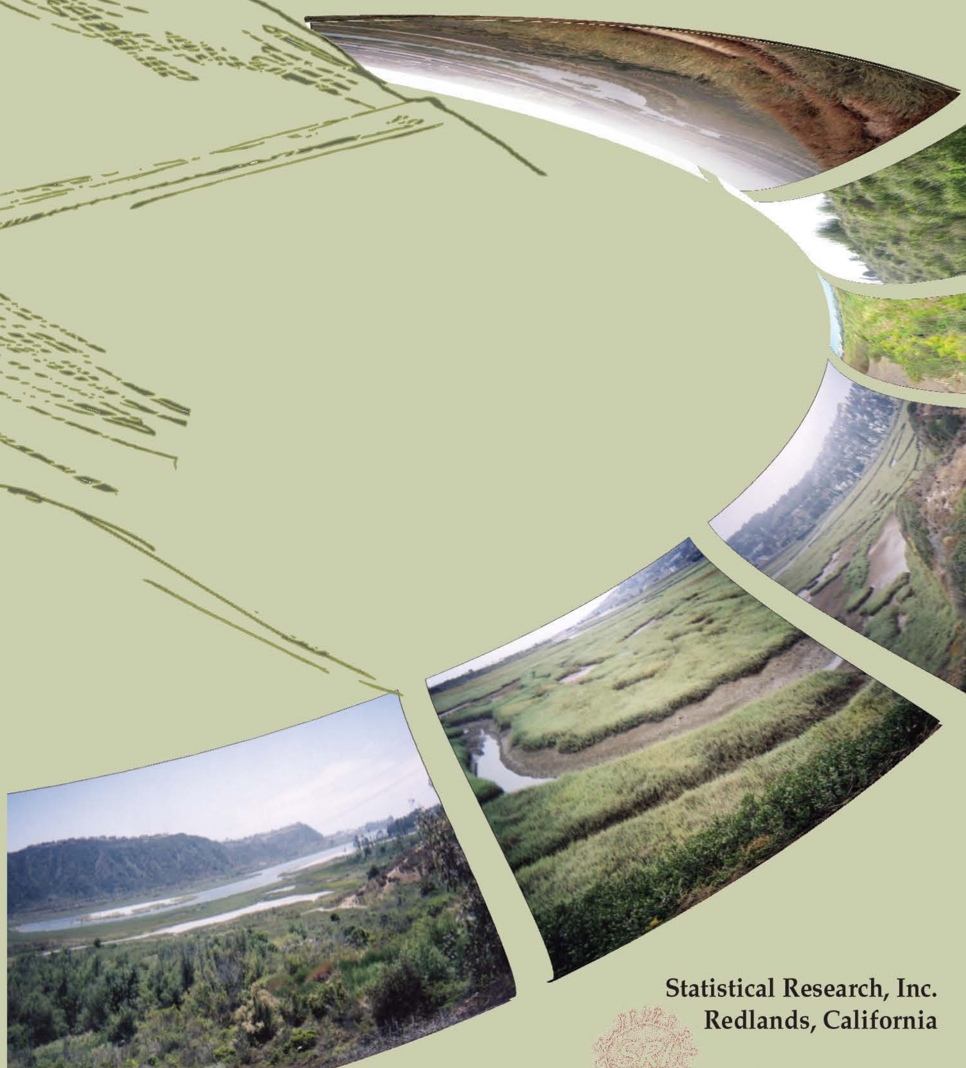
Overlooking the Wetlands

Archaeological Investigations at the West Bluffs Project CA-LAN-63, CA-LAN-64, and CA-LAN-206A Playa del Rey, California

Edited by John G. Douglass, Jeffrey H. Altschul, and Richard Ciolek-Torrello



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Volume 2

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Chapter 1

Introduction

John G. Douglass and Jeffrey H. Altschul

This report details the archaeological monitoring and data recovery efforts undertaken by Statistical Research, Inc. (SRI), at CA-LAN-63, CA-LAN-64 and CA-LAN-206A (hereinafter the prefix CA- will be omitted), archaeological sites located at the West Bluffs property in Playa del Rey, California (Figure 1.1). LAN-64 and LAN-206A were solely prehistoric, whereas LAN-63 contained both prehistoric and historical-period components. The archaeological monitoring and data recovery, scheduled in advance of residential construction on the property, was conducted in three phases: remote sensing work from September 7 to 14, 2000; data recovery from September 11 to 29, 2000; and subsequent data recovery and monitoring from May 14 to September 4, 2003. Additional archaeological monitoring by SRI and Native American monitoring was conducted between September 5, 2003, and March 19, 2004 (Douglass and Altschul 2004a), and between September 16 and October 13, 2004 (Douglass and Altschul 2004b). All this work was conducted to comply with the conditions of approval protecting cultural resources stipulated in the October 1998 Subsequent Final Environmental Impact Report (SEIR) and to fully implement the historic properties treatment plan (HPTP) (Altschul et al. 2000). In 2000, remote sensing was conducted to create a noninvasive map of LAN-63 and LAN-64 to identify potential features. Archaeologists from SRI and remote sensing experts analyzed the subsequent data and used it to guide excavation. In 2003, archaeological data recovery and monitoring of grading occurred within the mapped boundaries of all three sites and, in several cases, extended well outside of them. Along the edge of the bluff and Hastings Canyon, grading occurred as close to the edge as was safe. The work was sponsored by the Catellus Residential Group (Catellus), in accordance with a memorandum of agreement (MOA) between the U.S. Army Corps of Engineers, Los Angeles District (Corps); the California State Historic Preservation Officer (SHPO); Catellus; and representatives from the Gabrielino/Tongva Indians of California Tribal Council and the Gabrielino/Tongva Tribal Council.

Regulatory Framework

The West Bluffs project is overseen by several federal, state, and local regulatory agencies in regard to the cultural resources present on the property in compliance with various applicable laws. The principal statutes discussed here are Section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended (16 U.S. Code 470f), Section 404 of the Clean Water Act, the California Environmental Quality Act (CEQA), and the California Coastal Act.

The proposed development at West Bluffs will consist of 114 single-family residential units, three parks, and other open space. Construction required filling an erosional feature, locally known as Hastings Canyon, that would impact jurisdictional waters of the United States. Pursuant to Section 404 of the Clean Water Act, development of the property required a permit from the Corps. Such a permit is considered an undertaking as defined by the NHPA, requiring the Corps to comply with Section 106 of the NHPA. The Corps, in consultation with the SHPO and two organizations representing different

Gabrielino groups, defined the area of potential effects (APE), as the portion of the development site in and immediately surrounding Hastings Canyon. Historic properties found within the APE would have to be treated according to federal law.

In addition to the Corps's jurisdiction, the California Coastal Commission had regulatory control over the bluff face and foot of the West Bluffs property pursuant to the California Coastal Act. Because none of the archaeological sites on the property are mapped within the coastal zone, however, this act does not apply to them. Similarly, the California Department of Transportation (Caltrans) has a regulatory interest in the project due to the construction of a road that enters Lincoln Boulevard. This construction work necessitated Catellus to apply for an encroachment permit from Caltrans. As a result, Caltrans, the permitting agency, has the obligation to consider the effect of the road construction on cultural resources. However, because the Corps had already been determined to be the lead federal agency for compliance with Section 106 of the NHPA, and the City of Los Angeles was taking the lead for CEQA compliance (discussed below), Caltrans has deferred its archaeological oversight to the Corps and the City of Los Angeles.

The West Bluffs development was considered a "project" subject to CEQA and CEQA Guidelines, as amended. For potential impacts to a cultural property to be considered significant under CEQA, the resource in question must be a "historical resource"; that is, one that is listed in or determined to be eligible for listing in the California Register of Historical Resources (CRHR), included in a local register of historical resources, or determined by the lead agency to be a historical resource (CEQA Section 21084.1; CEQA Guidelines 15064.5). The controlled destruction of archaeological sites at the West Bluffs project is considered, under CEQA, a significant effect on the environment because there is "the potential to substantially . . . eliminate important examples of the major periods of California history or prehistory" (CEQA Guidelines 15065).

For projects that affect "unique" archaeological resources in California, Section 21083.2 of CEQA requires the lead state or local agency (in this case, the City of Los Angeles) to treat adverse effects to those resources as a significant effect and prepare an environmental impact report (EIR). A "unique" archaeological resource is defined as:

> an archaeological artifact, object, or site, about which it can be clearly demonstrated that, without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:
>
> (1) Contains information needed to answer important scientific research questions and there is a demonstrable public interest in that information.
>
> (2) Has a special and particular quality such as being the oldest of its type or the best available example of its type,
>
> (3) Is directly associated with a scientifically recognized important prehistoric or historic event or person.

Because of the presence of three archaeological sites on the West Bluffs property, CEQA applies to the entire 44-acre parcel. The City of Los Angeles has a statutory obligation to ensure that CEQA regulations are followed.

Regulatory History

In 1986, Howard Hughes Realty, Inc., hired Archaeological Associates to test LAN-63 and LAN-64 as part of the process of evaluating the significance of cultural resources on the West Bluffs property under CEQA. It was at this time that David Van Horn, of Archaeological Associates, designated a surface scatter on the southwestern corner of the property as LAN-206A. Van Horn (1987) and his associates developed an excavation plan, as required by CEQA, that was approved by a senior advisory board established for the project. This board was composed of Franklin Fenenga, Clement Meighan, Charles Rozaire, James Sackett, and William Wallace. In his report, Van Horn (1987) concluded that the adverse effects of the proposed development at LAN-63 and LAN-64, under CEQA, had been adequately mitigated through archaeological study, and the senior advisory board agreed. After this work was complete, however, Howard Hughes Realty, Inc., did not pursue development of the vacant property.

In 1997, SRI evaluated the adequacy of previous cultural resource investigations on the West Bluffs property in preparation for the submission of an EIR. An EIR had been prepared for a previous developmental proposal for the property in 1993–1994 but was never certified by the City of Los Angeles. Altschul (1997) assessed previous work by Van Horn (1986, 1987) and concluded that the data recovery efforts met CEQA requirements for mitigation of the cultural resources (see also Altschul 1999). The City of Los Angeles agreed with this assessment. SRI proposed a monitoring program as part of their evaluation, which was approved by the City of Los Angeles, under CEQA, as portions of the EIR and SEIR. This monitoring program under CEQA is considered a portion of the data recovery program under NHPA Section 106.

The Corps reviewed Van Horn and his associates' work and determined, in consultation with the SHPO and two Gabrielino groups, that LAN-64 was eligible for listing in the National Register of Historic Places (NRHP), but that LAN-206A was not. The Corps also stated that their regulatory interest in the West Bluffs project stopped at LAN-64, rather than also including LAN-63. The Corps also determined that regardless of the fact that Van Horn's work met CEQA standards, it did not meet NHPA standards. Because of competing regulatory standards for different sites on the property, SRI adopted Section 106 standards, which are the more stringent standards for archaeological investigation. As a result, SRI submitted a HPTP for LAN-64 (Altschul et al. 2000) that went well beyond measures required by CEQA. Moreover, to ensure comparability of treatment, the standards set forth in the HPTP for LAN-64 were adopted for LAN-63. LAN-206A was found not eligible for listing in the NRHP. For this report, however, collected data was treated similarly to that at the other sites on the property. This treatment plan called for three phases of data recovery and monitoring:

I. *Exploration and Discovery.* This first portion consisted of remote sensing of both LAN-63 and LAN-64. This nondestructive exploration mapped anomalies which could be prehistoric features or burials.

II. *Feature Recovery.* In this stage, the anomalies identified with remote sensing were excavated to find significant cultural features and burials. During this portion of data recovery, 21 features were excavated at LAN-63, whereas none were found at LAN-64. No burials were identified during this feature recovery portion of data recovery.

III. *Controlled Grading.* After the completion of feature excavation, the project area was graded, under the supervision of archaeologists and Native Americans.

Hereafter, this program will be referred to as a data recovery program. All three stages of this program are reported here. In November 1999, consultation with various Native American Gabrielino/Tongva communities was formally initiated by SRI, acting as an agent for Catellus, and the Corps for the creation of an MOA. The Advisory Council on Historic Preservation (Council) was notified of the impending project and was provided the opportunity to become a signatory party of the MOA. The Council reviewed the material and declined participation as per regulations effective June 17, 1999, implementing Section 106 of the NHPA. A final version of the MOA was signed by the Corps, the SHPO, Catellus, and representatives from the Gabrielino/Tongva Indians of California Tribal Council and the Gabrielino/Tongva Tribal Council in July 2000. On July 6, 2005, it was determined by the Corps, in accordance with Stipulation VII of the MOA, that the MOA for West Bluffs shall remain in effect after July 7, 2005, until such time that all work under the HPTP is satisfactorily completed.

Research Objectives

The research objectives for the current project are designed to test competing models of site formation and site structure at West Bluffs and to understand more broadly the relationship between habitation at the West Bluffs sites during the Intermediate period (3000–1000 B.P.) and other sites in the greater Ballona region. As discussed in Chapter 3, previous research at West Bluffs (Van Horn 1987) concluded that occupation at LAN-63 and LAN-64 had been temporary during the Intermediate period. The current research was designed to test this model with a competing one, which suggests that there was more-permanent habitation and site structure at the two primary sites on the property.

An important point to make regarding the research for the West Bluffs project is that the data recovery work is designed to test and complement the previous data recovery work done by Van Horn (1987). As discussed above, the data recovery work done by Van Horn in the 1980s was found by the Corps to be adequate for CEQA, but not Section 106. The research design (Chapter 3; see also the HPTP for West Bluffs [Altschul et al. 2000]) for the work discussed in this report was created to use the Van Horn data in addition to data collected by SRI to better understand the sites at West Bluffs in relation to others in the Ballona. This report tests models proposed by Van Horn (1987), based on his previous work at LAN-63 and LAN-64, and offers the reader new insight into this well-documented area of west Los Angeles to better understand coastal adaptions by hunter-gather societies like the prehistoric Tongva/Gabrielino.

Report Organization

This report is divided into 16 chapters. In Chapter 1, we laid the interpretive foundation for this report by presenting the background to the current project. This included both a regulatory and historical background to the project. After this introduction, Chapter 2 presents a detailed summary of the prehistoric and historical-period background for both the specific project area at West Bluffs, as well as the larger regional background in the Ballona and greater Los Angeles. Chapter 3 presents both previous research in the Ballona and at West Bluffs and outlines the current research questions and foci for the project area in light of these previous excavations. Chapter 4 presents a detailed analysis of the soils and stratigraphy on the project area and how this relates to the archaeological investigations. Chapter 5 explains the methods and results of geophysical work at West Bluffs conducted prior to SRI's hand excavation on the property in 2000. Chapter 6 outlines the methods used during the various phases of the project and summarizes the results of the data recovery program. In a related role, Chapter 7 describes specific features studied as part of the analytical sample for this report. Chapters 8 through 11 detail specific analyses of different classes of artifacts, respectively flaked and ground stone, beads and ornaments, vertebrate faunal remains, and invertebrate faunal remains. Next, remains related to environmental and subsistence strategies are investigated in the micro- and macrobotanical remains chapter, Chapter 12. Human remains identified at West Bluffs, including descriptions of burials, are discussed in Chapter 13. Chapters 14 and 15 synthesize and evaluate the detailed data presented in Chapters 5–13. In Chapter 14, chronology for both the project area and the greater Ballona area is evaluated, and Chapter 15 discusses subsistence strategies present at the three West Bluffs sites. Finally, in Chapter 16, the various data collected and analyzed are discussed, research questions are evaluated, and conclusions are drawn.

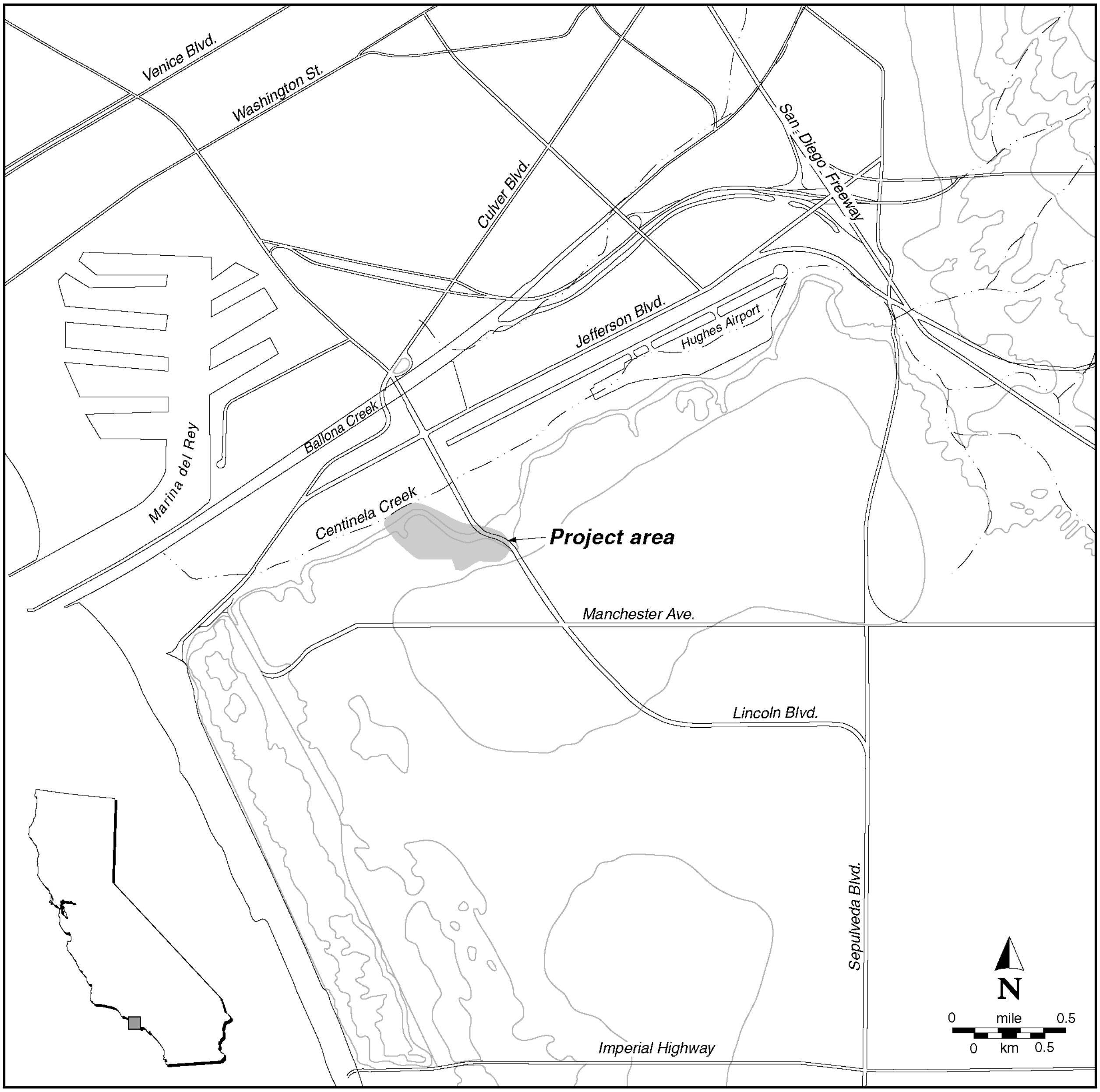


Figure 1.1. The West Bluffs project area.

Chapter 2

Research Context

Anne Q. Stoll, Benjamin R. Vargas, John G. Douglass, and Frederick W. Lange

In this chapter, we summarize the culture history of the Southern California coast, focusing on the area surrounding the West Bluffs property, including the Ballona Lagoon area (Figure 2.1).

Setting

The West Bluffs project area is located on the edge of an uplifted, windy cliff, overlooking a mud flat known as the Ballona Wetlands some 150 feet below (Figure 2.2). At its northeastern edge, the track of Lincoln Boulevard crosses the flats for 0.5 mile, crosses over channelized Ballona Creek, then heads on to the modern, glass-and-steel high-rises of Marina del Rey. Several hundred years ago, before it became choked with silt, the flatlands below were a tidal marsh marked by narrow channels of fresh to brackish water meandering toward the beach. Before that, the marsh was the Ballona Lagoon, an expanse of shallow, open water. One can imagine this coastal lagoon fringed by dense stands of sedges and reeds and alive with the calls of nesting shore birds. Fingers of sandy alluvium, which reached out from the base of the bluffs, made inviting places for prehistoric people to rest and camp.

The bluffs overlooking the wetlands also were an important area for prehistoric settlement. These bluffs occupy the northernmost edge of the Del Rey Hills (also referred to as the El Segundo Sand Hills or the Ballona Escarpment), which are in turn part of the larger Palos Verdes Hills. The escarpment ranges in width between 2 and 5 miles and in height between 85 and 185 feet above mean sea level (AMSL). The Del Rey Hills are interpreted as ancient sand bars that have been reworked by wind and water. Aerial photographs and older topographic maps show that, prior to the development of the City of Westchester, these hills formed a region of small knolls separated by a network of erosional sinks and drainages. At times, the bluff tops were dotted with vernal pools, small hardpan-floored depressions that filled with water during the winter (Barbour and Major 1988). The bluff faces are incised by several erosional gullies and a north-facing ravine named Hastings Canyon, all of which would have provided access to the lowlands. An important topographic feature adjacent to the east of the project area is the natural inset of the escarpment now occupied by Lincoln Boulevard. As erosion cut into the bluffs, a sandy ramp was created, representing a natural access route for the prehistoric inhabitants of the bluff tops to reach the resources of the lagoon below. To the south of the bluffs was the Los Angeles coastal prairie, which contained numerous resources to prehistoric inhabitants in addition to those in the Ballona Lagoon area to the north of the bluffs.

Paleoenvironment

Paleoenvironmental reconstruction of the ecosystem that encompassed both the bluffs and the Ballona Wetlands has progressed significantly during SRI's 10 years of research in the area (Altschul et al. 1991, 1992, 1998, 1999; Grenda et al. 1994). Geomorphological forces active during the Pleistocene were responsible for much of the landscape visible today. In the project area, Pleistocene marine and non-marine sediments known as Palos Verdes Sand are overlain by younger dune sands of Holocene age. Portions of the Palos Verdes Sand are highly fossiliferous. Tectonic uplift formed these marine terraces along the mainland coast of California, as determined by radiometric dating of fossil coral (Valentine and Veeh 1969).

