 artifacts were analyzed.

After sampling, 403 flakes and pieces of shatter had been selected from a grand total of 3,546 originally recovered from the site. This sample included 300 artifacts out of 2,958 for section D, 37 of 374 for the surface-gully, 15 of 67 for quarry 2, 10 of 10 for section B, 11 of 11 for section C, 15 of 62 for section E, and 15 of 64 for section F. All pieces of shatter and broken flakes (261) were removed from the sample of 403 artifacts leaving 142 flakes which were analyzed for the discussion in chapter 4.

Site 4838

This habitation site is undated but is located near the Pololū adze-manufacturing site; its assemblage contains polished and unpolished flakes as well as finished and possibly unfinished adzes recovered

from one part of the site, pit A. Two (approximately 10 percent) of the polished flakes were randomly selected for petrographic analysis (chapter 3), and two complete adzes were analyzed (chapter 5).

PAUL H. ROSENDAHL, INC., HILO, HAWAII

Paul H. Rosendahl, Inc. is a cultural resource management firm located on the island of Hawai'i, and artifacts recovered from the activities of the company are curated at the firm's office and laboratory in Hilo, Hawai'i. I spent one week at the company's headquarters in 1987 analyzing complete/partial adzes and adze fragments from dated sites on the island of Hawai'i that were curated in their collections and already described in written reports. Relevant sites included Bobcat Trail 5004, Pu'ueo, Helco substation, 'Ōuli 5614, 5625, 5627, 8010, and 8018, and Kahalu'u 7702 and 5611. All complete and partial adzes from all of these sites were analyzed (chapter 5). Also analyzed were all adze fragments (see Withrow 1991) from all the sites except sites 7702 and 5611 at Kahalu'u where large numbers of artifacts had been recovered. For 7702, written reports indicated that approximately 650–700 adze fragments were recovered; each was described on a separate file card/form at Paul H. Rosendahl, Inc. A 10 percent sample was analyzed by selecting every eighth card in the artifact card file, locating these artifacts in storage, and analyzing them; sixty-six artifacts were analyzed. For site 5611 at Kahalu'u, there were eighty adze fragments; again 10 percent of the artifact cards were removed, and the eight artifacts located and analyzed. Some of the artifacts examined at Paul H. Rosendahl, Inc. were submitted for petrographic analysis (chapter 3). This was accomplished by examining all the artifacts analyzed, removing complete adzes and items too small for thin-sectioning, and submitting all the remainder (forty-four artifacts) for petrographic analysis.

HISTORIC SITES DIVISION, DEPARTMENT OF LAND AND NATURAL RESOURCES, STATE OF HAWAII, HONOLULU, HAWAII

Three sets of artifacts under the jurisdiction of the Historic Sites Division were analyzed.

First, Dr. Ross Cordy of the Historic Sites Division provided one artifact for petrographic analysis (chapter 3); it was collected during recent inspection of one of the sites described in earlier research conducted by Cordy (1981).

Second, artifacts originally excavated from several sites at Lapakahi (Tuggle and Griffin 1973) by

the University of Hawai'i are now curated at Lapakahi State Historical Park on the island of Hawai'i. In 1987 two complete adzes from sites 6940 and 6941 were analyzed (chapter 5). Five adze fragments for petrographic analysis (chapter 3) were randomly selected from twenty-seven artifact forms filed at the park. Sample size was based on funds available for petrographic analysis and the number of artifacts park officials were willing to submit for petrographic analysis.

Finally, artifacts excavated from site 262 at Kēahole by independent archaeologists/contractors conducting investigations for the Division of State Parks are also curated at the Historic Sites Division office in Honolulu. All (three) complete adzes from the site were analyzed (chapter 5). No artifacts were submitted for petrographic analysis.

CULTURAL SURVEYS OF HAWAI'I

All adze artifacts recovered from dated sites 7976 and 7967 at Hōlualoa by H. Hammatt and others of his cultural resource management firm were examined. None were submitted for thin-sectioning; two complete adzes were analyzed (chapter 5).

NATIONAL PARK SERVICE

Two sets of artifacts under the jurisdiction of the National Park Service were analyzed. These included one complete adze (chapter 5) from site 911 within the Hawai'i Volcanoes National Park, which is curated at park headquarters, and artifacts from several sites at Pu'uhonua o Hōnaunau curated at the site. All complete/partial adzes that could be located at the Great Wall (A1–A2), the 'Ale'ale'a temple, site A-27, and site B-105 were analyzed (chapter 5). No artifacts were submitted for petrographic analysis.