Global sea level rise during the Pleistocene, beginning approximately 18,000 years B.P., was the formative factor in the Ballona Wetlands. Initially the inundation of the preexisting shoreline created an open bay. For 6,000 years, sea level rise and tectonic activity in this area were approximately equal and affected one another, leading to a period of relative stability in the shoreline. This inundation continued until about 7,000 years B.P., when the rate of rise of sea level tapered off and other factors, such as the sedimentation rate, became more significant in determining shoreline position. At approximately 7,000 B.P., a sand barrier developed across the outlet, creating a coastal lagoon, defined as "an area of relatively shallow water that has been partly or wholly sealed off from the sea by the formation of depositional barriers, usually of sand or shingle (gravel), built up above high tide by wave action" (Bird 1994). During the next 2,000 years, the lagoon existed in a quasi-static equilibrium state marked by extensive marshes and tidal flats, alternating between fresh- and saltwater conditions. By 5,000 B.P., the sand barrier was permanent. The Ballona gradually evolved from an open estuary to a lagoonal estuary increasingly influenced by freshwater discharge. Higher and drier sandy "islands" formed within the marsh and may have served as seasonal occupation sites for prehistoric populations using the lagoon (Brevik et al. 1999).

Core samples taken in the Ballona sediments show that between 4240 and 1070 B.P., freshwater influences became dominant. The edge of the open-water lagoon probably reached to just west of where Lincoln Boulevard now runs. Centinela Creek, transporting freshwater from springs in the Baldwin Hills, flowed along the base of the bluffs in this area and provided a reliable source of potable water in all but the driest years. In terms of resource procurement and habitation sites, an extensive range of environmental options was available to prehistoric people in and around the Ballona. Slowly, over a period of some 3,000 years, the marsh advanced westward as the lagoon filled with sediment to become mud flats.

A model of long-term predictability for lagoon environments has intriguing implications for understanding human adaptation to the Ballona over time. In fact, an estuary can be seen as stable only in the broadest sense. Within any given lagoon system, the forces of nature are in constant flux, affected daily by tides and seasonally by river runoff and weather. However, the dynamic qualities of a lagoon environment also make it reliably productive of usable resources. Taking a large-scale view, the Ballona can be viewed as a cohesive, relatively predictable ecological system encompassing bluff tops, terraces, and lagoon edges. All other factors being equal, one might expect resource predictability to be matched by a tendency toward sedentism rather than mobility in human populations. The effect of catastrophic environmental events such as floods, severe droughts, or earthquakes, might assume greater importance in determining the spatial distribution of human populations over the landscape against an inherently stable backdrop (Grenda et al. 1994). Nevertheless, sudden natural events would cause only temporary displacement of people or abandonment of parts of the area, but would not be expected to result in a true hiatus of occupation of such a rich resource. Our attention is now shifting to the importance of the Los Angeles prairie as a second important resource as the result of recent paleoenvironmental work presented by Peter Wigand in this report.

A 1,700-year gap in occupation between about 4700 and 3000 B.P. is, however, a highlighted feature of the culture history proposed by previous archaeological research on the bluff tops (Van Horn 1987).

Our view of this gap is now being revised. At the most basic level, the integrity and contextual association of the dates with the cultural material is unclear. One goal of this investigation is to determine whether this hiatus reflects true abandonment or is perhaps a failure of previous investigations to acquire and analyze the data necessary to test this question.

Prehistoric Chronology

Paleocoastal Period

Spanning prehistory prior to 6500 B.P., the earliest period of human occupation on the Southern California Bight, termed the Paleocoastal period, is understood in only the broadest terms (Figure 2.3; see Figures 2.1 and 2.2). Sites from this time period are characterized by an abundance of ground stone artifacts, stone ornaments, large, crude projectile points, and charm stones. The people of this early period, often referred to as Paleoindians, located their sites in grassland and sagebrush communities on elevated landforms somewhat distant from the modern shoreline (Vellanoweth and Altschul 2002:100). Erlandson and Colten (1991:3) assert that as many as 75 Paleocoastal sites dating in excess of 7500 B.P. are known from the California coast. They are not found evenly distributed along the coastline, but instead are in two large clusters. One group ranges from San Luis Obispo south to the northern and western Santa Barbara coast and includes the north coasts of Santa Rosa and San Miguel Islands. The second cluster of early sites is concentrated around the ancient lagoons of San Diego County.

Solid evidence for Paleocoastal sites in the intervening areas of Ventura, Los Angeles, and Orange Counties is scant and problematic. Breschini et al. (1992) listed five sites in Los Angeles County that have produced radiocarbon dates older than 7000 B.P. These five are the Malaga Cove site (LAN-138), the La Brea Tar Pits site (LAN-159), the Haverty or Angeles Mesa site (LAN-171), the Los Angeles Man site (LAN-172), and LAN-271. Questions revolving around the dating of these sites have made their antiquity suspect, however. For example, the early Holocene age of LAN-271 is based on marine shell now thought to have been contaminated by fossil shell (Erlandson 1994:222). A short review of these sites explains the circumstances which have fostered this uncertainty.

Reports of evidence of "Early Man" in Los Angeles were heralded as a major discovery in 1914, when human remains were found in the Rancho La Brea Tar Pits (LAN-159) in general association with the bones of extinct animals (Merriam 1914). Assuming the remains to be contemporaneous with Pleistocene Rancholabrean fauna, this find spawned the sensational notion that human occupation of southern California extended back as far as 34,000 years B.P., clouding serious investigation for years to come. Radiocarbon dates on archaeological materials have brought the range into the more reasonable span of 9000–4450 B.P.; nevertheless, problems inherent in dating bone-collagen extract and in decontaminating samples taken from a tar seep still suggest these dates should be regarded with caution. Contamination of the skeletal material from oil impregnation cannot be ruled out (Erlandson 1994:222).

The discovery of deeply buried human skeletal material by construction workers for the Haverty Company in 1924 at Angeles Mesa (LAN-171) in the Baldwin Hills (Stock 1924) provided more fuel for the debate. Skeletal remains of at least eight individuals—three males, three females and two subadults of indeterminate sex—were uncovered in close association at this site at depths between 5.8 and 7 m (19.03 and 22.97 feet) (Brooks et al. 1990). Bone awl fragments, a quartzite core tool, and some freshwater gastropods were found near the skeletons in the marshy area at the base of the Baldwin Hills. The depth of the finds and the partial mineralization of some of the bones suggested to Stock (1924) that the remains might be Paleoindian; a subsequent amino-acid racemization (AAR) age estimate of more than 50,000 years made some 60 years later seemed to confirm this conclusion (Taylor et al. 1985:137).
In 1936, a third discovery of a so-called Early Man was made: a single skeleton, dubbed "Los Angeles

Man," was uncovered 2 miles west of Angeles Mesa (at LAN-172) in a similar stratigraphic context to mammoth bones (Lopatin 1940). By this time, even some of the early skeptics were convinced.

These finds thrust the topic of Early Man in the Los Angeles Basin into an era of controversy from which it has only recently begun to emerge, as more reliable radiocarbon dates have become available. Conducting the first comprehensive, multidisciplinary review of the Angeles Mesa remains, Sheilagh Brooks and her colleagues (Brooks et al. 1990) subjected the bones to new conventional (decay-counting) ^{14}C dating, then obtained a suite of accelerator mass spectrometry (AMS) dates from noncollagen organic bone (osteocalcin) components as a cross-check.

The wide range of dates and disparate results depend on the technique used and indicate that dating issues for these sites remain unresolved. Haverty Man No. 4, for example, is apparently anywhere from 3,870 ± 350 to 15,900 ± 250 years old, a span that exceeds an acceptable margin of error for radiocarbon dates. As to their significance, Brooks et al. (1990:80) felt that "the assumption that all of the Haverty skeletons are of similar age also may need to be reassessed," to which Erlandson countered, "It is hard to imagine that the burials are not temporally related" (Erlandson 1994:223). Without additional data about their original context, not likely to be obtained at this late date, or a new series of more reliable dates, the meaning of the Haverty skeletons remains in limbo.

The Malaga Cove site (LAN-138) figures importantly in the discussion of early Holocene adaptions in the Los Angeles area, but its inclusion on the list of Paleocoastal sites is questionable. A multicomponent site located on a bluff overlooking the Santa Monica Bay just north of the Palos Verdes Peninsula, Malaga Cove was "sampled" by collectors such as F. M. Palmer as early as 1906 (Palmer 1906). Two loci at Malaga Cove were first systematically excavated by Richard Van Valkenburgh in 1931–1932 as part of the Van Bergen–Los Angeles County Museum Expedition; however, he never published the results of this work. As Wallace commented, "It is a great pity that Van Valkenburgh never got around to reporting the results of his investigations, for he found some unique materials and his field notes indicate that he had some good insights into local prehistory" (Wallace 1984:1).

In 1936–1937, Edwin F. Walker of the Southwest Museum began excavation at Malaga Cove (LAN-138) (Walker 1937, 1952). Walker identified four discrete occupational strata in the 28-foot-(8.5-m-) deep sequence; the stratum of interest in the search for Early Man was the lowest of the four, about a meter (3 feet) thick, which he labeled Level I. Walker called the Level I occupants of the site "the Scraper People," believing them to belong to the Paleocoastal period (Walker 1937), which Wallace (1984) later endorsed by equating them with the San Dieguito culture. Both men based their conclusions on an analysis of the artifacts found—specifically, small chert drills that Walker called "microliths," worked shells, flaked and core tools, "rude scrapers," and two crude, leaf-shaped bifaces. Bone and shell artifacts were relatively abundant in Level I, as were shell beads (primarily spire-removed *Olivella*) and bone beads, but milling stones were entirely absent (Walker 1952).

Subsequent radiocarbon dating at Malaga Cove produced a series of dates ranging from 215 ± 80 B.P. (UCLA-1008A) on material from a disturbed area of the site to 7130 B.P. (UCR-1196) on a shell bivalve (Breschini et al. 1992:14). The oldest date was obtained from a shell removed from the sea cliff in an unknown stratigraphic context, throwing its accuracy in some doubt (Erlandson 1994:224). The possibility exists that what Walker labeled as Level I at Malaga was not a discrete deposit. Careful examination of photographs taken during Walker's excavation (Braun Library, Southwest Museum, Walker Papers, Nitrate Box 17) indicated significant bioturbation in Level II at its contact with Level I. In the absence of radiocarbon dates from a secure stratigraphic context, the antiquity of Level I at Malaga Cove remains in doubt.

As will be discussed below for the Millingstone period, a series of dates from LAN-64 at West Bluffs dated to what in some areas of southern California would be termed the Paleocoastal period. We feel secure that the contexts of these dates, shallow pits dug into the B horizon, are good ones for dating the features (see also the chronology chapter, Chapter 14). The collections from these features (shell dumps, small amounts of faunal bone and debitage), however, did not resemble what is normally considered a Paleocoastal assemblage (abundance of ground stone; large, crude projectile points, etc.). As a result, we feel that these early dates better reflect Millingstone period, and therefore, the local chronology for western Los Angeles County reflects this (see Figures 2.1 and 2.3).

Millingstone Period

The Millingstone period, sometimes referred to as the Early period in some southern California chronologies, is currently conceived of as a 5,000-year span, beginning about 8,500 B.P., and ending with the first dramatic increase in regional human population about 3,000 B.P. (see Figures 2.1–2.3). Important sites in the region that help define the period are the Angeles Mesa site, the Tank Site (LAN-1) (Treganza and Bierman 1958), the Malaga Cove site (LAN-138) (Hubbs et al. 1960:201; Wallace 1955), and the Little Sycamore Site (Wallace 1954; Wallace et al. 1956). Materially, this time period is identified in part by an artifact assemblage that includes specific artifacts, such as discoidals, crescents, cogged stones, and certain projectile points. As the name of the time period suggests, there tend to be a large proportion of ground stone at Millingstone period sites.

Millingstone period sites have also been discovered in the Ballona, on the bluff-top sites adjacent to the West Bluffs property, and to the east in the Baldwin Hills, where ephemeral camps were located near an inland swamp known as Las Cienegas. This Millingstone period in the Ballona region coincides with the era of relative environmental equilibrium when the lagoon was first established, as discussed above. Early archaeological surveys of this area identified a series of 15 sites in the upper Ballona with artifact collections that included cogged stones, a few large projectile points, and a large number of ground stones (Farmer 1934, 1936; Rozaire and Belous 1950). The Berger Street site (LAN-206), located just to the southwest of the West Bluffs property, was among this group of sites. A component of this site, LAN-206A, was located in the southwest corner of the project area. It is unclear if the component on the West Bluffs property dates to the Millingstone period or to a later time period.

Bluff top chronology, as established by Van Horn (1987), was known to begin until recently with a radiocarbon date from a single shell fragment recovered from 50 to 60 cm below the surface at the Berger site (LAN-206). The shell valve (*Chione* sp.) returned a date of 6480 B.P. (Van Horn and White 1997c:19). Tenuous though it was, this single radiocarbon date, the earliest from any site in the Ballona region, had been used until recently to mark the advent of the Millingstone period (Altschul et al. 1998). Evidence that distinctive artifact types were produced by the people living on the bluffs during the Millingstone period found at various sites in the Del Rey Hills (Lambert 1983), as discussed above, indicates an early occupation that was more widespread than is currently documented, perhaps even earlier than suggested by the chronometric date from the Berger site. Altschul and his colleagues (Altschul and Ciolek-Torrello 1990; Altschul, Ciolek-Torrello, and Homburg 1992; Altschul, Homburg, and Ciolek-Torrello 1992) have echoed Wallace's earlier (1984) concern that the presence of Lake Mohave points at the Hughes site (LAN-59) is difficult to reconcile with later radiocarbon dates from sites in the Del Rey Hills, and that probably this artifact type reflects a much earlier occupation of the bluff tops. Interestingly, evidence of occupation of the Ballona lowlands during the Millingstone period is scarce, but not completely absent. As documented in this report, however, there is now strong evidence of Millingstone occupation both on the bluff top (at LAN-64), at the base of the Bluff (LAN-62), and along Ballona Creek (LAN-54). Especially at the base of the bluff, at LAN-62, there appears to be numerous episodes of occupation from the Millingstone period up to the Mission period.

Van Horn and White (1997c) argued that the occupants of the Millingstone period component at the Berger Street site (LAN-206) fished and collected shellfish from the nearby Ballona estuary. The paucity of tools and faunal remains in the midden was consistent with a short-lived campsite. Presumably, individual occupations did not last more than a few weeks at any one time. The picture that emerged is one of brief forays to the lagoon from campsites on the bluff tops overlooking the bay. In small mobile groups, Millingstone period residents of the Ballona region exploited nearshore and lagoonal fish and shellfish. The data analyzed and presented in this report from several shell dumps at LAN-64 dating to this period seem to suggest a similar settlement pattern to that argued by Van Horn and White.

During the Millingstone period, there is a hiatus between approximately 6,000 to 5,000 years ago (between the early and late components of the Millingstone period) which is not well understood (see Figures 2.1 and 2.2). The lack of radiocarbon dates during this approximately 1,000-year period may suggest abandonment during this time period. An abandonment of the Newport Bay area to the south during the Late Millingstone period (ca. 4,700 to 3,000 B.P.) has been attributed to a shift in the course of the Santa Ana River (Hurd and Macko 1989). Similarly, the propensity of the Los Angeles River to change its course between the Ballona Lagoon and San Pedro Bay may have caused the abandonment of the Del Rey Hills for a time during this period. As mentioned above, the possibility, however, also exists that this hiatus is more apparent than real and represents a data gap or calibration error.

Many questions remain regarding the Millingstone period in the Ballona region. The dating of cultural material from this period continues to pose methodological and interpretive challenges. One of the primary concerns is that, because some sites are multicomponent, it may be difficult to identify fully early components which are ephemeral. In the case of LAN-64, for example, controlled grading of the site was possibly the only way to fully identify this early component of the site; sampling through data recovery hand excavation by both Van Horn and SRI missed this component entirely. The same may be true of LAN-206 and LAN-206A, as discussed above. Although these problems exist, however, recovery of features at sites like those on the West Bluffs project area offer opportunities to develop models more fully to better understand this early time period in the occupation of the Ballona region.

Intermediate Period

After ca. 3000 B.P., both the bluffs and the Ballona received an influx of settlers. Stability in settlement patterns, economic activities, mortuary practices, and technology suggest this distinct occupation lasted until around 1000 B.P., defining the Intermediate period (also called the Middle period in some southern California chronologies) (see Figures 2.1–2.3). The Intermediate period at major sites, such as Level 3 at Malaga Cove (LAN-138), is represented by implements for fishing and sea-mammal hunting. This occupation, thought to date to ca. 1450 B.P., is also characterized by big stone mortars and pestles, abalone shellfish hooks, bone harpoon barbs, chert knives and scrapers, steatite vessels, and shell ornaments. These artifacts marked the beginnings of maritime exploitation at the site (Walker 1952; Wallace 1984).

Five major settlements on the bluffs (LAN-59, LAN-61, LAN-63, LAN-64, and LAN-206) were occupied more or less continually during the Intermediate period, from 3000 to 1000 B.P. In addition, one site, LAN-54, located along Ballona Creek, was occupied during the early portion of this period. Three of these, LAN-63, LAN-64, and LAN-206A, are located within the project area at West Bluffs. Large midden sites were established on almost every elevated knoll along the edge of the Westchester Hills. These sites contain relatively thick deposits, many of which yield radiocarbon dates that span the entire Intermediate period (Altschul et al. 1999, 2003). Intermediate period sites also appear at the foot of the bluffs along Centinela Creek in an almost continuous occupation strip (LAN-60, LAN-62, LAN-193/H and LAN-2768)(Altschul et al. 1999; Grenda et al. 1994). Previous researchers in the Ballona region have hypothesized that some Intermediate period cultural traits indicate the arrival of people from the desert region (Van Horn 1987) (see also the chronology chapter, Chapter 14). These traits include tanged projectile points, cremation of the dead, and a lack of shell artifacts. The paucity of shellfish in collections from Intermediate period creek-edge sites and the preference of stone over shell as raw material for making beads also suggest the presence of desert-adapted people, those without a strong maritime tradition. Bluff-top sites, however, such as LAN-63 in the West Bluffs project area, had a high density of shell in particular portions of the midden. The question of desert migrations during the Intermediate period has been discussed by many scholars in the region over the last four decades (Altschul and Grenda

2002; Altschul et al. 2003; Ciolek-Torrello and Grenda 2001; Koerper 1979; Kowta 1961; Kroeber 1925; Moratto 1984; True 1966; Van Horn 1987, 1990). Most have suggested that an arrival date of around 1450 B.P. is consistent with the data; however, a few have argued for a much earlier migration. Both may be correct; it is possible that multiple migrations took place over hundreds, if not thousands, of years.

Intermediate period sites in the Del Rey Hills also contain evidence of a split-cobble lithic industry common at coastal and inland sites, as well as a microlith tradition that is unlike any other lithic technology observed on the coast (Van Horn 1990). Although these two observations were used to argue for the desert migration theory, in fact the significance of split-cobble artifacts is unclear. Their production might simply have been a function of raw materials being readily available to the bluff top residents. Furthermore, the presence of a microlith industry in the Ballona and the absence of a comparable industry in other contemporary coastal estuaries such as Newport Bay and Bolsa Chica may reflect social boundaries more than economic activities. The fact that the bluff top microblades did not appear to have been used in shell bead manufacturing (as they were on Santa Cruz Island, for example) is again suggestive of a desert-related technology. As evidence suggesting a desert migration continues to accumulate, the need for further testing at the bluff sites to resolve chronological issues becomes imperative. Numerous sites below the bluffs, along the lagoon edge or along the banks of Centinela Creek, were also occupied during this period (including LAN-60, LAN-62, LAN-193 and LAN-2768). Intermediate period sites in the Ballona also contain projectile point types that appear to derive from desert styles and, at LAN-62, may show a shift from inhumation to cremation burial practices (Freeman et al. 1987; Peck 1947). Recent research by SRI at sites at the base of the bluff, such as LAN-62, also revealed an occupation prior to the Intermediate period (as discussed for the Millingstone period, above) that was dispersed and relatively sparse.

In sum, then, there are differences in settlement patterns and economic organization from the previous period. In the Ballona region, the number of settlements, and the types of settlements, appear to change. Although there was occupation during the Millingstone period both above and below the bluff, much of this occupation appeared to be sparse and temporary. During the Intermediate period, there now appears to be much more intensive occupation both above and below the bluff. In addition, there is some evidence to suggest that there may have been a migration of population from the desert, as that area became drier and resources became scarcer. The Ballona, then, which in the Millingstone period was only marginally attractive to human settlement, experienced greater occupation during the Intermediate period.

Late Period

The Late period, beginning around 1000 B.P. and ending with European contact in A.D. 1542, was a time of tremendous population growth along the southern California coast (see Figures 2.1 and 2.3). A greater number and variety of sites have been found that date to the Late period than at any other time in prehistory. Villages with complex site layouts emerge, suggesting corresponding differentiation within the social system. No village sites, however, have been discovered in the Ballona area as yet.

Until recently, our understanding of the Late period in the Ballona Wetlands was limited to an analysis of relatively small sites on the periphery, such as LAN-47, known as the Admiralty site (see Figure 2.2). Data recovery at LAN-47 (Altschul, Homburg and Ciolek-Torrello 1992) revealed an occupation typical of the Late period throughout coastal California. Nearshore and estuarine species were most numerous in the faunal collection, and the lithic material was dominated by flake core, split-cobble, microlith, and bipolar technologies. However, the nature of life in the Ballona could not be assessed adequately from this small site.

Late period settlement, which had earlier been established along the upper reaches of Centinela Creek (Grenda et al. 1994), moved westward along the base of the bluffs following the increasing siltation of the lagoon. From the preliminary analysis of artifacts found during testing in the Ballona, it appeared that both LAN-211/H (Stoll and Taylor 2000) and LAN-1932/H (Taskiran and Stoll 2000a, 2000b) spanned the temporal gap between the Late period and the Protohistoric period. LAN-1932/H was a redeposited runway site which most likely hails originally from LAN-211. Both contained flaked glass and glass trade beads and may hold important clues to the survival of native populations into historical times and help answer questions concerning the existence and location of Guaspit (see Altschul 1999; Altschul et al. 1991; Van Horn and White 1997a, 1997b). LAN-211/H is undergoing data recovery during the fall of 2005 by SRI.

Another large Ballona site, the Peck site (LAN-62/H), also contains Late and Protohistoric period components. Previous excavation at this site (Peck 1947; Van Horn and Murray 1984) suggested this site may hold the key to answering many questions about the Late period. The presence of a well-developed midden, a wide range of artifacts and faunal remains, and the presence of burials all suggested it may have been a village site. This site underwent data recovery by SRI between November 2003 and September 2004 by SRI, and analysis is on-going. Excavation did confirm, however, a Late period component.

In the Ballona region, therefore, the Late period is not fully understood, in part due to the lack of data from a number of sites in the region. Within the boundaries of the West Bluffs property, there is little evidence to suggest a Late period occupation, outside of limited evidence in one location within the site boundaries of LAN-63, based on findings by Van Horn (1987) (see the chronology chapter for details).

Protohistoric and Early Historical Periods

The original Spanish contact with southern California was by water and was strongly tied to northern Baja California. In 1542, Juan Rodriguez Cabrillo sailed into the Santa Monica Bay, being the first Spaniard to see this part of California. In 1769, Portolá explored both by land and by sea, reaching as far north as the Monterey Peninsula. One of his soldiers, Juan Jose Dominguez, had traveled with both Portolá and Father Junipero Serra, and he eventually received the first Spanish land grant in the area in 1784, the Rancho San Pedro. The original grant encompassed 75,000 acres and included the entire Los Angeles harbor area. Although not directly affecting the Ballona/West Bluffs project area, this grant marks the beginning of our historical foundation for the project area.

The line between the Late and Protohistoric periods in southern California is admittedly an arbitrary one. Protohistory is defined as beginning with the European contact in A.D. 1542 and proceeding through the establishment of the Mission San Gabriel in 1771, when direct and recurrent contact began between the Gabrielino and the Spanish (King 1978:46). The early Historical period (also known as the Mission period) follows, dating from 1771 until secularization in 1834.

The Protohistoric period is arguably the least-documented interval in all of southern California prehistory. A distinct time bias against remains from this period can be seen in the work of some early archaeologists, such as Edwin Walker, who excavated in pursuit of Early Man, disregarding later occupants. Walker summarized the Protohistoric and early historical-period evidence he found at Malaga Cove in a single sentence: “Level 4 reached the historic stage as shown by the presence, at its very top, of a few small glass trade beads of the type introduced by Spaniards at the beginning of the 19th century” (Walker 1952:68). Similarly, scant evidence—three glass trade beads—of protohistoric occupation of the bluff tops overlooking the Ballona was found at LAN-63 (Van Horn 1987). Below the Loyola Marymount University bluff, the finds are more numerous: glass trade beads and early historical-period shell beads were recovered during testing at LAN-211/H, LAN-1932/H, and LAN-2676. Radiocarbon dates from LAN-2676, a redeposited midden located under Hughes’ runway, suggest that a portion of this largely Late period midden dates between A.D. 1450 and 1660 (Altschul et al. 1998). This redeposited site material is most likely a truncated late component from nearby LAN-62, located at the base of the bluff. Data recovery at LAN-211/H, which contains a Protohistoric component, is undergoing data recovery in the fall of 2005 by SRI. Whereas there was no Protohistoric period occupation on the bluff, outside of three beads identified by Van Horn (1987) at LAN-63, a substantial occupation along the edges of

Centinela Creek and the Ballona Lagoon might have been present during Protohistoric times. Current excavations by SRI at LAN-211, as well as analysis of some components of LAN-62, may offer important insight into this time period. There are no hard documentary data and only random historic artifacts for the West Bluffs side of the Ballona during the Protohistoric period (see the chapters on chronology and research, Chapters 14 and 3, for details).

The Search for Guaspita

It was initially hoped that the West Bluffs area might add some positive insights to the debate surrounding Protohistoric and early Historical period occupations in the Ballona, specifically the search for the Gabrielino village of Guaspita. Although for the past few years, the search for this village has been focused in the area east of Lincoln Avenue below the bluffs, there had been some previous speculation that one or more of the protohistoric villages might have been located in the West Bluffs sector of the Ballona (Van Horn 1987).

W. W. Robinson (1939a) learned in an interview with long-time Ballona resident Cristobal Machado that there were two communities of Native American laborers on the Rancho La Ballona, one near the Machado residential complex and the other at the base of the bluff below present-day Loyola Marymount University.

Guaspita was the name given to a land grant received by Antonio Ignacio Ávila, which later was combined with the Salinas land grant to become Rancho Sausal Redondo, present-day Westchester (Figure 2.4). McCawley included a copy of the *diseño* for the Rancho Sausal Redondo, which shows the names "Guspita" and "Coral de Guspita" on the bluff overlooking the "Rio de la Bayona" (Ballona Creek) in essentially the same location as the word "Guacho" is shown on the *diseño* for the Rancho La Ballona. This diseño also shows the "Casa de Y Bruno Avila" and the Aguaje de Centinela that was the spring that was the main motivation for the founding of the town of Inglewood and the beginning of the Centinela Ranch. Bruno Avila was the brother of Antonio Ignacio Avila, and he received the adobe from Ygnacio Machado. The Avila adobe had been built in 1826 on a hill near the springs, and today is located under the baseball diamond at Centinela Park.

Machado also told Robinson that the word "Guacho," sometimes written "Huacho" and shown on the eastern border of the rancho on the 1839 *diseño* for the Rancho Ballona, was a Native American term meaning "high place." Robinson felt this word referred to the Westchester Bluffs, on the southern edge of the Ballona (Robinson 1939a:104). Beneath the word "Guacho" is the wording "Lindero del Sr. A. I. Abila", meaning that the adjacent property was that of A. I. (Antonio Ignacio) Avila, first grantee of the Rancho Sausal Redondo. Thus, the "Guacho" or high place referred to is most likely the West Bluffs project area. Recent research has shown a connection between Guacho or Huacho and the Gabrielino place-name "Guaspita." (McCawley 1996:63).

The most thorough recent publication on the Gabrielino is *The First Angelinos* by William McCawley (1996). In this work, the author examined the issues surrounding a community he labeled "Saa'anga," noting the multiple contradictory statements in the historical and ethnographic records. McCawley continued his discussion of Gabrielino communities in the Ballona with a section on the place-name "Waachnga." He commented that the listed variant spellings—Guasna, Guashna, Guaspet, Guachpet, Guashpet, and Guaspita—"provide an important clue to the location of this community" (McCawley 1996:61). McCawley (1996:63) suggested that "Guaspita was derived from the earlier Gabrielino placename" of Waachnga and that the grant for Sausal Redondo included the site within its boundaries. Although he seemed to be supporting the placement of Guaspita on the bluff tops west of Lincoln, McCawley cautiously left the question of its exact location unresolved.

Evidence for the location of Guaspita in the Ballona continues to mount. A copy of the 1937 Kirkman-Harriman map, recently located at Loyola Marymount University, also shows the label "Gaucha" (or Gaucho) with the symbol for an "Indian settlement" nearby, apparently west of Lincoln

Boulevard (Figure 2.5). The line of the cliff is not shown, but both Centinela and Ballona Creeks are clearly depicted. The symbol for the Indian settlement is placed alongside Centinela Creek, whereas the word "Gaucha" (probably a misspelling of Guacha, also rendered as Guaspita) floats to the north out in the Ballona.

Chester King (1992, 1994) provided additional information on Guaspita in his work on Native American place-names in the Santa Monica Mountains. King mentioned Guaspita in connection with an important Gabrielino village he called "Comigranga" (also written as Comicraibit, Comicrabit, and possibly Johnston's [1962] Coronababit), which was most likely located in the vicinity of present-day Santa Monica. Citing his research on San Gabriel Mission records, King stated that some of the men who lived at the villages of Comicranga and Guaspita had names with Chumash suffixes and were interrelated with the Gabrielino by marriage. About Guaspita, he reported that "this important village had a large number of ties to Catalina Island (Pimunga). No other mainland villages had as many ties with the Island" (King 1992:28). He also noted that Guaspita might have been located "near the mouth of Ballona Creek because this location would be consistent with its apparent importance as a port town, the presence of Chumash names, and its many ties to Comicraibit" (King 1992:29). In this work, King presented data on the number of people recruited by the San Gabriel Mission from villages located west of "Yanga," near the Pueblo in downtown Los Angeles. Interestingly, recruitment at Comicranga and Guaspita, which began in 1790, peaked at the same period, between 1803 and 1805, then dropped to zero in 1819. Probably not coincidentally, 1819 was the same year that the Machado and Talamantes brothers began grazing cattle in the Ballona. With the arrival of permanent ranching activities in the Ballona, the process of mission recruitment was apparently halted. It may be that the Machado and Talamantes brothers moved into an area that had been vacated by the local Native American population. King suggested that more research in the San Gabriel Mission records may prove fruitful for research into Chumash names among the Gabrielino and may reveal more about mission recruitment in the Ballona as well.

A copy of a partially burned document in the Freeman family papers dated 20 December 1884, continues to refer to the Rancho as Sausal Redondo and Guaspita, although the name "Guaspita" is only inserted as an addendum at various places in the text.

One of the most thorough excavations conducted in the area to date claimed to have eliminated the eastern part of the bluff top as the location of Guaspita. As part of their West Bluffs project, Van Horn and White (1997a, 1997b) examined the question of a Protohistoric or early Historical-period site on the bluff. Although they found three glass trade beads dating to the late eighteenth and early nineteenth centuries at the Del Rey site (LAN-63),Van Horn and White felt the Westchester Bluffs were not plausible candidates for the location of a Gabrielino village. The Del Rey and Bluff (LAN-64) sites were characterized by poorly developed middens, suggesting temporary use. Further, radiocarbon dates indicated that the main use of the sites occurred during the Intermediate period, between 2,000 and 1,500 years ago, many years before the arrival of glass trade beads in California. Van Horn and White (1997a:5) concluded their argument against the presence of a village on the bluff top by stating,

> While it is true that a few Late Prehistoric and Protohistoric artifacts have been found on the bluff tops, these are relatively rare and usually occurred on or near the surface. No doubt, the bluffs experienced some pedestrian traffic throughout their prehistory and one must assume that Late Prehistoric and/or Protohistoric people residing below the bluffs at local sites such as LAN-62 and LAN-211 would have traveled the bluff tops from time to time. But there can be no question regarding Late Prehistoric occupation of the West Bluff property. Indeed, it is abundantly clear that by around A.D. 1,000 prehistoric occupation was concentrated at lagoon-side sites below the bluffs.

In sum, direct evidence of use of the Ballona and the Westchester Bluffs during the Protohistoric period is quite sparse compared to some earlier time periods, such as the Intermediate period. There are a few exceptions, however. Excavations by SRI at LAN-62 identified a burial area dating to the end of the

Protohistoric period, and excavations at LAN-211 during the fall of 2005 by SRI uncovered hearths and assorted artifacts associated with domestic activities during the Protohistoric period. Much of this material is yet to be analyzed, but could offer important insight into this less-understood time period.

Historical Period: Euroamerican Occupation

The broad sequence of events for the Historical period (A.D. 1771–1941) in the Ballona has become well established through repetition in published sources. Until recently, lingering gaps between known significant dates have resisted the probe of historical research. As the outline of Ballona history is fleshed out through continuing archival discoveries, new areas of interest are presented for examination. The first mention of the Rancho Sausal Redondo, the rancho most directly related to the West Bluffs sector of the Ballona project area, is in 1822, and the first of three grants to Antonio Ignacio Avila (Cowan 1977:96). Newly available documents summarizing the land tenure of the Freeman family (LMU CLSA 21) help to define more clearly the relationships and successions among the principal actors in the Ballona area during the historic period: Juan Dominguez, the Avilas, the Machados, the Talamantes, Daniel Freeman, and Howard Hughes.

Although the location of the ethnographic Gabrielino village of Guaspita remains in doubt, recent research in the Freeman family papers (LMU CLSA 21) confirms that it was not located on the tract of land treated by the West Bluffs project, or anywhere else on the Ranchos Sausal Redondo and Centinela.

With the rise of the Hispanic mission and rancho systems, the Gabrielino began to abandon their camps and village sites, probably including those sites they occupied in the Ballona. Disease and cultural upheaval forced the native population into steep decline, and the survivors merged with other displaced populations. Between 1781 and 1831, the mean death rate was 95 per 1,000 individuals, compared to a mean birth rate of 44 per 1,000. Mean life expectancy at birth was only 6.4 years (McCawley 1996:197). Hugo Reid, a Scotsman married to a Gabrielino woman, wrote in 1852 that the result of this period of turmoil was a massive migration of the remaining Gabrielino away from their traditional homeland, many resettling as far north as Monterey (Reid 1926). The impression has long been given in the literature that, except for the well-known pockets of aboriginal settlement around a few large ranchos and the expanding pueblo, the Los Angeles Basin was essentially empty of native peoples by the late 1850s.

As native Californian lifeways slipped more and more into the past, the future became the domain of Hispanic settlers newly arrived from Mexico. A scant 10 years after the founding of the Mission San Gabriel, the settlement named Pueblo de Nuestra Señora la Reina de Los Angeles was begun on the plain near what became known as the Los Angeles River. Eleven families arrived in 1781 from Sonora and Sinaloa to begin the community. Sixteen years later, the patriarch of the Machados, José Manuel, a soldier-guard stationed at Santa Barbara, moved with his large family to the growing pueblo. They were followed shortly thereafter by the Talamantes family, and these two families were to become closely associated with the Ballona over the next century. José Manuel's fifth son, José Agustín Antonio Machado, was three years old when the family moved to Los Angeles. Agustín, as he was generally known, and his close friend, Felipe de Jesus Talamantes, were employed as young men to care for the family stock herds. At times, they were accompanied on their horseback treks by their brothers, Ygnacio Machado and Tomás Talamantes, forming a partnership of four that would last for many years (Robinson 1939a).

In 1784, King Carlos III had made the first Spanish land grant in California to Juan Jose Dominguez, a retired solider who came to California, first with the Portolá expedition and later with Father Juniperro Serra. The original grant was called Rancho San Pedro and encompassed 75,000 acres, including the entire Los Angeles harbor.

The Hispanic community of Los Angeles grew quickly, and soon the need to find new grazing lands for horses and cattle became acute. The Machados and Talamanteses found the land to the southwest in the Ballona to be attractive, in part because its distance from San Gabriel had kept it outside the mission's land claims. Beginning about 1819, with Alcalde Joaquin Higuera's blessing and a permit from the military commander, José de la Guerra y Noriega, the Machado and Talamantes brothers moved their stock to the area now known as Culver City. In their petition of September 19, 1839, for the grazing land that became the Rancho La Ballona (Marie 1955:52), the men stated, "we occupied, with our grazing stock, houses and other interests, the place called 'Paso de las Carretas,'" but more generally known by the name of "the Ballona." Paso de las Carretas (or Wagon Pass) has been interpreted as corresponding to the low place between the sand hills known as the Ballona Gap. Of the road running through the Pass of the Carretas, Robinson shows it as following the path of today's Washington Boulevard (Robinson 1939a:105). The common interpretation states that "the *paso* fronted on the sea astride the *rancho*'s northern boundary" (Rolle 1952:147). The term "Ballona" may have derived from Bayona, the Spanish birthplace of the Talamantes family.

The statement in the grant petition referring to their occupation of the Ballona has led researchers to assume that because the brothers were grazing cattle there, the Machado and Talamantes families must have lived in the Ballona in 1819. In these early years, only one of the four ranchers, Agustín Machado, lived on the land, and he was at most a part-time resident.

Antonio Ignacio Avila's original 1822 grant for the Rancho Sausal Redondo was augmented twice, once in 1837 and again in 1846, for a total of 22,459 acres that were ultimately patented in 1875 (Cowan 1977:96). This ranch encompassed most of what is now known as Westchester, El Segundo, and Inglewood. A second rancho, the Rancho Centinela, was somewhat surreptitiously created within the Rancho Sausal Redondo by Ignacio Machado, well-known member of one of the other prominent early California families that has been mentioned previously in terms of land-holdings farther east in the Ballona. Machado built at the springs known as the Aguaje de Centinela.

In 1837, the governor of California confirmed the Avilas' ownership of the Rancho Sausal Redondo, while granting (and probably respecting political and economic realities of the time) provisional title of the Aguaje de Centinela to Ignacio Machado. Ignacio Machado had moved to the rancho in 1834, and he later claimed the Aguajé del Centinela west of Inglewood's Centinela Springs (Robinson 1939a:109). An adobe built ca. 1833 and known today as La Casa de la Centinela represents the first Californio occupation of this rancho (Robinson 1939a). Located on Midfield Avenue in Westchester, it is currently the home of the Centinela Valley Historical Society. Bruno Avila regained the Aguaje de Centinela for his family in 1838 via a land swap with the Machados for some land in Los Angeles.

At the conclusion of the Mexican-American War in 1848, Alta California was ceded to the United States, and four years later, in October 1852, the Hispanic families owning Rancho La Ballona filed their claims with the Land Commission for the confirmation of their grant. At first, the Machado and Talamantes families had smooth sailing: on February 14, 1854, the board upheld the Rancho La Ballona grant, and the U.S. District Court upheld the decision on appeal (Robinson 1939b).

Antonio Ignacio Avila, owner of the Rancho Sausal Redondo, was not so fortunate. He had incurred debts that he could not repay, resulting in foreclosure on his property and sale of the ranch; following several subsequent changes in ownership, Sir Robert Burnett of Scotland acquired the ranch from Joseph Lancaster Brent in 1860.

In 1873, personal reasons compelled Sir Robert Burnett to return to Scotland. He leased 25,000 acres of the Rancho Sausal Redondo to Catherine Freeman, wife of the Canadian entrepreneur Daniel Freeman, who had moved his family to southern California because of his wife's health problems. Unfortunately, she died the following year. The lease permitted the rancho lands to be acquired outright, and this was eventually accomplished through a series of transactions in the years 1881–1885, directly with Daniel Freeman. The ranchos were the foundation for Freeman's best-known business enterprise, the commercial development of real estate.

Freeman rented out large portions of the two ranches for agricultural endeavors. His real estate development efforts were focused east of Range 14 West, around the town of Inglewood, where he lived. In addition, examination of various lease and sale documents indicates that no improvements ever took place west of Range 14 West. As part of the purchase agreement with Sir Robert Barnett, Daniel Freeman was allowed to discount the costs of the improvements made during the time that lands had been leased from Barnett.

The land boom of the 1880s heavily affected the areas around the Ballona, but this development only lightly touched that part of the rancho in the project area. Throughout the 1890s and into the early 1910s and 1920s, as the old ranchos were bought up and subdivided by new Euroamerican owners, the cities of Santa Monica, Playa del Rey, Palms, Culver City, Inglewood, Westchester, El Segundo, Playa Redondo, and Venice were platted and the land quickly sold off. These cities now form a circle of dense development surrounding the open space of the West Bluffs/Ballona project area. The area west of what is today Lincoln Boulevard, north of West Bluffs, remained marshland, interspersed with small bodies of standing water; it too was extensively used. Through the years, the wetlands saw numerous recreational uses, such as duck hunting (Robinson 1939b); boat racing, and automobile racing during the 1910s when a race track called the Motordrome was in place (Osmer 1996:20); and sightseeing by tourists brought by the Pacific Electric Line to Playa del Rey beach (Robinson 1939a:119). The Motordrome was the country's first wooden board track (all previous ones were dirt) and the location where an automobile was first documented to exceed 100 mph.

By the 1920s, several important earth-moving projects in the Ballona had been undertaken. By 1923, channelization of upper Ballona Creek had been completed as far as Lincoln Boulevard (Foster 1991). About a year later, a trunk sewer line was laid along the bluff adjacent to the project area, followed by a maintenance road graded along the length of the line some years later. Another major project was the construction of Lincoln Boulevard to the north and down the bluff.

The 1920s also saw the beginning of the oil boom in the Ballona. Highly profitable oil wells sprouted from the wetlands in what was known as the Venice Oil Field. In 1930, there were 325 wells in operation in the Ballona (Spalding 1930); most were dismantled by the 1960s. Later in the 1930s, methane gas wells joined those drilled for oil, and several were dug near what is now the intersection of Imperial and Sepulveda Boulevards (Foster 1991:1). Although there is some evidence to suggest that mineral rights (including oil) were important to owners of the West Bluffs project area generally during this period, based upon the selling of the property but retaining a proportion of the mineral rights (see below), there is no indication that any oil drilling activity took place on the property itself. Several adjacent parcels, however, still retain oil wells to this day.

A 1938 air photo shows a large farmstead with outbuildings on the eastern end of the project area along the 80th Street/Rayford Drive and Colegio Drive. This farmstead has disappeared in an air photo from 1945. During a portion of the data recovery program at West Bluffs in 2003, SRI documented two features related to this farmstead: a set of twin septic systems located in the central south portion of LAN-63, and a telephone pole hole located in the central eastern portion of LAN-64. Little is known about this farmstead beyond documentation of it in aerial photographs.

Hughes Aircraft Company Period

In 1940, the Ballona's most famous owner, Howard Hughes, Jr., had just landed his first small government contract and found the empty land at the base of the bluff an ideal spot to relocate Hughes Aircraft Company (Altschul et al. 1991:86). His purchase of the land in 1941 began an era of intense development at the Ballona that lasted until 1986. With the outbreak of World War II, Hughes' interest in the property shifted to industry, and the area became the new home of his business, the Hughes Aircraft Company. The Culver City plant (a misnomer, as it was never located within the city limits) grew from a handful of wood buildings in 1941 to become the center of a cutting-edge aerospace production facility by 1953. During this initial period, Howard Hughes bought up property all along the top of the bluffs, adjacent to his large factory and airfield, to protect his airspace.

A preliminary title report for the three parcels all or partially within the West Bluffs project area (15 September 2003) indicated there were preliminary plans to subdivide the area in the 1930s, and planning maps were filed with the recorder of Los Angeles County. Parcel 1, which includes most of the West Bluffs site area, was not slated for subdivision, whereas Parcels 2 and 3 are shown as planned subdivisions. No construction ever took place, however. Also, Hastings Avenue, which apparently was to come through the Hastings Canyon cut, was never built, nor were some of the other named streets that are shown on the submitted plans. Because this northern extension of Hastings Avenue was planned, although never built, this section of road actually exists on many modern maps of the area.

The Hughes Tool Company acquired Parcel 1 from Cletus H. J. Jollies, and the deed was recorded on January 25, 1950, in Book 32073, p. 18; it is notable that Jollies retained 50 percent of the mineral rights for the parcel (see the discussion of oil development in the area, above). Aerial photographs show that in about 1951, a single line of power utility poles were strung across the West Bluffs project area, approximately from the Lincoln/80th street intersection to a point on the northeast corner of the West Bluffs tract. An oblique photograph taken on February 20, 1958, shows a small structure and a line of utility poles located on the northern edge of the bluff on the northern edge of LAN-64, just to the east of Hastings Canyon. It has been speculated that this was a radar station for the Hughes Aircraft runway, but no confirming documentation has been located. Both the poles and the structure seem to have been removed by 1958 or 1959. One of the power pole holes was found during the grading of LAN-64.