Appendix C **Thin-section Preparation**

By Jo Ann Sinton, Laboratory Technician
Institute of Geophysics, University of Hawai'i-Manoa

1. Cut rock to fit a 1 x 2 inch glass slide.
2. Lap rock chip flat and smooth on a rotating lap wheel with #600 grit silicon carbide.
3. Clean and dry rock chip on a hot plate set at 65 degrees Centigrade.
4. Apply epoxy to the clean lapped surface.
5. Lay a clean, frosted slide on the rock and push out air bubbles.

6. Allow to cure.
7. Cut off excess rock.
8. Lap to 30 microns on a rotating lap wheel with #600 grit silicon carbide.
9. Clean and dry on a hot plate at 120 degrees Centigrade.
10. Apply Canada balsam for cover slip, if necessary.
11. Lay down a clean cover slip on the rock section and push out air bubbles.
12. Allow Canada balsam to cure approximately 8 minutes.
13. Remove from hot plate; allow to cool.
14. Clean off excess balsam with alcohol.

Appendix D **Number of Artifacts of Various Raw Material Types by District, Locality, and Site**

PUNA

No artifacts were sourced.

HILO

No artifacts were sourced.

HĀMAKUA

One artifact from one site, the Bobcat Trail shelter (5004) (locality 5, fig. 3.5), was sourced. It was of unidentified material.

KOHALA

Kalāhulpua'a (locality 3, fig. 3.5)

Artifacts from three sites (324, 355, and 368) were sourced.

Site 324. Seven artifacts sourced, 6 Mauna Kea, 1 Kīlauea

Site 355. Seven artifacts sourced, 6 Mauna Kea, 1 Kīlauea

Site 368. Eight artifacts sourced, 3 Mauna Kea, 5 unidentified

Mudlane-Waimea (locality 7, fig. 3.5)

Artifacts from six sites (2727, 2732, 2776, 5998, 8824, and 8825) were sourced.

Site 2727. Three artifacts sourced, 2 Mauna Kea, 1 unidentified

Site 2732. Eight artifacts sourced, 6 Mauna Kea, 1 type A, 1 unidentified

Site 2776. Nine artifacts sourced, all Mauna Kea

Site 5998. Two artifacts sourced, 1 Mauna Kea, 1 Pololū

Site 8824. Two artifacts sourced, both Mauna Kea

Site 8825. Two artifacts sourced, both Mauna Kea

‘Ōuli (locality 8, fig. 3.5)

Artifacts from four sites (5625, 5627, 8010, and 8018) were sourced.

Site 5625. One artifact sourced, Mauna Kea

Site 5627. Two artifacts sourced, 1 Kīlauea, 1 unidentified

Site 8010. One artifact sourced, Mauna Kea

Site 8018. Three artifacts sourced, all Mauna Kea

‘Anaeho‘omalū (locality 13, fig. 3.5)

One artifact from one site (303) was sourced. It was of Mauna Kea material.

Lapakahi (locality 15, fig. 3.5)

Five artifacts from one site (6941) were sourced. Four were of Mauna Kea material and one of unidentified material.

Pololū Valley (locality 18, fig. 3.5)

Four artifacts from site 4838 were sourced. One was of Mauna Kea material and the other three of unidentified material.

KONA

Kailua-Kawaihae (locality 4, fig. 3.5)

Artifacts from two sites (701A and 1349) were sourced.

Site 701A. Four artifacts sourced, all Mauna Kea

Site 1349. One artifact sourced, Mauna Kea

Kahalu‘u (locality 6, fig. 3.5)

Artifacts from four sites (D4-48, D4-51, 5611, and 7702) were sourced.

Site D4-48. One artifact sourced, type C

Site D4-51. One artifact sourced, Mauna Kea

Site 5611. Three artifacts sourced, all Mauna Kea

Site 7702. Four artifacts from sections dating to AD 1400–1650, 3 from Mauna Kea, 1 unidentified; plus 27 artifacts from sections dating to AD 1650–1800, 15 Mauna Kea, 5 Pololū, 1 Kīlauea, 3 type B, 3 unidentified.

Kalaoa (locality 9, fig. 3.5)

One artifact from one site (4-16-6) was sourced. It was of Mauna Kea material.

Kuakini (locality 10, fig. 3.5)

Artifacts from four sites (D6-21, D6-41, D7-27, and D8-52) were sourced.

Site D6-21. One artifact sourced, Mauna Kea

Site D6-41. Three artifacts sourced, all Mauna Kea

Site D7-27. Three artifacts sourced, all Mauna Kea

Site D8-52. One artifact sourced, Mauna Kea

HelCo substation (locality 11, fig. 3.5)

One artifact from one site (T-1) was sourced. It was of Pololū material.