Although the West Bluffs area was also part of the Hughes property during this period, examination of a long sequence of aerial photos (1945–1976) shows that no significant earth-moving activities occurred. During much of this period, the property was used primarily as either a location for farming, or during the 1980s and 1990s, as undeveloped open space. The establishment of Marina del Rey in the 1960s led to a further evolution of the area into a recreational destination. Today, the region boasts a diverse economy, ranging from movie production to light industry. When Van Horn carried out his excavations in 1984, the West Bluffs tract was owned by the Howard Hughes Real Estate group. The Westchester Bluffs have become fashionable and desirable as an upscale residential development close to the booming commercial heart of the South Bay corridor.

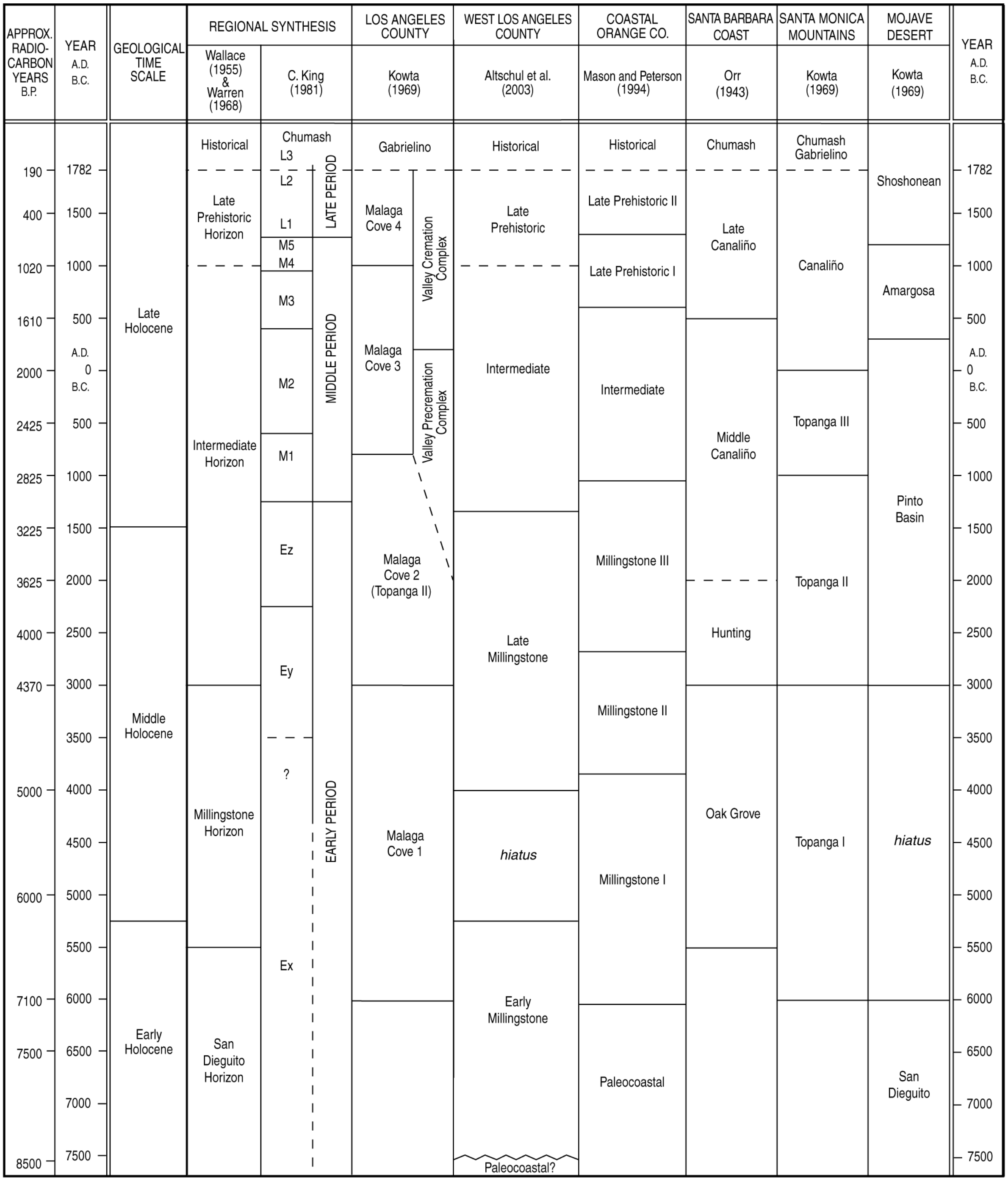


Figure 2.1. Culture history sequence for southern California.

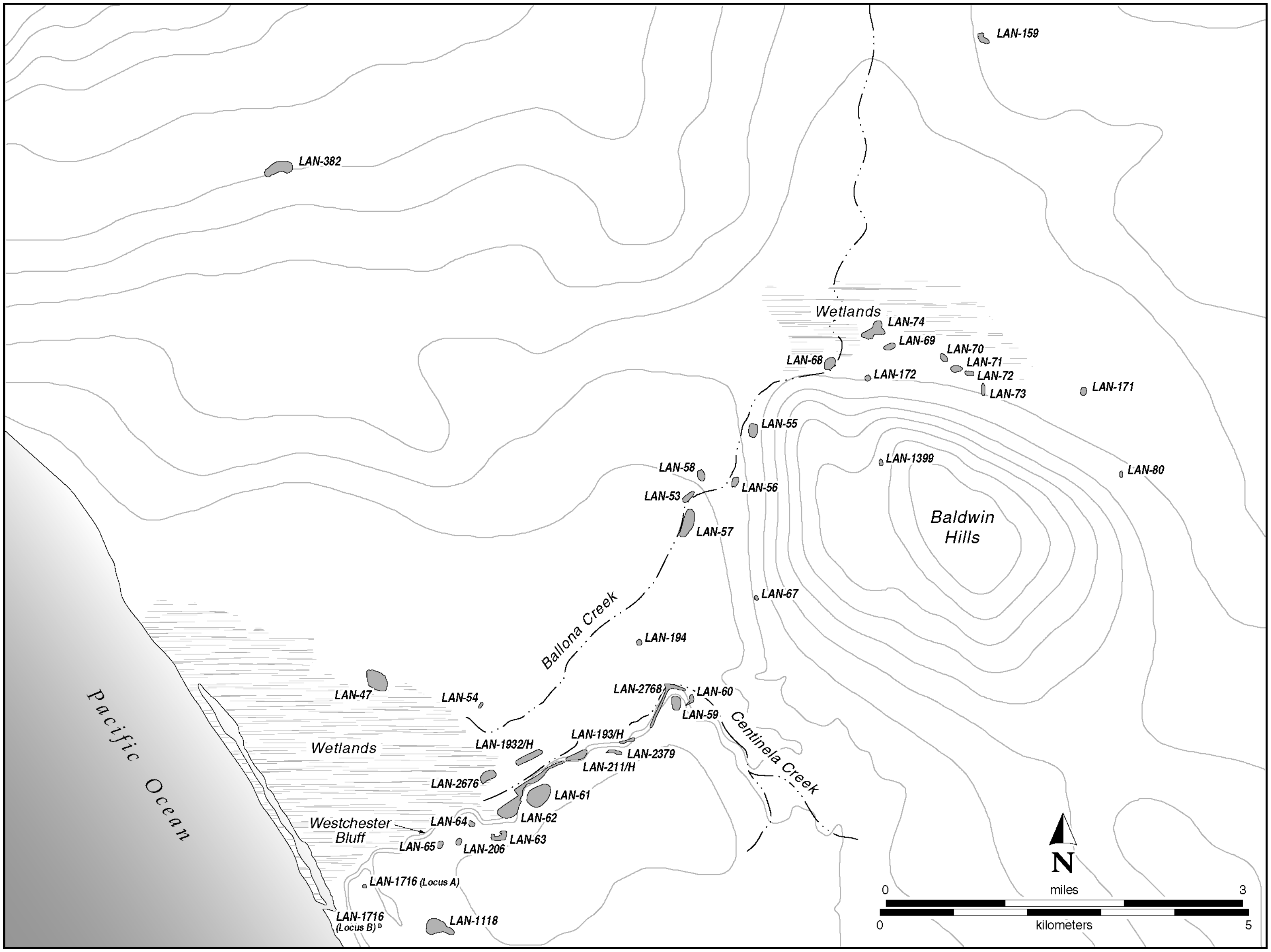


Figure 2.2. Prehistoric archaeological sites in the Ballona region.

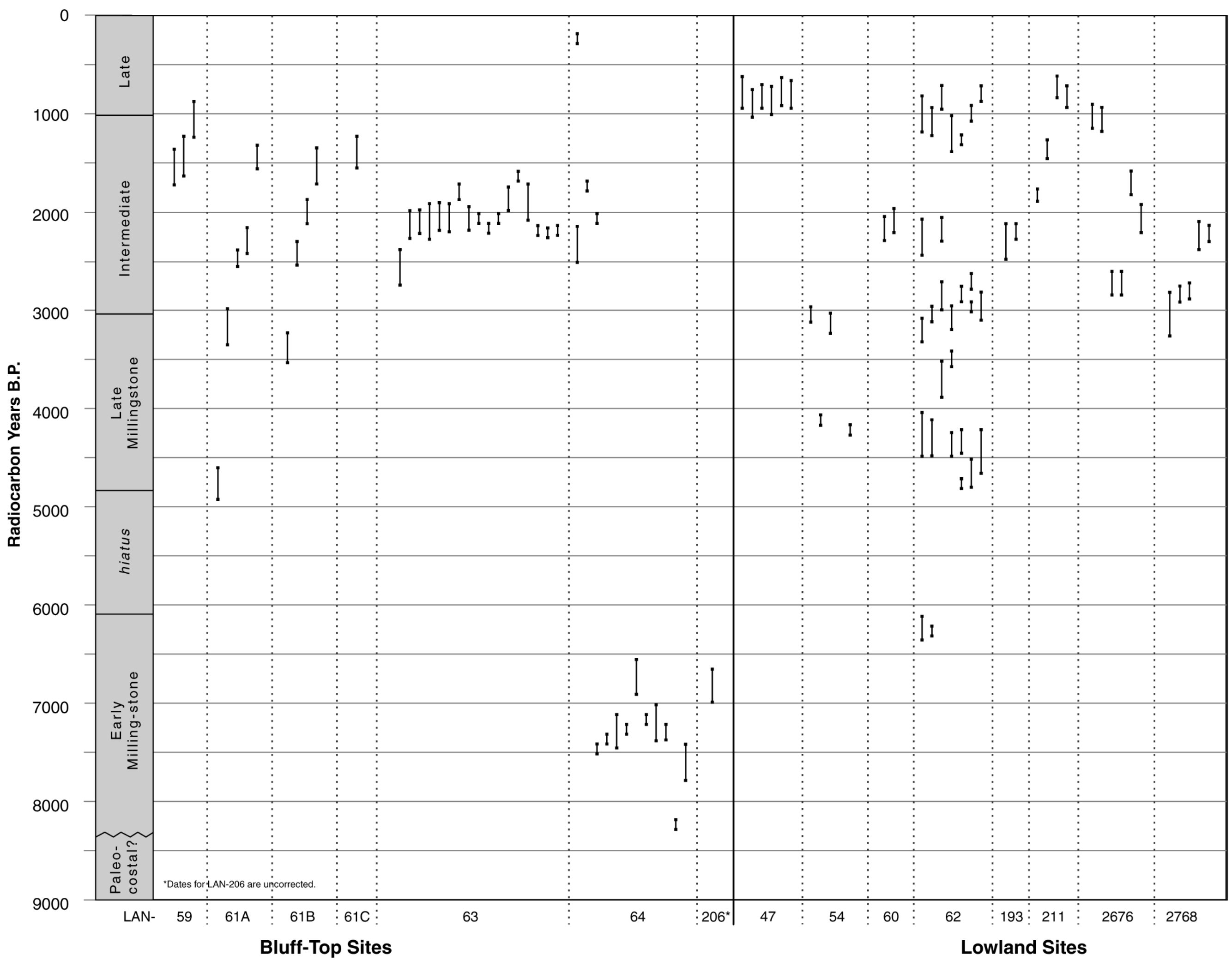


Figure 2.3. Radiocarbon dates for sites in the Ballona region, including new data from sites on the West Bluffs property.

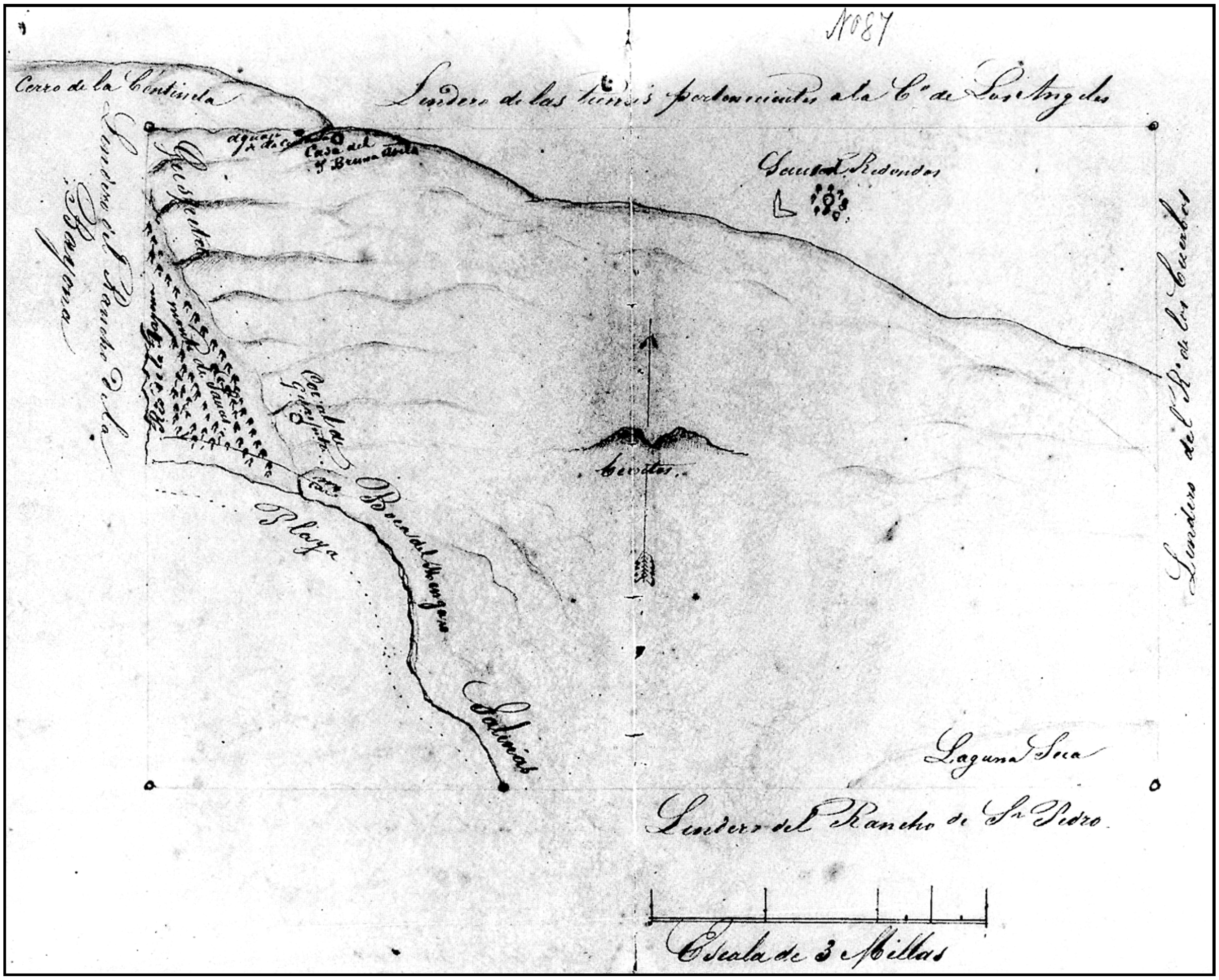


Figure 2.4. *Diseño* for the Rancho Sausal Redondo. Note the location of "Guspita" and "Coral de Guspita" in the upper-left corner of the map (courtesy of the California State Archives, Sacramento).

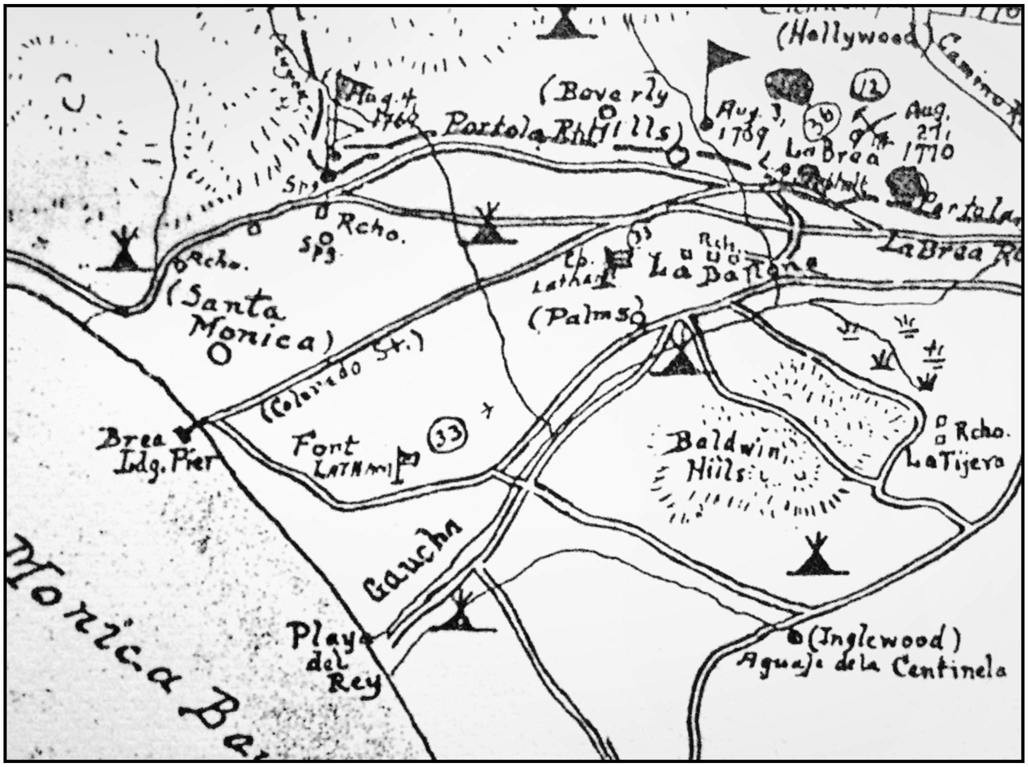


Figure 2.5. Location of Guacha (adapted from the 1937 Kirkman-Harriman Pictoral and Historical Map, Charles Von der Ahe Library, Loyola Marymount University).

Research at the West Bluffs Property

Jeffrey H. Altschul, Anne Q. Stoll, Donn R. Grenda,
Richard Ciolek-Torrello, and John G. Douglass

Archaeological research has a long history in the Ballona. Beginning in the 1920s, most of this work was performed by amateur collectors, sometimes under the guidance and encouragement of professional archaeologists. Survey results have more recently been augmented by large data recovery efforts at sites on the Del Rey Hills (Van Horn 1984, 1987; Van Horn and Murray 1985), along Centinela Creek (Grenda et al. 1994), and on the edge of the historical Ballona Lagoon (Altschul, Homburg, and Ciolek-Torrello 1992). Table 3.1 is a summary of relevant archaeological investigations recorded at the South Central Coastal Information Center (SCCIC) at California State University Fullerton and of more-recent work conducted by SRI in the Ballona region. Figure 3.1 plots all recorded archaeological sites in the Ballona region.

Early Archaeological Investigations

Much of what is known about the archaeology of the Ballona was compiled by amateurs and students prior to 1970. Of particular interest to this project is the work of Malcolm Farmer, an active collector who inventoried the sites during his forays into the area. For some of his early survey in the Ballona area, he was accompanied by Eugene Robinson. Farmer made various sketch maps and took notes in which he labeled the sites in the West Bluffs project area. His February 20, 1936, descriptions of sites place his Playa del Rey Sites 5 and 6, currently known as LAN-63 and LAN-64, within the project area. In addition, the placement of his Site 7 on the map suggests this was either LAN-206 or LAN-206A. Farmer interpreted his Sites 5 and 6 as village camps, whereas Site 7 was noted as a campsite. These same sites were given different numbers by Farmer in a subsequent and undated set of notes. At the request of the late Dr. Clement Meighan of UCLA, Farmer submitted his handwritten notes from 1936 to that institution (Farmer 1936).

Also important to the study of the bluff tops is the collection of artifacts compiled by William Deane, another amateur archaeologist. Deane's brother-in-law worked as a contractor for Hughes Aircraft in the 1940s and gave Deane artifacts he found while working at the site. Deane then began his own collecting efforts on the Hughes property in 1947 and permitted Marlys Thiel to photograph them as part of a student project for an anthropology class at UCLA. Deane's collection from his Ballona Sites 1–6 included human remains and artifacts of shell, stone, and bone (Thiel 1953).

In 1950, two more UCLA students, Russell Belous and Charles Rozaire, prepared a paper on Ballona Creek archaeology. The paper is a compilation of primary sources on the geology, environment, and archaeology of the region and includes the site forms the students completed for the sites they visited (Rozaire and Belous 1950). Among the 23 sites recorded by Rozaire and Belous were LAN-63, LAN-64, and LAN-206, located either entirely or partially on the West Bluffs property. LAN-63 was interpreted by

Rozaire and Belous as a village. The approximate site dimensions were 400 by 200 feet (123 by 62 m), and surface observations noted dark midden soil, shell fragments, and scattered lithics. Based on artifactual data, the site was thought to have been occupied during the Late period.

By contrast, LAN-64 was interpreted by Rozaire and Belous (1950) as a smaller campsite measuring 123 by 62 m. Artifacts noted on the surface included flakes and shell fragments. Rozaire and Belous (1950) reported that others had seen manos, metates, mortars, pestles, and projectile points at the site. The presence of arrow points suggested a Late period occupation. LAN-206 had been visited in the 1940s by Deane, who found cogged stones on the site. Rozaire and Belous reported the site in 1950, but it was not formally recorded until 1953 by another UCLA student, Hal Eberhart. Named the Berger site, LAN-206 also measured approximately 123 by 62 m and was thought to be the most ancient of the sites that once lay along the length of the bluff tops (Van Horn and White 1997c).

Finally, in 1967, George Schofield, a student at Santa Monica City College, wrote a student paper on what he called the "Loyola University Sites." Based on sketch maps included in Schofield's paper, these sites are interpreted by SRI to be LAN-63, LAN-64, and either LAN-206 or LAN-206A. Between 1964 and 1967, Schofield and colleagues surveyed the surface of these sites on weekends, collecting a range of artifacts, including ground stone, flaked stone, formal tools, beads, shell, pigment stones, and ceramics. Unfortunately, Schofield appears to have had little experience in archaeology and, as a result, offered little interpretation or documentation of the sites and artifacts beyond simply acknowledging their presence.

Recent Archaeological Projects

Following these early efforts, the Ballona region was ignored by archaeologists for nearly 20 years (see Table 3.1). In 1979, R. L. Pence was contracted by the Summa Corporation to conduct a reconnaissance survey of its Culver City parcel, which included the West Bluffs property. Pence (1979) reevaluated LAN-63, LAN-64, and LAN-206. He found LAN-63 to be largely intact and relatively undisturbed except for annual plowing. Pence (1979:14) went on to state that "artifacts noted on the site were quartzite scrapers and choppers, a quartzite core, a hammer stone, a bifacial mano, and a bowl fragment. Lithics for this site include the usual quartzites, chalcedony, chert, and an unusual piece of schist which may be the Sierra Pelona type. This site must be preserved."

During his 1979 survey, Pence found LAN-64 to be very similar to LAN-63. The site was in good condition; the only major disturbance noted was a possible radar station that had been erected on its northern edge. Pence concluded that LAN-64 should also be preserved.

Pence also visited LAN-206, much of which had already been destroyed by development. Remnants of the site existed in a vacant lot; at the time of Pence's visit, it was being looted extensively. He argued that the presence of cogged stones and the lack of mortars and pestles suggested a single-component Millingstone occupation. Pence recommended that mitigation measures be instituted immediately. As mentioned below, LAN-206A, a component of LAN-206, was found on the West Bluffs property. The primary component of LAN-206 was found on the southwest corner of 80th Street and Berger Place, diagonally across from the West Bluffs property.

Although formal data recovery was not performed, LAN-206 was the subject of two phases of salvage excavations. Limited test excavations sponsored by Howard Hughes Realty, Inc., were conducted on the southwest corner lot of Berger Place and 80th Street in 1983. This work consisted of the manual excavation of four test units—two 1-by-1-m units and two 2-by-2-m units. In 1984, a volunteer effort was mounted within the same lot after a grading permit for the property had been issued, and the site was scheduled for destruction. At that time, four additional units were manually excavated (one 2-by-2-m unit and three 1-by-1-m units), and three trenches and four pits were mechanically excavated. In all, 62 m³ were excavated at LAN-206, of which 12 m³ of fill were manually excavated (Van Horn and White 1997c).

Data recovered from the Berger site were remarkable in large part for two reasons. First, as discussed above, an early radiocarbon date returned on a marine-shell assay confirmed the early occupation suspected by Pence (1979) and others. The second remarkable aspect of the collection was its marked similarity to other, apparently later, nearby sites. Van Horn and White (1997c) documented a ground stone collection containing 25 manos or mano fragments, 11 metate (all basin shaped) fragments, 3 abraders, 1 discoidal, 5 cogged stones (all found prior to the excavation), and 2 problematic and 9 unidentified ground stone items. Flaked stone recovered from the site included 37 cores, 1,564 flakes, 15 utilized flakes, 3 choppers, 21 scrapers, 15 drills, 1 biface fragment, and 1 projectile point. Chert, most of which was Monterey chert, was the most frequent raw-material type noted in the collection, followed by two other locally available materials—metavolcanics and quartzite—and in much lower quantities, chalcedony. Of special note, 11 of the cores were microcores, and all the drills were microdrills.

Other artifactual items recovered at LAN-206 included hammer stones, fire-cracked rock, ochre, asphaltum, and a tar rock. A possible human molar was also found in Unit 3. Modern debris was recovered from all parts of the site and at all depths in the units.

Twenty-three terrestrial animal species were represented in the midden. Mammals included deer (*Odocoileus* sp.), dog or coyote (*Canis* sp.) badger (*Taxidea taxus*), raccoon (*Procyon lotor*), rabbit (cottontail [*Sylvilagus* sp.] and jackrabbit [*Lepus* sp.]), weasel (*Mustela* sp.), ground squirrel (*Spermophilus* sp.), pocket gopher (*Thomomys* sp.), kangaroo rat (*Dipodomys* sp.), mouse (*Perognathus* sp.), and shrew (Soricidae). Birds represented were goose (Anatidae), loon (*Gavia* sp.), northern shoveler (*Anas clypeata*) and cinnamon teal duck (*A. cyanoptera*), grebe (*Aechmophorus* sp.), and hawk (Accipitridae). Reptiles and amphibians were found in small numbers and included pond turtle (*Actinemys marmorata*), gopher snake (*Pituophis melanoleucus*), rattlesnake (*Crotalus* sp.), and king snake (*Lampropeltis getulus*). As is typical in Southern California, the remains were highly fragmented, presumably as a result of processing and cooking techniques and poor preservation. Faunal remains were most numerous between 40 and 60 cm below the surface, decreasing precipitously and then evening out between 60 and 120 cm below surface.

This distribution of faunal remains was interpreted as consistent with a campsite that was used repeatedly over a long period (Colby 1997). Waterfowl represented in the remains are prevalent in the Ballona between the late fall and spring, although seasonality of these species does not rule out occupation of the site at other times of the year.

Excavations at the Berger site also recovered 185 fish elements, representing 3 species of shark, 5 species of ray, and 11 species of bony fish (Salls 1997). Sea otter (*Enhydra* sp.) remains were also found. As suggested by the species represented, fishing activity apparently focused on open-coast, sandy beaches and bay and estuary environments. No evidence of pelagic (open water or deep sea) fishing was found. Not surprisingly, shellfish remains were found in significant quantities. Of the 776 diagnostic specimens counted at the Berger site, 98 percent were represented by three types: Venus clam or cockle (*Chione* sp.; 56 percent), speckled scallop (*Plagioctenum circularis*; 28 percent), and native oyster (*Ostrea lurida*; 16 percent). These species would all have been available in mudflats and intertidal zones (DiGregorio 1997).

Van Horn and White (1997c) distinguished three components at LAN-206. The earliest, Component C, dated to the Millingstone period. Residents fished and collected shellfish in the nearby estuary and made few tools. Although their context is unknown, the cogged stones were suggested to have been associated with this component by Van Horn and White. Component B dated to the first millennium B.C. (Intermediate period) and was characterized by a greater emphasis on milling and a decreased focus on shellfish exploitation. Fishing was part of the subsistence strategy, but a greater emphasis appears to have been placed on hunting terrestrial game. Component A, dated to the end of the Intermediate period, represented the terminal occupation. Most of the flakes, milling implements, and fire-cracked rock were associated with Component A. Van Horn and White (1997c) also associated the microcores and microdrills with this component.

Van Horn and White (1997c:22) concluded their discussion of LAN-206 as follows:

> In summary, it appears that the Berger site was in use by around 4500 B.C. and that fish and shellfish consumption were prominent activities on the hilltop during the early period. The distribution of shellfish valves indicates that this early use was probably confined to the highest elevation of the hilltop. At some unknown time represented by the 50 cm. point in the vertical sequence, marine shell gathering ceased to be of importance to the site's users. While fishing did remain important, increased animal bone suggests that there was a new emphasis on hunting. Finally, during the latest period of the site's use, manufacture of chipped stone implements, most notably micro-cores and scrapers, and use of milling equipment become prevalent.

In 1986, Van Horn and his colleagues returned to LAN-206. At the time, Archaeological Associates, Ltd. (Van Horn 1986), was testing the Del Rey (LAN-63) and Bluff (LAN-64) sites as part of evaluating the significance of cultural resources on the West Bluffs property. Recognizing that the Berger site extended onto the property, Van Horn and his colleagues designated the surface scatter within the West Bluffs property line LAN-206A. Surface artifacts were plotted, and three 1-by-1-m test units were excavated. In all, 125 artifacts were found to extend north from 80th Street and east from the property line for a distance of about 100 m. These artifacts consisted largely of flakes (n = 54) and fire-cracked rock (n = 47). Additionally, 10 hammer stones, 9 cores, 3 mano fragments, and 2 scrapers were found. The scatter of artifacts conformed largely to the slope of the hill, with the greatest density evident in the south and decreasing quickly to the north. Test units demonstrated that artifacts were restricted to the uppermost 30 cm; no cultural material was found at depths greater than 60 cm below surface. Beyond flakes, material recovered in the test units included bone, cores, and a microdrill. No shell was recovered. Rodent activity was noted in all units, and modern debris was found as deep as 30 cmbs.

Van Horn and White (1997c:25) interpreted LAN-206A as "a peripheral scatter of material relating to the later phases of the Berger site (Components A and/or B)." They argued that none of the material was unique. They concluded that LAN-206A had little research potential and therefore was not significant under the criteria set forth in CEQA.

In 1987, Van Horn reported on salvage excavations at LAN-63 and LAN-64. Both sites were endangered by a proposed residential development, and Van Horn (1987) was responsible for mitigating the adverse impact of the development through data recovery, analysis, and curation of the materials recovered. Van Horn first resurveyed the property and derived site boundaries through surface collection, mechanical augering, and changes in the color of the soil. Whereas the site boundaries for the Bluff site (LAN-64) were similar to those recorded by other investigators (e.g., Pence 1979; Rozaire and Belous 1950), the Del Rey site (LAN-63) was redrawn to cover a much smaller area (Figure 3.2).

Van Horn (1987) excavated 233 units, covering 1,903.1 m² and containing 1,245.8 m³ of fill (see Figure 3.2). Most of this effort was spent at the larger Del Rey site, which was separated into the eastern knoll (East Camp) and the western rise (West Camp). At the Del Rey site, an area encompassing more than 1,000 m³ was excavated, 75 percent of it by machines. At the Bluff site, an area of 225 m³ was excavated; almost 90 percent of this was done by machine.

The 61 units excavated by hand were placed so that all parts of both sites were tested. The machine units were placed sequentially in eight long, linear transects. These transects were placed in areas that had the most artifacts or shell on the surface or were characterized by dark, organic soil.

The collection recovered from the two sites is impressive. About 38,000 pieces of lithic debitage were recovered at the Del Rey site, and another 7,500 were found at the Bluff site. A wide variety of raw materials was observed, including Monterey chert, quartzite, chalcedony, metavolcanics, fused shale, and obsidian. The lithic technologies represented included both the split-cobble tradition and the microlithic tradition found at other sites in the Del Rey Hills.

Flaked tools represented were drills, reamers, choppers, scrapers, crescents, and knives. Projectile point styles suggested a wide occupation span, ranging from Intermediate period points, such as Canaliño, leaf-shaped, Gypsum, and Marymount, to later side-notched and triangular arrow points. The ground stone assemblage contained three types of manos and six types of metates, mortars, bowls, abraders, and discoidals made of granitic, sandstone, metavolcanic, and sedimentary materials; steatite was also well represented. Other stone tools related to economic behaviors included digging-stick weights, net weights, hammer stones, tarring pebbles, and stone anvils. Tools made of bone were common, including awls, spatulas, gorges, compound hooks, and atlatl spurs. Nonutilitarian items were found in abundance. These included schist ornaments, steatite discs, charm stones, stone tubes, quartz crystals, bone pendants, and ochre. Beads made of shell, bone, stone, and glass were also recovered.

Faunal remains from both bluff sites were dominated by shell. The most common genus represented in the midden was *Chione* (84 percent), followed by markedly lower numbers of *Ostrea* (7.1 percent), *Plagiocentium* (4.6 percent), and *Protothaca* (4.3 percent). DiGregorio argued that shellfish remains at both the Bluff and Del Rey sites were located away from living and food-processing areas. This pattern of food disposal was also noted at the other bluff sites (DiGregorio 1987:230).

After examining the horizontal and vertical distribution of shell remains at the bluff-top sites, DiGregorio (1987:229) concluded that "a change in the lagoon's environment may have caused corresponding changes in the shellfish population. Specifically, it is hypothesized that flooding or some other relatively rapid change in the lagoon's environment discouraged the oyster population but did not effect the chione." There is persuasive corroborating evidence for ancient flooding events in the Ballona presented in the ostracod analysis. Beginning about 6580 B.P. and spiking again at 4500 B.P, strong peaks in the count of freshwater species were observed in the cores. Also, several cores revealed segments lacking fossils in coarse-grained sediments. Such deposits are commonly associated with high-energy fluvial episodes (Palacios-Fest 1996:21). It is reasonable to assume that such flooding events did have some as-yet incompletely understood effect on the shellfish populations and subsequent human consumption in the Ballona.

Fish and terrestrial fauna were well represented at the Del Rey site, but less so at the Bluff site. The Del Rey site was second only to the Hughes site (LAN-59) in the number of fish elements present per cubic meter of excavated fill for all sites in the area that have been explored so far, including lagoon-edge sites (Sandefur and Colby 1992:313). It contained a surprising number of bony-fish remains—7,325 elements (or 47 percent) of the fish collection. This percentage of bony-fish remains in a collection was higher than that of any other site on the Del Rey Hills; for the entire Ballona region, the percentage was second only to the lagoon-edge Admiralty site. The relative frequencies of deer, dog, and sea-mammal remains indicate that these animals were of roughly similar importance in the diet. Smaller animals were also taken in fair numbers, including waterbirds, rabbits, hares, squirrels, and on occasion, turtles, snakes, badgers, weasels, bobcats, and rodents (Colby 1987a, 1987b).

Fifteen features were found at the Del Rey site, and one was noted at the Bluff site. Features were classified into four types (Figure 3.3). The most frequent type was either a hearth or a cluster of hearths associated with an artifact scatter (n = 8). Following closely in frequency (n = 6) were caches of various types, ranging from ground stone tools to shells. Two categories were represented by one specimen each; these were a pit hearth and an earth oven, both at the Del Rey site. Van Horn (1987) argued that most of these features related to the processing of food sources. Three, however, were inferred to have been associated with rituals: the earth oven and two of the caches that were composed of intentionally burned ground stone artifacts. All three features were hypothesized to be affiliated with women—the pit oven, with cleansing or menstrual activities, and the caches, perhaps with the disposal of a deceased person's possessions.

As noted in Chapter 2, features excavated by Van Horn appear to be differentially placed over the surface of the site. The hearths with associated artifact scatters, which Van Horn inferred to be residential loci of nuclear families or domestic groups, were generally located along the margins of the site. Shellfish remains were deposited adjacent to, but not in, these loci, suggesting a strong pattern to waste disposal and further supporting the use of the site margins as residential areas.

Caches, the earth oven, and the pit hearth were located in the center of the site. This pattern is even stronger taking into consideration that Feature 12, which was only partially excavated, could be interpreted as a cache of burnt steatite objects rather than as a hearth. These features may have been created as part of group activities. The placement of caches and group ovens (i.e., large roasting features) close to each other in a central location, and away from domestic loci, is intriguing.

Beyond prehistoric items, Van Horn recovered a number of historical-period artifacts. These included three glass trade beads dated between 1769 and 1800 (White 1987:218) as well as more than 30 pieces of various materials dated to the early twentieth century. White (1987) argued that the twentieth-century material probably originated from a farmhouse that once stood on the ridge just south of the Del Rey site and another contemporaneous building complex that was located on the Bluff site. Historically, the parcel was dry-farmed, beginning in the early 1900s. An aerial photo from the 1930s shows a complex of at least two structures on the highest elevation of the Bluff site and a second building complex on the ridge southeast of the Del Rey site. Both of these complexes were gone by 1949 (Van Horn 1987:9). No evidence of these structures was found in Van Horn's excavations, although the trenches and hand units were not placed in reference to the possible location of the historical-period structures (based on historical photographs of the site). The land remained vacant after it was purchased by Howard Hughes in the 1940s.

Five shell samples from the Del Rey site and one from the Bluff site were submitted for radiocarbon dating. These dates were all relatively close, ranging from 2530 ± 90 to 2020 ± 70 B.P. (see the chronology chapter, Chapter 14, for details on this data in the context of the Intermediate period in the Ballona). The dates were not corrected for the various factors known to affect shell samples (Altschul, Homburg, and Ciolek-Torrello 1992:193–196), but they do support an Intermediate period occupation that is consistent with the artifact collection. The presence of crescents (Millingstone period) and glass trade beads (Protohistoric or Mission periods), however, suggest that the sites were used over a longer time span (see the chronology chapter, Chapter 14, for detailed discussion of dates from the West Bluffs sites).

Van Horn concluded that the adverse effects of the proposed development on both sites had been adequately mitigated through archaeology. Specifically, he (1987:274) stated,

> It is evident from the text of this report that this project recovered data to the point of redundancy. Thus, there can be no reasonable doubt that a representative sample of typical finds from the two sites has been gathered and will be permanently preserved for future study. However, in order to observe orthodox archaeological mitigative procedure, we recommend that grading operations connected with development of the property be monitored by a qualified archaeologist. This individual should be a professional capable of distinguishing redundant material from new finds meriting investigation.

A peer review team consisting of Clement Meighan, James Sackett, Charles Rozaire, and William Wallace concurred with this finding. As discussed in the introductory chapter, however, the Corps found that whereas the excavation and report was adequate to address CEQA requirements of the time, it was not adequate for Section 106 standards. As a result, the Corps required additional data recovery for the mitigation of adverse effects. As was discussed in the introductory chapter, because the Corps had jurisdiction over Hastings Canyon, only LAN-64 and LAN-206A were their responsibility. In addition, because LAN-206A was found not eligible for listing in the NRHP, a HPTP was created only for LAN-64. The stricter Section 106 standards, however, were adopted for both LAN-63 and LAN-64 by Catellus and SRI.

As a result, SRI initiated additional data recovery investigations in the fall of 2000 and continued with an intensive monitoring and data recovery program in the spring and summer of 2003. Both of these are reported on here. A preliminary report on findings from both monitoring and data recovery for the West Bluffs property was prepared and approved by the Corps (Douglass and Altschul 2004a). Subsequent to data recovery by SRI in 2000 and 2003, archaeological monitoring by an archaeologist and a Native American was conducted through the fall of 2004 (Douglass and Altschul 2004b, 2004c).

Research Design and Research Questions

Van Horn correctly noted that the use of the site concept leads to spurious conclusions about the archaeology of the area. The Del Rey and Bluff sites were isomorphic with topographic rises that create small knolls on top of the Del Rey Hills. Small groups of people used the knolls on a periodic basis throughout the year either as temporary camps or as logistical base camps (Altschul et al. 1999; Van Horn 1987:272). This pattern of use lasted thousands of years. Distinguishing the deposits into different sites may be a useful bookkeeping device, but the two sites should not be viewed as separate occupations. They were both formed by the same or similar groups performing similar behaviors and were, in essence, one site with multiple loci.

Van Horn argued that activity areas can be discerned at bluff-top sites. Specifically, he argued that the campsites or cooking areas were separate from the shell middens. The location of features from Van Horn's work suggests that they were differentially placed over the surface of the site. It is interesting to note that the location of the shell dump essentially overlapped the depression. This pattern appears to support Nodine's (1987) arguments that hunter-gatherers dispose of trash along site perimeters away from living areas. If these observations are accurate, these sites are ideal candidates for testing coastal settlement models (e.g., Altschul, Ciolek-Torrello, and Homburg 1992; Grenda and Altschul 1994, 1995; Grenda et al. 1998; Mason and Peterson 1994; Van Horn 1987) because they will provide data on three critical issues: sedentism, site function, and site structure.

Sedentism, Site Function, and Site Structure

Van Horn (1987) suggested that the bluff-top sites functioned as temporary camps for one or two domestic groups. If this model is correct, each site should be seen as a discrete unit reflecting the behavior of a social group maintaining a permanent residence elsewhere. There is no indication of permanent structures on the bluffs, which is consistent with an ephemeral occupation.

Grenda and Altschul (1994) have proposed a perspective that incorporates both the bluff sites and the Ballona lagoon-edge sites into a dynamic, interdependent settlement system. The long-term success of the local settlement system was made possible by the flexibility of populations and a social hierarchy that allowed for controls over land and resource use. In this model, all sites do not fit into one mold. There should be a range of sites of various sizes occupied for various time spans, extending from weeks to years.

If correct, it would follow that bluff-top occupations should also be highly variable, some representing more or less permanent occupations (indicated by permanent facilities and year-round resources), whereas others would reflect exploitation of specific resources or that would require occupation of only a short duration, such as ritual use (no facilities and restricted resource base).

Van Horn's (1987) model conceived of all bluff sites as being primarily devoted to resource procurement. At LAN-63 and LAN-64, this function was expressed by evidence of a restricted set of activities, largely focused on estuarine and grassland resources. Whereas both the lithic and faunal data do appear to reflect simple procurement, other data, such as the distinctive caches of burned stones, are not so easily explained. There is no interpretive mechanism within Van Horn's model to suggest a function for nonutilitarian archaeological resources, which may be ritual in nature.

By contrast, Grenda and Altschul's (1994) explanatory framework predicted that occupations represented by these sites should be highly variable. Some may correspond to resource-procurement camps. Others, however, should be permanent residences at which the entire range of cultural activities took place, including those of a ritual nature. These latter occupations should have evidence of resource procurement, in the form of faunal remains and economic tools (i.e., projectile points, fishhooks, etc.); tool manufacture and refurbishing, as reflected by lithic debitage and raw material; ceremonies and religious activities, as represented by beads, pendants, effigies, and mortuary practices; regional exchange, as demonstrated by nonlocal lithics or shell beads; and storage, as embodied in pit features or nonlocal plant remains (e.g., acorn or pinyon nutshells).

A model of internal site structure is a vital component in site interpretation. The structure of shell-midden sites has received remarkably little attention in southern California. Shell middens are often treated as internally homogeneous deposits of artifacts and other cultural materials, without consideration of their formation or the relationship between midden formation and site structure. In addition, the excavation methods typically used to investigate shell middens yield data that cannot address this topic (Claassen 1991).

The successful interpretation of site structure requires the recognition of discrete residential units. Unfortunately, obvious indicators of house structures, such as postholes, house floors, and other structural remains, are rare in southern California, owing to disturbances by burrowing animals along with the effects of agriculture and other human developments. As a result, to address issues of site structure and make inferences about relationships with social organization, we must rely on more-subtle indicators of residential units. Grenda (1997), following Gargett and Hayden (1991), argued that residential units may be indicated by the presence of hearths, roasting pits, refuse concentrations, and artifact clusters.

Grenda (1997) was able to reconstruct residential areas at a hunter-gatherer site known as the Elsinore site in Southern California through indirect means. His analysis was based on the assumption that different activities are differentially distributed within a site, and that there is a quantitative relationship between the specific activity that took place and the resulting archaeological record (Carr 1985; Hietala 1984; O'Connell et al. 1991).