Kā‘u

Site H1 (locality 1, fig. 3.5)

Five artifacts were sourced. One was of Mauna Kea material, one Pololū, and three type B.

Site H8 (locality 2, fig. 3.5)

Fifteen artifacts were sourced. Six were of Mauna Kea material, one Pololū, one Kīlauea, two type A, one type B, two type C, and two unidentified.

Site H2 (locality 12, fig. 3.5)

Two artifacts were sourced. One was of Mauna Kea material and the other type A.

Site H65 (locality 16, fig. 3.5)

Three artifacts were sourced. All were of Mauna Kea material.

Wai‘ahukini (locality 17, fig. 3.5)

Artifacts from two sites (22-64 and 22-248) were sourced.

Site 22-64. Six artifacts sourced, 3 Mauna Kea, 1 type A, 1 type C, 1 unidentified

Site 22-248. Three artifacts sourced, all Mauna Kea

Pu‘ueo (locality 14, fig. 3.5)

One artifact from site 73 was sourced. It was of Mauna Kea material.

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Index

- adaptationist approaches, 6-7, 30-31, 65, 67-69
- adzes,
function of, 55, 59-60, 62
Hawaiian
analysis of, 51-53
cross section of, 53-55
homogeneity in, 54, 55-58, 62
production, nature of, 46-48
profile of, 53-55
proportions of, 41
resharpening of, 61-62, 62-63
size of, 14, 55-62
as valuables, 60-61
See also craft specialization, in adze manufacture; petrographic analysis
- bevel
angle, 62, 63
flaking, 36, 41-42
- bidirectional flaking, 36, 41; 43-44
- bulb of percussion, 35, 40
- chiefdoms
definition of, 3
development of, 6
in Hawai'i, 4-6
See also adaptationist approaches; political approaches
- chronological periods
in Hawai'i, 17, 52-53
site placement in, 71-73
- collections used for analysis, 75-78
- cores, 37
- cortex, 34-35, 36, 37
- craft specialization
in adze manufacture, 46-49, 54-55, 58, 62, 63-64, 66
archaeological indicators of, 31-32, 51, 66-67
- definition of, 30
in Hawai'i, 29-30
and homogeneity, 51-64
independent vs. attached, 30, 66-69
- cultural complexity, 3-4
in precontact Hawai'i, 4-5
in postcontact Hawai'i, 5-6
See also chiefdoms; adaptationist approaches; political approaches
- data and methodology, 16-21, 34, 51
- dating, 71-73
- dorsal ridges, 35, 40
- exchange. *See* redistribution.
- flakes
attributes of, 34-35
secondary reduction, 39-40
shape of, 35
size of, 37-39, 43
- frequency distributions of adze measurements, 57-58, 62
- Mauna Kea adze quarry, 21
adze manufacture, 37-42, 42-46
See also craft specialization, raw material, distribution of; raw material, sources of
- petrographic analysis, 18-24, 74-77
flow structure, 20-21
groundmass (matrix), 19
magma, alteration of, 19-20
phenocrysts, 18-19
rock texture, 18
sites used in, 19
- political approaches, 7-10, 11, 31, 67-69
- political economy, 7-9, 30, 68
- Pololū adze-manufacturing site, 22
attributes, of flakes at, 34-35; of unfinished adzes at, 36-37
description of, 32-34
- form of raw material at, 37
methodology at, 34
productivity and success at, 32, 44-46
- sampling at, 34
- stages of manufacture at, 37-40
- skill and efficiency at, 42-44
- standardization at, 46
- unfinished adzes, rejection of 40-41
See also cores; craft specialization, in adze manufacture; raw material, distribution of; raw material, form of; raw material, sources of
- raw material
at sites, 26
by district, 83-84
by time period, 25, 27
characteristics of, 21
distribution of, 24-28
effects of, 55
sources of, 21-24
- redistribution
and craft specialization, 30-31
definition of, 10
in Hawai'i, 8, 11-12
of Hawaiian adzes, 65-66
as mobilization, 10-11
regional studies of, 13-14
role of, 10
temporal change in, 28
- site-specific analyses, 14-16
- sampling, 17-18, 75-78
- staple finance, 10, 30
- subsistence economy, 8, 9, 28, 30, 68
- tanging, 36, 42, 53
- thin-section preparation, 34, 77
- termination type, 35, 43
- wealth finance, 10-11, 30