Midden-Formation Models

Our knowledge of spatial patterning within shell middens is even more sparse than that for hunter-gatherer sites in general. However, two related studies have yielded some interesting patterns that are applicable here. Meehan's (1977a, 1977b, 1982) study of the Gidjingali aborigines of northern Australia yielded tremendous insight into the behavior of hunter-gatherers with regard to maritime adaptation, in general, and shellfish-gathering behavior in particular. Meehan (1982) demonstrated that shell-refuse disposal occurs in a systematic fashion, typically ringing the activity areas of a short-term encampment in a "toss zone" (Binford 1983:317), a pattern noted in several other ethnographic studies (e.g., Bartram et al. 1991; Gargett and Hayden 1991; Murray 1980; O'Connell et al. 1991). Meehan (1982) also pointed out that hearths are constructed only at "dinner time" camps (those where meals are consumed) and that reuse of an area for this type of behavior will result in several overlapping deposits with hearths.

Using this data, Nodine (1987) proposed a model of midden formation in which repeated use of the same area at different times results in the superimposition of short-term encampments and, thus, their refuse-disposal areas (see also May 1982). Nodine (1987:20) predicted higher densities of hearths in the central activity area and of refuse in the peripheral areas. As the midden accumulates, refuse disposal is likely to be concentrated in areas that are both easily accessible and less important to everyday living, such as slope areas away from the central activity area of the site.

The problem in understanding site structure in a site constructed primarily from refuse is reoccupation—the central activity areas and peripheral refuse-disposal areas will not necessarily be in the same locations during later occupations. Reoccupation of short-term encampments will confuse the depositional pattern, with materials being moved or reshaped (e.g., filling in depressions and clearing areas for activities), thus resulting in the mixing of materials from different occupations.

This model yields a pattern very similar to that observed during excavations at ORA-116 near Newport Bay. Grenda et al. (1998) successfully defined 11 house pits clustered on top of a hill overlooking the bay. These pits were filled with different amounts of refuse deposited by later occupants of the site. The earliest houses, as indicated by earlier radiocarbon dates and the most-extensive refuse deposits, were located close to the edge of the bluff, with subsequent occupations gradually moving away from the edge as it eroded. The latest houses with the least amount of refuse were found farthest from the edge of the hill. As a result, at any given time, a horizontal distribution of houses was evident along the edge of the hill. Over time, this pattern was obscured through formation processes associated with reoccupation.

The pattern evident at ORA-116 may be revealed at the bluff sites. Activities appear to have been undertaken repeatedly in the same general locations, resulting in a vertical stratigraphic sequence of similar types of deposits and also in horizontally discrete examples of the same types of features. For example, at LAN-63, hearth and artifact scatters ringed a natural depression that is filled with refuse. If the site, like ORA-116, represents repeated occupation, then features within or close to the edge of the refuse-filled depression should be older than those farther from the depression. Repeated occupation of LAN-63 may have obscured a clear activity-distribution pattern. Van Horn (1987) found a single feature consisting of a hearth and artifact scatter at LAN-64 in a similar location adjacent to a shell midden. We suspect other similar features ringed this midden in a pattern similar to LAN-63.

The base camps envisioned by Van Horn (1987) were unstructured settlements with randomly distributed features resulting from repeated short-term food-gathering expeditions. These settlements are viewed as unrelated aggregations of individual hearths and refuse deposits. Van Horn's failure to consider temporal patterns limited his ability to discern site structure. In addition, the quantity and variety of artifacts and features were inconsistent with intermittent short-term occupations as envisioned by Van Horn.

Our conception of the bluff sites differs from Van Horn's. Analysis of these sites should reveal a more formal spatial structure with distinct areas defined by activity. Site occupants may have maintained separate areas for food preparation, tool manufacture, refuse disposal, and storage. If there are components at these sites that represent permanent occupations by more than one domestic group, then we may find these spatial patterns replicated around each hearth area across the site. Additionally, there may be common areas, such as cemeteries, that were used by all the residents; alternately, each domestic group may have maintained their own burial areas.

The differences between Van Horn's and our interpretations of these two settlements (Table 3.2) can be summarized as follows:

- If Van Horn is correct, then features should be randomly distributed in time and space across the site. Analysis of these sites and their internal structure should reveal a low diversity of cultural remains and few discrete activity areas.

- If our interpretation is correct, then we should be able to establish classes of contemporaneous features and their distribution relative to refuse deposits should be patterned. A wider diversity of cultural remains should also be present. The site should be spatially complex with a larger number of discrete activity areas representing a wider range of activities.

Research Approach

As the underlying approach for this research on midden formation and site structure, SRI will focus in this report on two related types of data: excavation results from the 2000 and 2003 data recovery work done by SRI, and Van Horn's data from the 1980s. As was discussed in the introductory chapter, an important consideration for the research discussed in this report is using all the different types of data available to understand the nature of site occupation at the sites on the West Bluffs property. Van Horn and his colleagues excavated a tremendous amount of material during their work in the 1980s. Although their report was found by the Corps to be up to then-current CEQA standards but not to Section 106 standards (as was discussed in the introductory chapter), the data in Van Horn report are invaluable to the work described and analyzed in this report. The data collected by SRI and Van Horn using these methods were ideal for testing the competing models described above.

As a result, the methods for creating samples for a variety of types of analysis (e.g. flaked and ground stone, vertebrate and invertebrate faunal remains, beads and ornaments, etc.) was designed to complement and test the data collected by Van Horn and colleagues, as discussed above. Because SRI was interested in learning about activities performed by the prehistoric inhabitants of the West Bluffs sites, SRI picked a sample primarily composed of features. In certain cases, such as those involving vertebrate and invertebrate remains, SRI complemented the sampled features with unit data to be able to characterize features and the surrounding midden. Features were picked for sampling based on a variety of criteria, including size, density and diversity of artifacts (based on field notes and laboratory processing), and vertical and horizontal position within the midden.

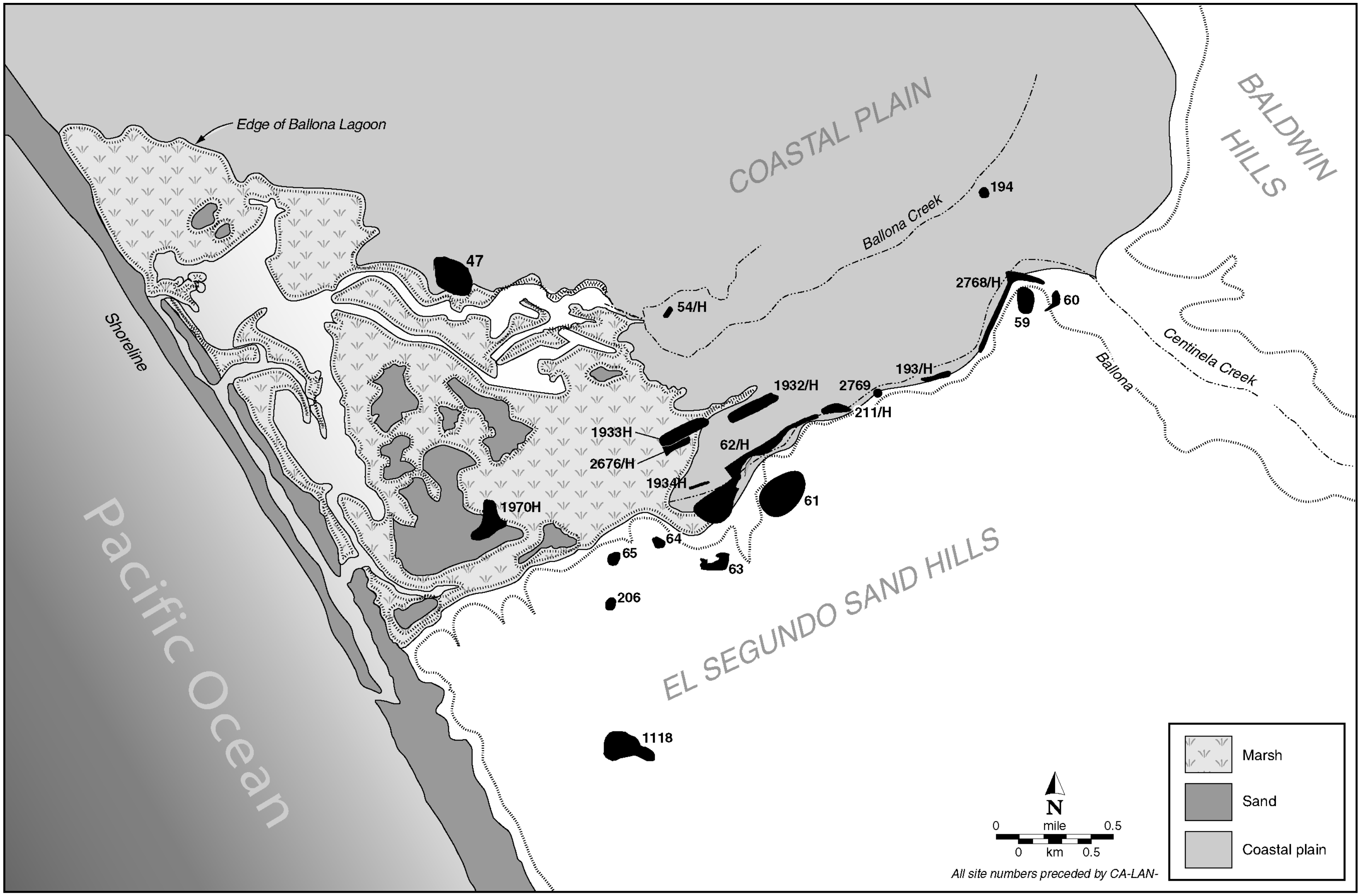


Figure 3.1 Location of all known prehistoric sites in the Ballona region.

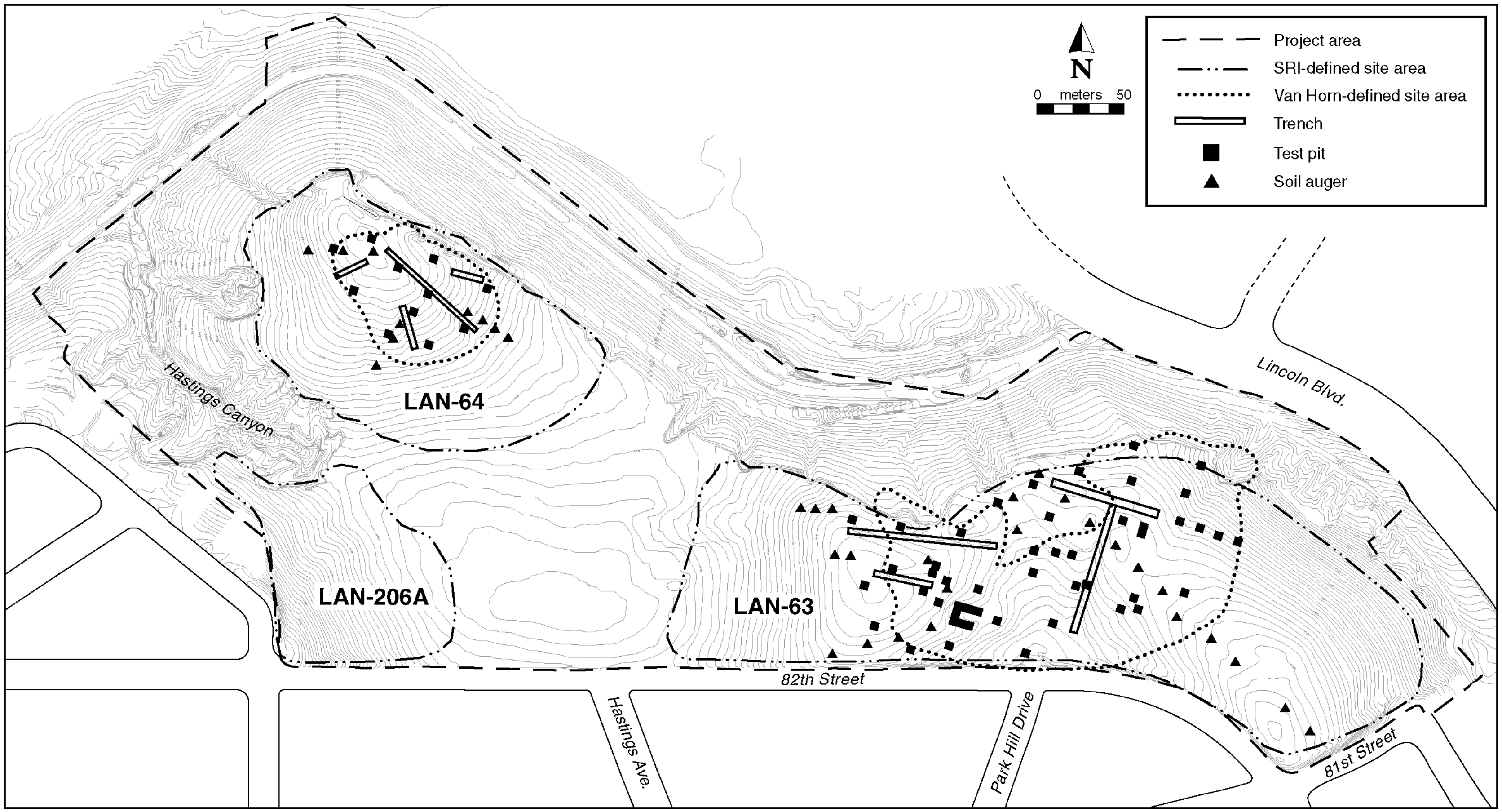


Figure 3.2 Site boundaries of LAN-63, LAN-64, and LAN-206A, as defined by Van Horn (1987; Van Horn and White 1997c), and the location of Van Horn's excavation units.

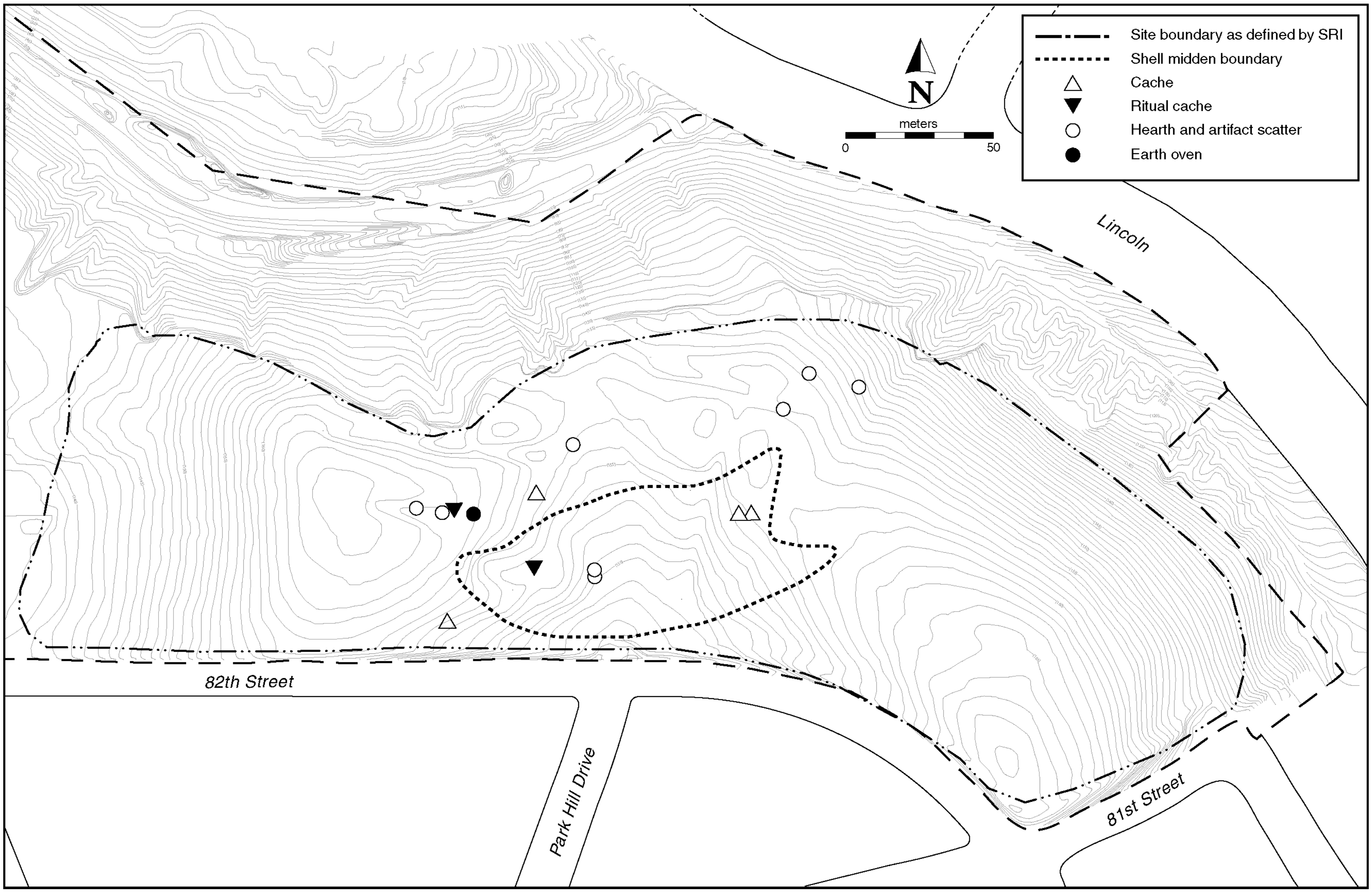


Figure 3.3 Feature locations at LAN-63 based on Van Horn's data recovery excavations.

Table 3.1. Previous Archaeological Projects near or on the West Bluffs Property

Project Type	Report	Site Recorded, Tested, or Excavated
Photo documentation	Theil (1953)	LAN-54/H, 59, 60, 61, 62/H, 63, 64, 65, 67, 206, and 211/H
Survey	Neuenschwander (1989)	LAN-1018 and 1698
Survey	Peck (1947)	LAN-62/H
Survey	Rozaire and Belous (1950)	LAN-53, 55, 56, 57, 58, 59, 60, 61, 62/H, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 171, and 172
Survey	Farmer (1936)	LAN-59, 61, 62/H, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, and 74
Survey	Altschul et al. (1991)	LAN-54, 60, 62/H, 193, 211/H, and 2769
Survey and auger Testing	Van Horn (1986)	LAN-63, 64, and 206
Testing	Pence (1979)	LAN-54/H, 59, 60, 61, 62/H, 63, 64, 65, 193, 203, 204, 206, 211/H, 212, 213, 216, and 1018
Testing	Vargas and Altschul (2001)	LAN-54/H
Testing	Altschul et al. (1999)	LAN-60, 193, and 2768
Testing	Dillon (1982)	LAN-61, 62, and 1018
Testing	Van Horn (1983)	LAN- 61 and 1018
Testing	Altschul et al. (2003)	LAN-62/H
Testing	Dillon et al. (1983)	LAN-62/H
Testing	Aycock (1983)	LAN-63 and 64
Testing	Stoll and Taylor (2000)	LAN-211/H and 2676/H
Testing	Peak (1990)	LAN-1018 and 1698
Testing	Taşkıran and Stoll (2000a)	LAN-1932/H
Testing	Taşkıran and Stoll (2000b)	LAN-1932/H and 211/H
Testing	Altschul et al. (1998)	LAN-2676/H
Excavation	Altschul, Homburg, and Ciolek-Torrello (1992)	LAN-47
Excavation	Keller and Altschul (2002); Vargas and Altschul (2001)	LAN-54/H
Excavation	Van Horn (1984); Van Horn and Murray (1984)	LAN-59
Excavation	Grenda et al. (1994)	LAN-60
Excavation	Van Horn (1984)	LAN-61 and 62/H
Excavation	Van Horn and Murray (1985)	LAN-61A & B

Project Type	Report	Site Recorded, Tested, or Excavated
Excavation	Altschul et al. (2003); Vargas et al. (2005)	LAN-62/H
Excavation	Altschul (1997, 1999); Altschul et al. (2000); Douglass and Altschul (2004); Sals (1987); Van Horn (1987)	LAN-63, 64, and 206A
Excavation	Van Horn and White (1997c)	LAN-206

Table 3.2. Models of Midden Formation

Observed Pattern	Van Horn's Interpretation	SRI's Interpretation
Site function	Bluff sites are primarily devoted to resource procurement. They are base camps occupied by single domestic groups.	Bluff sites show a wide range of activities by multiple domestic groups.
Site structure	unstructured; all activity takes place around a central hearth, the location of which shifts regularly	formal spatial structure, distinct activity areas defined (food preparation, tool manufacture, storage, etc.)
Depositional pattern	trash thrown outside and distributed homogeneously, not collected or redeposited in any formal manner	trash deposited in depressions at periphery of activity areas

Geoarchaeological Investigations

Jeffrey A. Homburg and James H. Mayer

This chapter summarizes the regional and local geology, including a paleoenvironmental reconstruction of the Ballona, and then presents interpretations of the soil stratigraphy in the upper deposits of the West Bluffs project area where cultural deposits were exposed. This geoarchaeological study was aimed at: (1) documenting the soil stratigraphy in different parts of the site; (2) interpreting geologic processes that account for the formation, alteration, and preservation of cultural deposits and artifacts; and (3) relating variability in artifact density in cultural deposits to the major soil horizons. Fieldwork was completed over five days (September 11–13 and 27, 2000, and December 8, 2000), with two brief visits during the monitoring investigations in the summer of 2003. Fieldwork involved describing seven soil profiles in test pits or trenches placed at each of the three sites, and collecting soil samples from representative profiles. Soil profiles (or pedons) were described in terms of standard soil science nomenclature (Schoenberger et al. 2002; Soil Survey Staff 1993, 1999). Soil analyses completed by Mary Jo Schabel of the Milwaukee Soil Laboratory were aimed at characterizing basic soil properties (pH, organic matter, and soil texture) for selected profiles. Two small blocks (approximately 8 by 5 by 5 cm) of soil-micromorphology samples were collected and analyzed to assess the formation, alteration and preservation of cultural deposits at the microscopic scale.

Southern California, as well as the entire west coast of North America, is extremely active geologically. Small-scale geologic processes such as earthquakes, and broad-scale tectonic events that have caused uplift and subsidence of large landmasses have shaped coastal California's landscape. These processes, combined with alluvial and aeolian deposition and erosion and sea-level fluctuations reflecting glacial advance and retreat, are responsible for the modern appearance of the coastline and the West Bluffs property.

The West Bluffs project area lies in the western Los Angeles basin, about 2.5 km inland from the Pacific Ocean and about 3.5 km west of the Baldwin Hills and the northern terminus of the Torrance Plain (Figure 4.1). The West Bluffs property is irregularly shaped, encompasses about 44 acres, and sits atop a prominent terrace bluff known as the Ballona Escarpment. This escarpment is a major east-west-trending erosional feature about 40–50 m high. West Bluffs provides a commanding view of the Ballona Lagoon and Wetlands to the north and northwest, as well as much of the Los Angeles basin. Figure 4.2 shows the configuration of the lagoon and wetlands that existed when the area was first mapped in 1861. This map depicts the estuarine complex and its associated sandy islands, tidal marsh, and drainages (Ballona and Centinela Creeks) that fed the estuary. Recorded archaeological sites are also shown in Figure 4.2. Ballona Creek occupies a remnant channel of the Los Angeles River in the Ballona Gap (see Figure 4.1). For an undetermined period of time prior to 1825, the Los Angeles River flowed westward across the Downey Plain and through the Ballona Gap before emptying into the Ballona Wetlands. During a large flood in 1825, the Los Angeles River switched course to a southerly route towards San Pedro Bay via the Dominguez Gap (Poland et al. 1959:21). Floods in 1862 temporarily returned the Los Angeles River to its western course, but since flooding in 1884, the channel has discharged southward into San Pedro Bay, a route that has been maintained artificially by concrete flood-control levees constructed in the 1930s. The large size of the submarine delta fan offshore from the Ballona Lagoon indicates that the Los Angeles River mainly flowed westward into the Ballona in prehistory.

The West Bluffs project area is bordered by Lincoln Boulevard to the northeast, 80th Street to the south, Berger Avenue and Hastings Canyon to the west, and the steep bluffs to the north (Figure 4.3).

Hastings Canyon was partially filled as part of residential development in 2003, to halt further erosion of the canyon. The topography consists of gently rolling terrain on the bluff top, with elevations ranging from about 41 to 52 m (135 to 170 feet) above mean sea level.

Three archaeological sites have been recorded within the West Bluffs property: the Del Rey site (LAN-63), which dates to the Intermediate period (approximately 2100–2400 B.P.) (Figure 4.4); the Bluff site (LAN-64), which is mainly an Intermediate period occupation (approximately 1800 B.P.) with some occupation during the Millingstone period (approximately 6800–7500 and approximately 8300 B.P.) (Figure 4.5); and a component of the Berger site (LAN-206A) that may date to the early Millingstone period (approximately 6500–7000 B.P.). Given the location of features at LAN-206A on the southern edge of Hastings Canyon, near LAN-64, however, it is possible that this component actually dates primarily to the Intermediate period. These age estimates are based on radiocarbon dates of shell (mainly *Chione*, a clam that thrives in sandy mudflats in back bays and lagoons, and *Argopecten*, a scallop that lives below low tide in sandy to muddy substrates of bays and lagoons [McLean 1978]) collected from intrusive cultural features at LAN-63 and LAN-64 in excavations by SRI, combined with previous excavations at the Berger site by Archaeological Associates (Van Horn and White 1997). The occupation age ranges provided above are rounded to the nearest century, based on conventional radiocarbon ages (that is, uncalibrated to the bristle-cone chronology and uncorrected to account for the marine reservoir effect, but corrected for isotopic fractionation); the radiocarbon dating results are presented and interpreted in this report's chronology chapter, Chapter 14.

Very little work on the stratigraphic context of LAN-63 and LAN-64 was provided in Van Horn's (1987) report on the original test excavations. DiGregorio and White (1987:55–56) noted that two stratigraphic units exist at LAN-63: "(1) an upper layer of light sand and (2) a lower layer of darker sand which is thought to have derived its darker color as a result of both cultural activity and natural sources (e.g., decaying vegetable material)." They reported that these units corresponded to ones observed at the Hughes (LAN-59), Loyola (LAN-61B), and Marymount (LAN-61A) sites to the east along the bluff. The upper unit, which varied from 10 or 20 cm to more than 1 m thick at LAN-63, was interpreted as an aeolian deposit and referred to as the "blow sand" stratum. This unit was found throughout the site, except in deflated and eroded areas near the bluff edge. DiGregorio and White (1987) reported that rodent burrowing, plowing, and accelerated erosion had disturbed the cultural deposits. Other than the observation that the midden deposit is thinner at LAN-64 than at LAN-63, Van Horn's (1987) testing report provided no information on the stratigraphy at LAN-64.

Regional and Local Geology

Quaternary Terrace deposits about 20–35 feet (6.1–10.7 m) thick cap the Ballona Escarpment. These deposits overlie earlier Pleistocene marine deposits that are more than 400 (122 m) thick, which in turn overlie Tertiary sedimentary rocks that are thousands of feet thick. As part of a geotechnical study for West Bluffs grading plans, four geologic units were identified and mapped on the property (Alwash and Wolfe 1999): Pleistocene Sediments, Quaternary Terrace, Alluvium, and Recent Alluvium. In addition, areas of surface failures (that is, gullies) were mapped along the edge of the shoulder slope of the bluff and modern artificial fill. No faulting or folding was identified by the geotechnical study. The following descriptions for these units are based mainly on Alwash and Wolfe's geotechnical report (1999).

Pleistocene Sediments (Ps) are from marine deposits consisting of fine- to medium-grained micaceous sand that is typically pale yellow to yellowish orange, and medium to dense compaction. This unit is moderately cemented where it is covered and protected from weathering, and it is exposed only on the backslope on the middle to lower flanks of the Ballona Escarpment at West Bluffs. This unit is mainly massive, with occasional discontinuous layers of gravel from relict stream channels and clay from slack water deposits. The gravel beds are composed of well-rounded pebbles and cobbles less than 30 cm thick, and the clay layers are greenish brown and less than 8 cm thick.

The Quaternary Terrace (Qt) deposit capping the Ballona Escarpment is aeolian in origin, a unit that has been mapped as the El Segundo Sand Hills (see Figure 4.1) (Cooper 1967; Mattoni and Longcore 1999). The El Segundo Sand Hills extend from the Palos Verdes peninsula to 3–7 km inland and northward to the Ballona Escarpment (which is also called the Ballona bluffs or Westchester bluffs), terminating at the West Bluffs property. This aeolian deposit coincides with the Oakley Sand, a soil unit mapped by Nelson et al. (1919). Sediments consist of fine- to medium-grained sand that is typically brown to reddish brown in the upper 10–15 feet (3.3–4.6 m). This unit is mainly massive, with occasional 30–60-cm-thick cross beds characteristic of aeolian deposition. The aeolian deposit thins and becomes finer textured to the east, away from sand sources on the Pacific Ocean beach to the west (Page 1950). Minerals in the fine sand fraction are dominated by quartz and magnetite, with lesser quantities of zircon, tourmaline, and calcite (Mbila and Homburg 2000). Archaeological deposits are all associated with the upper part of Unit Qt, buried by a thin sheet of reworked aeolian sand. The sandy soils of Unit Qt are somewhat excessively drained, with slow to rapid runoff and moderate permeability. In most of the project area, soils formed in the upper part of Unit Qt consist of thin brown to grayish brown A horizons overlying sandy subsoil containing thin, discontinuous clay lamellae. These deposits are discussed in more detail in the field results portion of this chapter

Alluvium deposits (Qal) were mapped along the base of the Ballona Escarpment below Cabora Road. This alluvium consists mainly of sandy fan alluvium that was redeposited from the Pleistocene Sediments and Quaternary Terrace units exposed upslope on the bluff. Recent alluvium (Qral) consists of unconsolidated deposits at the mouth of Hastings Canyon that are about 5–15 ft (1.5–4.6 m) thick in the northwest part of West Bluffs, plus sloughed material eroded from the wall of Hastings Canyon. This recent alluvium dates to the last few decades, which shows how quickly headcutting can occur once a gully is initiated. Units Ps and Qt are poorly cemented where exposed on the bluff, and the sandy sediment is easily eroded, which accounts for the rapid deposition downslope in Unit Qral.

About a dozen surface failures were mapped on the shoulder and backslope of the bluff. The largest one, by far, is Hastings Canyon (Figure 4.7), a broad gully that roughly parallels Berger Avenue on the west side of West Bluffs. Hastings Canyon varies in width from about 50 to 250 feet (15 to 76 m), and it has nearly vertical walls up to 30 feet (9 m) tall. Other surface failures are in smaller gullies on the shoulder of the bluff above Cabora Road. These deposits, eroded from Units Ps and Qt, consist of sloughed material that is about 3–5 feet (0.9–1.5 m) thick.

Artificial fill deposits were mapped on the lower backslope of the bluff face below Cabora Road on the bluff face, and along the periphery of the West Bluffs property. The area downslope of Cabora Road is associated with backfill from construction of the North Outfall Sewer and the overlying road. Fill on the southern and eastern edges of West Bluffs is associated with construction of Berger Avenue, 80th Street, and Lincoln Boulevard. Fill sediments consist of loose, unconsolidated fine- to medium-grained sand in a stratum that is up to about 3 m thick.

Local Paleoenvironmental Reconstruction

As part of SRI's work on the Playa Vista Archaeological and Historical Project (PVAHP), the shapes and changes of the Ballona Lagoon and neighboring landforms over the last 8,000 years were reconstructed (see, in part, Chapter 12). This section summarizes the landscape reconstruction by Shelley et al. (2003), including updated maps and associated archaeological sites based on the most recent radiocarbon dates obtained by the West Bluffs project (see the chronology chapter, Chapter 14) and the PVAHP. This Holocene landscape reconstruction has revealed that the prehistoric Ballona Lagoon was a rich but highly variable resource through time. As freshwater, brackish, and saltwater wetlands met, salinity levels rose and fell; habitable landforms emerged, subsided, and were inundated; and plant and animal species arrived, flourished, and receded. These changes were usually gradual, but catastrophic storms, floods, tsunamis, and earthquake also affected the environment, which, in turn, affected human land use in the Ballona. Human adaptive responses to the evolving lagoon and wetlands were also complex. Placing environmental events in time reduces the number of interpretive variables and provides a framework for evaluating cultural deposits.

The paleoenvironmental reconstruction is based on stratigraphic, radiocarbon, and paleoecological (molluscs, pollen, ostracodes, foraminifera, and diatoms) data obtained from about 200 cores, combined with observations and analysis of archaeological trenches and test excavations. These data were used to prepare a paleogeographic model for the last 7,000 years (Figure 4.8). A major uncertainty in reconstructing the Holocene paleogeography is the extent to which subsidence has influenced the nature, elevation, and distribution of marine, estuarine, and floodplain deposits. Subsidence may be due to compaction caused by dewatering and degassing of sediment, especially in the wetlands rather than marine and floodplain deposits, and locally to tectonism. Thus, an estuarine deposit now found at 15 m below sea level might have been deposited originally at 12 m or so.

At the end of the Pleistocene, the area where the Ballona Lagoon was to form was an open marine coastline. Deep sediments seen in cores from the Ballona include sand and gravel overlain by thick silt and clay (Poland et al. 1959). These strata are consistent with marine sands formed by the Pacific Ocean between ca. 15,000 and 7000 B.P. (Brevik et al. 1999) (these and other dates in this chapter are uncalibrated radiocarbon dates). This period was typified by global fluctuations in sea level and regional transgressions of the Pacific Ocean.

At 7000 B.P., the global sea level was about 10 m below present levels, and possibly 12–15 m below. The Pacific Ocean would still have been transgressing across the coastal/estuarine floodplain of the Ballona Creek/Los Angeles River system. This drainage system probably bifurcated into numerous distributaries among freshwater marshes, while mudflats and sand bars would have characterized the land-sea interface. There is no reason to suppose that the sea penetrated any farther inland than the small estuarine wedge shown in Figure 4.8. The shoreline at 7000 B.P. was at least 500 m offshore—and possibly more than 1 km—from its present location. The Los Angeles River flowed into the estuary for much of the last interglacial/glacial cycle, as indicated by the massive submarine fan-delta off the coast. This does not exclude other outlets (i.e., to Long Beach) because the river is known to have changed course frequently during early historical times. The Ballona bluffs were cut into the northern edge of the massive Pleistocene aeolian dune field that had accumulated downwind in response to the winnowing of the fan-delta and floodplain during the last glacial stage (and perhaps earlier). Erosion of the bluffs was caused by the Los Angeles River being pushed against the south edge of its floodplain by its own distributary deposits, as occurred historically with the Los Angeles and Tujunga Rivers in the San Fernando Valley. Marshy, vegetated areas rapidly developed in the eastern and southern portions of the bay, and these expanded with increased sedimentation (Brevik et al. 1999:9). Ostracode analysis from the Ballona reveals high sedimentation rates from ca. 6580 to 4600 B.P. (Palacios-Fest 2000). Palynological analysis of soil cores dating to this period also indicates an expansion of the salt marshes, suggested by the dominance of amaranth pollen (Davis 2000:12). Native populations probably fished, hunted, and collected wild plants across the broad floodplain around 7000 B.P., but the bluffs provided better-drained landforms for establishing more-permanent sites. Sites on the floodplain would have been submerged as sea level continued to rise.

By 5000 B.P., the marine transgression was nearing its eustatic end, as the continental ice sheets had largely disappeared in response to global warming. Thus, it is reasonable to invoke a broad “Ballona Bay” at this time, with ocean waters covering the Los Angeles River/Ballona Creek distributaries. Deep water at the coast, however, would have precluded the growth of extensive barriers at this time, although shoals and subtidal bars were likely being created just offshore of the present coastline because of the significant change in wave energy due to refraction. More likely, midbay bars and spits developed in “Ballona Bay” at the null point where seasonal fluvial processes were countered by perennial wave and derived current processes in the outer bay. We have little evidence for this, other than observations of such bays elsewhere, but it is significant that the underlying fluvial gravels in the Ballona aquifer rise to within 20 m of the surface in the location shown and could have provided a foundation for spit growth. Such sites may have been favored by fishing communities because they represented dry land amid marsh, mudflats, and open water. The midbay bar near LAN-61 may also have been favored by alluvial fan deposition. The salt marsh around the outer bay was probably limited in extent at this time because sedimentation reaching the intertidal zone would have been quite marginal. The open coastline was still probably 100–200 m seaward of the bluffs because much of the bluff erosion has continued since 5000 B.P., until they were stabilized by historical housing developments. The presence of oysters of 6,220 ± 80 B.P. at -4.72 m in Core 1B reflects open estuarine conditions then in existence in the outer bay. Oysters were also found at shallow depths, between -1.6 and -1.8 m in Core 100 at 4790 ± 120 B.P.. The presence of horn snail at -2.05 m and 4900 ± 140 B.P. in Core 61 indicates intertidal conditions here.

By about 4000 B.P., the eustatic transgression had ended. Subsequent changes in the configuration of "Ballona Bay" were attributable to: (1) fluvial sediment inputs from the Los Angeles/Ballona/Centinela Creek which would have caused alluviation of the inner bay in the form of longitudinal intertidal bars and mudflats; (2) salt marsh accretion on supratidal areas around the fringes of the outer bay, with midbay bars favoring leeward accretion; (3) marine/estuarine sedimentation in the outer bay, but still limited by the bay's broad dimensions such that intertidal sedimentation was essentially marginal; (4) growth of a nearly continuous beach spit-barrier across the mouth of the outer bay; (5) continued compaction and possible tectonic subsidence; and (6) hydroisostatic depression of the coastal zone generally, and the shelf area in particular, with hydroisostatic loading accounting for as much as 1 m for every 1,000 years of subsidence, relative to fixed inland datums. Soon after 4000 B.P., oyster and jackknife clams disappeared entirely from the bay and were replaced by horn snails. Horn snails are much more tolerant of freshwater, so this shift marks a significant increase in fresh water inputs (Shelley 2001:14; see also the invertebrate analysis chapter, Chapter 11). A radical shift in the ostracode population also signaled this change, as freshwater ostracodes replaced the marine ostracodes at around 4200 B.P. (Palacios-Fest 2000:26).

By 3000 B.P., the inner bay that formed in response to the initial transgression was largely erased beneath intertidal deposits of sand and mud, thereby restricting open water to the former outer bay. The coastal plain to the north expanded as supratidal fluvial (flood) and aeolian sediment accumulated and pushed the coastal plain/salt marsh interface southward. Salt marsh probably extended farther south from the north shore, as intertidal bars and mudflats extended westward from Ballona Creek. As in earlier times, much of this scenario would depend on the importance of discharge and sediment from Ballona Creek. If this creek still accommodated the Los Angeles River, at least intermittently, rates of accretion and shoreline progradation, as well as reworking during major floods, would have been much greater. If the creek did not receive Los Angeles River inputs, the area would have settled into a more passive state similar to that in historical times.

By 2000 B.P., the coastal plain (composed of fluvial and aeolian sediments) continued to encroach on the salt marsh along the northern margin. The salt marsh was somewhat more extensive, extending to cover much of the bay beyond the north shore and at the creek mouths. The barrier and bluff shoreline on the open coast was probably still about 50 m seaward of the present. An extensive intertidal, unvegetated mudflat developed in the bay or lagoon).

By 1000 B.P., salt marsh islands and intertidal mudflats had become more extensive. The open-coast shoreline was probably near its present location but, as earlier, there would have been perhaps a 100-m-wide backshore between the sea and the bluffs. A double barrier that is depicted later in historical maps is inferred to have formed by this time. Double barriers are found along many coasts and they have different origins, including (1) diversion of drainage by a single encroaching barrier; (2) multiple barrier encroachment in a sediment-rich environment; (3) floodwaters breaching an inner barrier but then diverted by a new barrier formed from the floodwater sediment; (4) subsidence; and (5) human interference. For the next millennium, increasingly high volumes of water flowed through Ballona and Centinela Creeks, which led to accelerated sedimentation, the spread of marsh and wetland areas, and a corresponding decrease in the area of open water in the lagoon (Brevik et al. 1999:10). This conclusion is confirmed by pollen data, which indicate that before 3000 B.P., the species present in abundance were those that thrived in open, brackish water (such as *Ruppia, Botryococcus, Pediastrum,* dinoflagellates, and foraminifera), whereas after 3000 B.P., shallow-water species such as cattail and tule *(Typha-Sparganium* and *Cyperaceae*, respectively) became more numerous (Davis 2000:26). By 1000 B.P., sedimentation had caused the Ballona Lagoon to shrink to a small remnant of its former expanse.

The configuration of the Ballona was mapped during the 1893 U.S. Coast Survey (see the last panel in Figure 4.8). By about 200 B.P., sediments had filled much of the lagoon and a complex of sandy islands and extensive salt and freshwater marshes developed throughout much of the former lagoon. The north shore of the lagoon moved slightly to the south as the coastal plain to the north continued to expand.

This paleogeographic reconstruction provides a model for explaining the evolution of cultural land-use patterns in the Ballona. Additional data are needed to further refine this model. Ideally, we need more subsurface evidence for the following: (1) the Core 1B area should be penetrated deeper to determine the depth of the underlying fluvial gravels from the late Pleistocene landscape; (2) petroleum drilling logs should be retrieved to better define the entire late Pleistocene land surface; and (3) additional cores should be extracted from the northern part of the basin and another deep core from the basin center.

Geoarchaeological Investigations

Seven soil profiles were described in selected backhoe trenches and test pits at West Bluffs. These units were selected to represent the range of landscape positions (summits, hillslopes, a swale, and an upland depression). Appendix A provides detailed formal descriptions (e.g., Munsell color and color name, texture, structure, consistence, root distributions, effervescence, reaction, boundary types, and other noteworthy observations) of the soil horizons observed in these profiles, along with interpretations of the types of horizons represented and information on the geomorphic setting, geologic parent material, and vegetation for each profile at the time of fieldwork. The seven profiles described included three at LAN-63 (Profiles 1, 2, and 5), two at LAN-64 (Profiles 3 and 4), one at the east edge of LAN-206A (Profile 6), and one in an upland depression between LAN-63 and LAN-206A (see Figure 4.3).

Laboratory data on pH, organic matter, and texture are summarized in Tables 4.1 and 4.2, and graphically depicted in Figures 4.9 and 4.10 to show trends with depth. Soil pH was measured electrometrically in a 1:1 suspension (weight basis) of soil and distilled and deionized water (Thomas 1996); organic matter was determined by loss-on-ignition (Heiri et al. 2001; Kolb and Homburg 1991); and particle-size distributions were determined using the sieve and pipette method (Gee and Or 2002:Methods 2.4.3.2 and 2.4.3.4), with samples pretreated with 30 percent hydrogen peroxide for organic matter digestion and a sodium hexametaphosphate solution for clay dispersion.

Soil micromorphological analysis was conducted for two samples from LAN-63, which involved analyzing undisturbed soil samples in thin section using a petrographic microscope. Soil micromorphology was conducted to determine what, if any, anthropogenic traces can be identified in the cultural deposits; and assess how natural site-formation processes have altered the cultural deposits. Thin sections were initially observed on a light table to note general characteristics such as color, presence or absence of pebbles or granules, and possible traces of human activity (e.g., chert, shell, and bone fragments). Samples were then observed on a stereomicroscope at magnifications ranging from about 7–20 x to make observations of the microstructure, void space types and percentages, sorting, and preliminary mineralogical identifications. Measurement of voids, pedofeatures (e.g., grain coatings, void fillings, etc.) and examinations of archaeological materials was conducted using a petrographic microscope. Digital images were obtained in both plane-polarized light (PPL) and cross-polarized light (XPL) for selected features.

Descriptions of thin sections were conducted in accordance with the terminology of Bullock et al. (1985), Courty et al. (1989), and Stoops (2003).

Table 4.3 and Figure 4.11 summarize the artifact density (lithic artifact counts and the weight in grams for faunal bone and shell remains) depth trends at LAN-63 and LAN-64 for each 10-cm level, standardized to a cubic meter and assuming 0.1 m^3 per level. Figure 4.11 is based on hand excavations of a total of 38.8 m^3, including 31.3 m^3 at the LAN-63 and 7.5 m^3 at LAN-64. Only 0.7 m^3 were excavated in two test pits at the Berger site (LAN-206A), and these units yielded only two lithic artifacts and 40 g of faunal bone (all in Level 1), so volumetric data on this site are omitted in Figure 4.11. The test pits on the Berger site, however, were on steep to moderately steep slopes at the eastern margin of the site, where little cultural activity would be expected.

Soils in the West Bluffs project are classified at the subgroup level as: (1) Psammentic Haploxeralfs (soils high in sand, with minimally developed argillic horizons resulting from illuvial clay accumulations, formed in xeric moisture regimes that are characteristic of Mediterranean climates such as the study area) in the older, more stable areas, such as at LAN-64; and (2) Alfic Xeropsamments (similar to the previous soil but formed on less stable slopes where B horizons are absent between the sites investigated); and (3) Typic Argixerolls (intermediate in development between the first two soils, but with dark, mollic epipedons more than 25 cm thick, such as the midden at LAN-63). More information on the definitions of these subgroups and their diagnostic horizons is available in the latest soil taxonomy (see Soil Survey Staff 1999).

Del Rey Site (LAN-63)

The horizon sequences for the LAN-63 profiles are as follows: Profile 1, Ap-A-Bw-2Ab-2BAb; Profile 2, Ap-A-BA-Bt; and Profile 5, Ap-A-Bt. Profile 1 was placed in the swale and Profiles 2 and 5 were placed on hillslopes outside of the swale (see Figure 4.3 for locations). The Ap horizon represents a plow zone, and the A and Bw (a cambic horizon, which is an incipient B horizon with some color change from the parent material) horizons formed in a brown sand sheet that is about 60–70 cm thick. The Ap horizons of Profiles 2 and 5 mark the sand sheet on the slopes away from the swale, and the sand sheet in these profiles is more representative of LAN-63 as a whole, with a thickness of about 20–30 cm. The age of the sand sheet is unknown, but it must be less than about 2,000 years old and possibly much less than that, based on radiocarbon dates from intrusive cultural features exposed below the sand sheet during grading operations.

Underlying the sand sheet in Profile 1 is an approximately 1-m-thick, 2Ab horizon that marks a dark grayish brown shell-midden deposit, the richest, thickest, and darkest midden identified in the entire West Bluffs project. Uncalibrated radiocarbon dates for the midden (2Ab horizon ranged from 2040 to 2140 B.P.; dates from the A horizon associated with the shallower midden, identified elsewhere on site below the sand sheet, range from 1720 to 2140 B.P. (see discussion of radiocarbon dates in Chronology chapter). The correlation between soil strata in Profiles 1 and 2, as well as other representative profiles in the West Bluffs project are depicted in Figure 4.12. The soil stratigraphic units described in Appendix A are believed to be time-stratigraphic units as well, and so these units, designated Units I–V from oldest to youngest, appear to be correlated. Figure 4.13 depicts the midden (Unit IV) and overlying sand sheet (Unit V) exposed in the swale where Trench 1 was placed, showing how the midden thins to the north as the topography in the swale rises. Figure 4.14 shows the southern part of Trench 1 where Profile 1 was placed. The A horizons of Profiles 2 and 5 are correlated to the 2Ab horizon of Profile 1, but the midden deposits there are shallower, thinner, and sparser than at Profile 1. Over-thickening of the A horizon in Profile 1 relative to other parts of LAN-63 is likely due mainly to the decomposition of a luxuriant growth of natural grasses in the swale, where sediment and runoff water was concentrated. The AB horizon of Profile 2 and the 2BA horizon of Profile 1 are transitional horizons that appear to be correlated, so they were designated Unit III. The two dates from the AB horizon (1920 B.P. and 2120 B.P.), however, are within the range of the overlying A horizon, and so it is possible that these two dates were obtained from shell that had been translocated downward by animal burrowing. Alternatively, this may indicate rapid deposition of the cultural material. A Bt horizon (a zone marked by the accumulation of illuvial, or translocated, clay that qualifies as an argillic horizon, given that more than 20 percent clay on a relative basis has been translocated downward to the Bt horizon from the overlying eluvial horizon) was noted in the bottom of Trenches 2 and 5, based on observations of clay bridges between, and clay coatings on, sand grains in the matrix.

Figures 4.9 and 4.10 show how Profiles 1 and 2 both increase in clay and silt content with depth, with a corresponding decrease in sand content. The peaks in organic matter shown in Figure 4.9 correspond to the midden deposits. Soil pH at Profile 1 varies from slightly acid (pH 6.0–6.2) in the sand sheet to slightly acid or neutral in the underlying midden. An increase in pH, though less dramatic, was also noted in Profile 2. The pH increases in the midden are probably the result of bone and shell additions resulting from human activities, which has more than offset the effects of organic acids associated with the elevated organic matter levels. This assessment was confirmed by observations of the shell in the midden at Profile 1, because the shell in the upper midden was more weathered and chalky in appearance, and better preserved in the lower midden where the pH rises. The ideal pH for bone preservation is 7.88, as noted by Linse (1992), based on the solubility of hydroxyapatite (or $Ca_5(PO_4)_3OH$) and other calcium phosphates reported by Lindsay (1979:Figure 12.8). Lithic, bone, and shell densities are significantly higher at LAN-63 than at LAN-64, and this is true for all material types and levels but the bone of Level 1.

Bioturbation from with pocket gopher burrowing was common at LAN-63, especially at the contact between the sand sheet and underlying midden (Figure 4.15). In some places, the burrowing is extensive, as indicated by krotovina (infilled burrows) filled with soil material from different horizons of varying color. Burrowing by pocket gophers has mixed the deposits to some degree, but the fact that soil horizons are visible indicates that stratigraphic integrity dominates over bioturbation mixing processes (see Figures 4.13 and 4.14, which show how easily it is differentiated from the sand sheet and midden deposits). Artifacts found in the sand sheet appear to have been mixed upward into the overlying sand sheet. Another measure of bioturbation, but the result of downward mixing, is provided by the distribution of historical-period artifacts with depth. These are sparsely distributed in the upper three levels, and absent in all underlying levels except Levels 5 and 8. So there has been some downward mixing, but the overall effect on stratigraphic integrity is minor.

The two soil micromorphology samples from LAN-63 were collected from Profile 1 in the thick midden of Trench 1 (see Figure 4.3). One sample was collected at 62–71 cm below surface at the Bw-2Ab contact (that is, at the contact between sand sheet of Unit I and the underlying surface horizon of Unit II), and the other from 103–112 cm in the 2Ab horizon. The mineralogy was very similar in the two samples, consisting mainly of quartz (approximately 85 percent), followed by plagioclase, orthoclase, microcline, chert, mica, opaque mineral grains (mostly or entirely magnetite), hornblende, and augite. Sand grains are moderately to well sorted, fine to medium, and rounded to subangular. Coarse sand constitutes less than 2 percent of the sample.

In the 62–71-cm sample, the Bw horizon is differentiated from the midden by significantly less amorphous organic matter, grain coats, and void fills (Figures 4.16a and b). The Bw horizon has a single-grained microstructure, with coarse and fine material represented primarily by only one size, in this case, sand. The Ab horizon shows very weak granular ped structure, with a pellicular microstructure (almost entirely sand-size grains coated with finer material) and a corresponding chitonic coarse-fine relationship in which finer material surrounds larger sand grains. Grain coats and void fills are primarily a mixture of amorphous organic matter and iron oxide–stained colloidal material (see Figure 4.16a and b). Silt grains also compose a portion of the void fills. Void space ranges from 15 to 20 percent across the image (Table 4.4). Grains in the Bw horizon are less densely packed than in the Ab horizon (see Figures 4.16a and b). An angular chert fragment, probably a microflake, was observed at the Bw-2Ab boundary, which shows an accumulation of secondary material on its upper side (Figures 4.16c and d). The 103–112-cm sample from the middle of the midden is similar to the upper 2Ab horizon, displaying mainly pellicular microstructure.

Bone fragments were found in both samples, but shell was observed only in the sample from 62 to 71 cm. Smaller (approximately 0.5-mm) fragments of bone and shell were observed in much larger voids (Figures 4.16e and f), indicating significant chemical weathering. Voids considered formed by bone or shell dissolution, termed remnant voids, are more common in the upper portion of the midden than in the middle. The shell and bone fragments, as well as the remnant void walls, have similar organic/iron-oxide coats as the mineral grains.

It is instructive to compare the micromorphological observations with archaeological and bulk soil chemical data. The maximum densities of shell and bone at LAN-63 are between 75 and 85 cmbs, and taper off abruptly below that, which indicates that the greater part of the occupation was above 100 cm, with the peak representing an occupation surface. Field observations indicated that elevated organic matter in the 2Ab horizon continued to a depth of 165 cm, which is well below most cultural material. This pattern corresponds well with the micromorphological observations, with significantly more bone and shell fragments in the 62–71-cm sample than in the 103–112-cm sample. Throughout the entire profile, soil pH is less than 6.9, which is significantly below the level ideal for bone preservation, as noted previously. Humic acids, combined with leaching effects near the surface, are probably the primary factors in the relatively low pH levels, resulting in substantial losses of both bone and shell at LAN-63. The shell dissolution is clearly shown in the remnant void of Figure 4.16F. This observation is consistent with field observations of the "chalky" and slightly decomposing appearance of shell in the upper midden, whereas shell at deeper levels was in better condition. Interestingly, analysis of soil micromorphology samples from other shell middens in nearby sites, including LAN-2768, indicates that some shell has also been lost (Mayer and Homburg 2005).

Bluff Site (LAN-64)

In contrast to LAN-63, the summits and slopes of LAN-64 have much lighter-colored soils, the result of their lower organic content (see Table 4.1 and Figure 4.9). Figure 4.17 shows a stepped trench excavated on the summit of LAN-64, a landscape position affected by moderate sheet erosion that has stripped off the uppermost soil. The shoulder slopes have undergone moderate to severe sheet erosion. These erosional effects probably account, at least in part, for the high density of lithic artifacts in Level 1 and the rapid decline in lithic artifact density with depth. The lithic artifacts near the surface probably concentrated there in lag deposits. Further support for the interpretation that the site has undergone moderate to severe erosion is that soils are more strongly developed, and at a shallower depth, than at LAN-63. One clear indication of this is the clay lamellae exposed near the surface of LAN-64. These lamellae are indicated by the dark, undulating ribbons that are faintly visible in Figure 4.17, and prominent in a gully on the upper shoulder slope at the northern edge of the site (Figure 4.18). Their dark color is the result of higher levels of clay, organic matter, and iron relative to the intervening zones.

Clay lamellae have been identified in climates ranging from subarctic to Mediterranean elsewhere in the U.S. (e.g., Midwest, Southeast, Great Lakes region, southern and central Great Plains, Northwest, California, Alaska, and sporadically in intervening areas) and other parts of the world (e.g., Belgium, Netherlands, Germany, and New Zealand). They are always associated with sandy sediments, such as those in the West Bluffs project, but in a wide range of depositional environments (e.g., aeolian, alluvial, coastal plain, and glacial outwash deposits). Geologists and soil scientists have long debated how lamellae form, and theories range from pedogenic (or soil-forming) processes to nonpedogenic, geologic processes related to sedimentation and lithologic discontinuities (e.g., Berg 1984; Bond 1986; Dijkerman et al. 1967; Folks and Rieken 1956; Giles 1979; Hannah and Zahner 1970; Miles and Franzmeier 1981; Mokma 1990; Robinson and Rich 1960; Schaetzl 1992; Torrent et al. 1980; Wurman et al. 1959). Although the present study was not aimed at explaining how the lamellae formed, they are probably the result of thin layers of clay being deposited on the dune sands of West Bluffs—possibly clay brought in from the Mojave Desert by Santa Ana winds—and subsequent downward translocation of the clay through the underlying sandy matrix. The clay is translocated in suspension during the heaviest storms due to wetting at greater depths below the surface. Because the speed of the wetting front varies both temporally and spatially, even over short distances, the lamellae move downward at different rates, which accounts for the undulating, ribbon-like appearance today. Their significance for interpreting the geology and geoarchaeology of West Bluffs is two-fold: lamellae mark landscape positions that are the most stable geomorphically (that is, neither totally removed by erosion, nor rapidly buried by later deposits), and the zones with lamellae generally lack artifacts. (One exception is that very faint and weakly developed lamellae noted in the midden exposed in Profile 1 at LAN-63.

An Ap-A1-A2-A3-AB horizon sequence was noted in Profile 3 on the summit to a depth of 125 cm, and an Ap-A-BA-Bt1-Bt2-BC-C sequence was recorded in Profile 4 to a depth of 168 cm. Correlations between the soil horizons and stratigraphic units for Profiles 3 and 4 are depicted in Figure 4.12. These hypothesized correlations are supported by the radiocarbon dates, also shown in Figure 4.12. The A sub-horizons of Profile 3 were differentiated based on differences in pH and color, and they are each separated by 3–4-mm-thick lamellae (Figure 4.19). Lamellae development was greater on the shoulder slope in Profile 4 (Figure 4.20), probably due to greater infiltration, and thus illuviation (downward translocation of fine material like clay, carried in suspension through soil pores) here than on the flatter summit. The lamellae of Profile 4 are yellowish brown, ranging from 3 to 6 mm thick. Some of the lamellae bifurcate or merge with others. The lamellae are thinner but more distinct higher in the profile, starting at 38 cmbs in the Bt1 horizon. Radiocarbon dates from the early Millingstone to Millingstone period occupation were found in the AB or BA transitional horizons (Unit III), which marked the bottom of the cultural deposits at the contact between the A and Bt horizons. Ten dates from Unit III range from 6770 to 8260 B.P., and seven of these dates clustered between 7180 and 7530 B.P.. (see the Chronology chapter for discussion of the dates). Two dates were obtained from the A horizon (Unit IV), one at 1780 B.P. and one at 2050 B.P., so this Intermediate period occupation overlaps with the much more substantial occupation represented at LAN-63.

Except in the uppermost horizons, organic-matter levels are lower than the A horizons associated with the midden at LAN-63, whereas the pH levels were generally similar to but more variable than at LAN-63 (see Figure 4.9). Because the pH increases to about 7.0 or above in the lower parts of the profile, bone preservation should increase with depth. The quantity of bone, however, decreases with depth, so this decrease must not be the result of any significant preservation bias, assuming the bone was buried quickly enough to protect it from oxidation at the surface (see Figure 4.11). Alternatively, and perhaps most likely, the bone distribution may largely reflect the incorporation of burrowing animals, especially the pocket gopher, that lived in the soil rather than subsistence remains related to human activity. Other major differences between the two sites are that shell is almost nonexistent at the LAN-64, and that much higher concentrations of historical-period artifacts were found here than at LAN-63. Historical-period artifacts are concentrated in Level 1, but they were found to extend down to Level 5 (see Table 4.3).

Berger Site (LAN-206A)

Only one soil profile was documented in this site, in the eastern locus. An Ap-BA-Bt/C horizon sequence was noted in Profile 6, which extended to a depth of 122 cm. The soil consists of brown to pale brown loamy sand throughout the entire profile. Lamellae were noted between 46 and 122 cmbs, in the Bt/C transitional horizon, with the deeper lamellae being thicker, more irregular, and having a jagged appearance in comparison to elsewhere at West Bluffs. The lamellae indicate the landscape is geomorphically stable, but the topographic setting is steeper than that of other profiles, with a slope gradient of 9 percent. No prehistoric artifacts were observed in Trench 1002 where Profile 6 was placed, and no soil samples were collected. This trench was placed just inside the fence marking the West Bluffs boundary, within 15 m of the northeast corner of 80th Street and Berger Avenue.

Upland Depression

Profile 7 was placed in the depression between LAN-63 and LAN-206A. Initially, we considered this depression to possibly represent a relict vernal pool. Vernal pools are ephemeral spring wetlands that form in depressions underlain by a confining layer (like bedrock or clay) in grasslands and woodlands. If this depression was indeed a vernal pool, it might be very important for interpreting the archaeology of West Bluffs, because many herbaceous plants are concentrated in these settings, some of which are known to be important to Native American groups in California as sources of plant food (as well as the animals drawn to such water sources), medicinal plants, and utilitarian plants useful for making basketry (Culbert 1996). Furthermore, this particular depression is indicated as a vernal pool in a map produced by Mattoni and Longcore (1997:Fig. 1), based on archival records used to reconstruct vegetation associations and a detailed analysis of aerial photographs covering the Los Angeles coastal prairie. This community was once extensive, covering all of the El Segundo Sand Hills (which extend over about 95 km^2), but has vanished over the last century because of widespread housing and commercial developments and associated changes in the hydrology. In an attempt to determine if this depression was truly a relict vernal pool, we collected sediment samples for ostracode, pollen, and macrobotanical analysis. Ostracodes are bivalved arthropods that are useful for identifying former aquatic settings, and when preserved, even reconstructing the permanence of water. Sediment samples were processed to extract ostracodes, but unfortunately, none were found. Their absence may be due to moderately to slightly acid conditions, with pH ranging from 5.5 at the surface to 6.5 at nearly 150 cmbs.

An Ap-Bw-2Ab1-2Ab2-2AB-2Btb1-2Btb2-2Btb3 sequence was recorded in Profile 7, extending to a depth of 146 cm (see Figure 4.12). Stratigraphic units for these horizons, and presumed correlations to units documented at LAN-63 and LAN-64 are shown in Figure 4.12. We hypothesize that Units III and IV from LAN-63 and LAN-64 pinch out before reaching the depression at Profile 7, possibly due to deflation and removal of sediment in the depression prior to deposition of Unit V. If so, then Unit V lies unconformably on Unit II in Profile 7. An approximately 70-cm-thick, buried A horizon was found, represented by the 2Ab1, 2Ab2, and 2AB subhorizons (these horizons were lumped together as Unit V). Because of the thickness, dark color (brown to dark brown or dark grayish brown) indicative of higher organic matter than elsewhere at West Bluffs (even the midden at LAN-63), this buried A horizon was considered a likely candidate for being associated with a periodically water-filled depression, overlain by more-recent sediment carried in with runoff. Organic matter is typically higher in such wetland soils, due to the combined effects of higher rates of plant biomass production and humification, as well as greater preservation due to reduced oxidation under anaerobic conditions (even if only intermittent). A radiocarbon date of 220 B.P. was obtained, which shows the buried A horizon is associated with the Mission period, not the prehistoric occupations represented at the West Bluffs sites. Even though this deposit is relatively late, soil data support the interpretation that this depression held water intermittently. This soil evidence consists of dark yellowish brown mottles, the result of iron oxidation after iron was reduced and mobilized during episodic saturated conditions. The trench did not extend deep enough to expose a clay layer, but one probably exists at some depth below about 1.5 m. In the end, then, the evidence is suggestive that this upland depression held water in the past. The absence of ostracodes, however, makes further determinations difficult.

Summary and Conclusions

This geoarchaeological study provided useful information for interpreting the formation, alteration, and preservation of cultural deposits at West Bluffs. This upland setting is unique, especially compared to the more intensive archaeological work previously conducted in and around the wetlands at Playa Vista and at the Admiralty site (LAN-47). Stratigraphically, the West Bluffs soils are relatively simple because the cultural deposits are generally shallow and thin (with the exception of the roughly 1-m-thick midden at LAN-63), and most cultural features were found at or just below the lower contact of a sand sheet that overlies the cultural deposits. Soil morphology, most notably the lamellae observed at the Bluff and Berger sites, was useful for pinpointing those areas with the greatest geomorphic stability and the depth where intact cultural deposits were not expected. Bioturbation has had a significant effect on cultural deposits at West Bluffs, but the fact that soil horizons are recognizable indicates that stratigraphic integrity is dominant over mixing processes. Soil pH generally increases with depth at all of the West Bluffs sites, tending toward levels where the best bone preservation would be expected. Soil micro-morphology indicates that shell in the upper midden, where pH is lowest, is being dissolved, and it is likely that some shell has been completely lost due to humic acids and leaching effects.

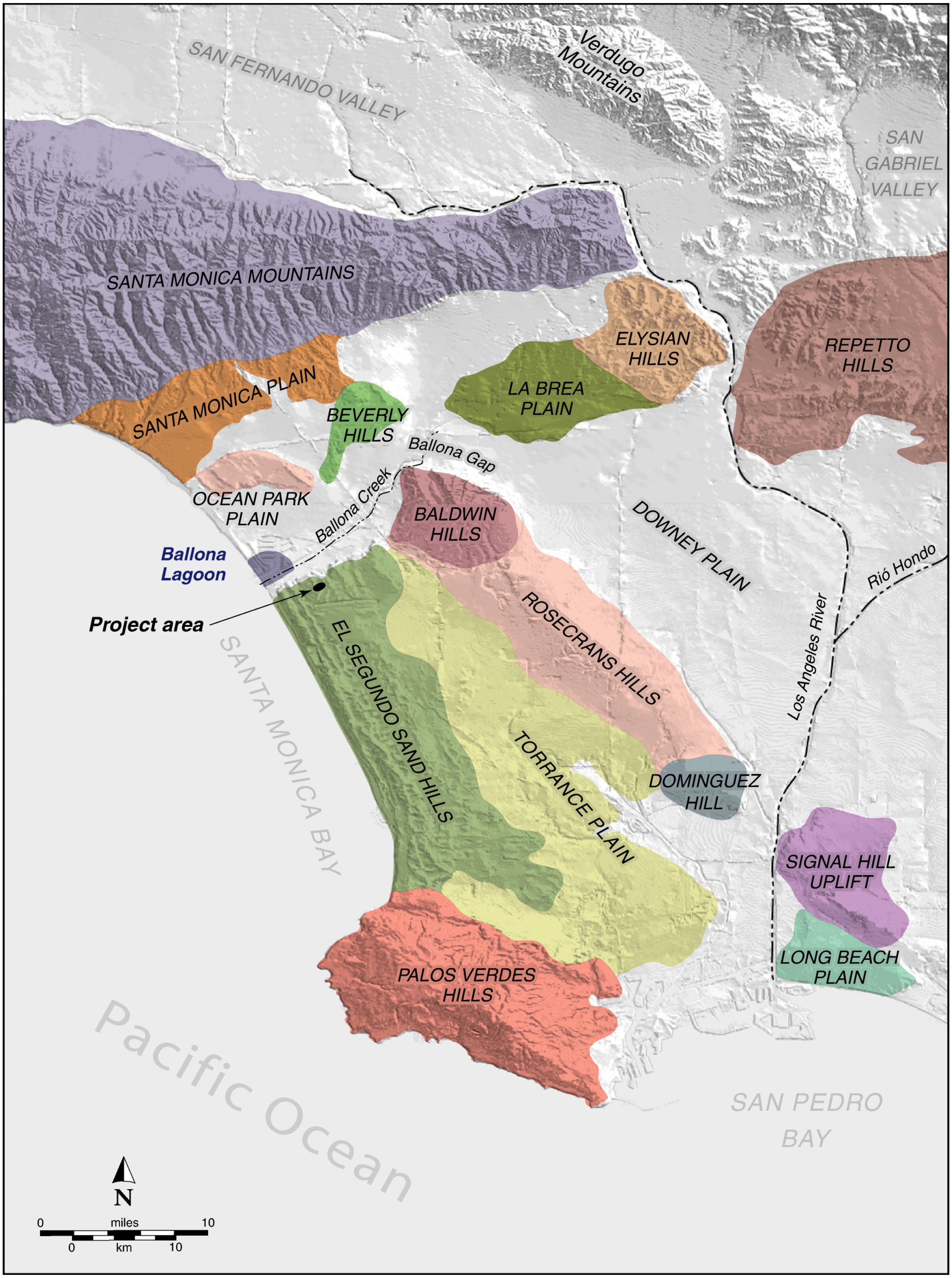


Figure 4.1. Geologic map of the western Los Angeles basin, showing the project area.

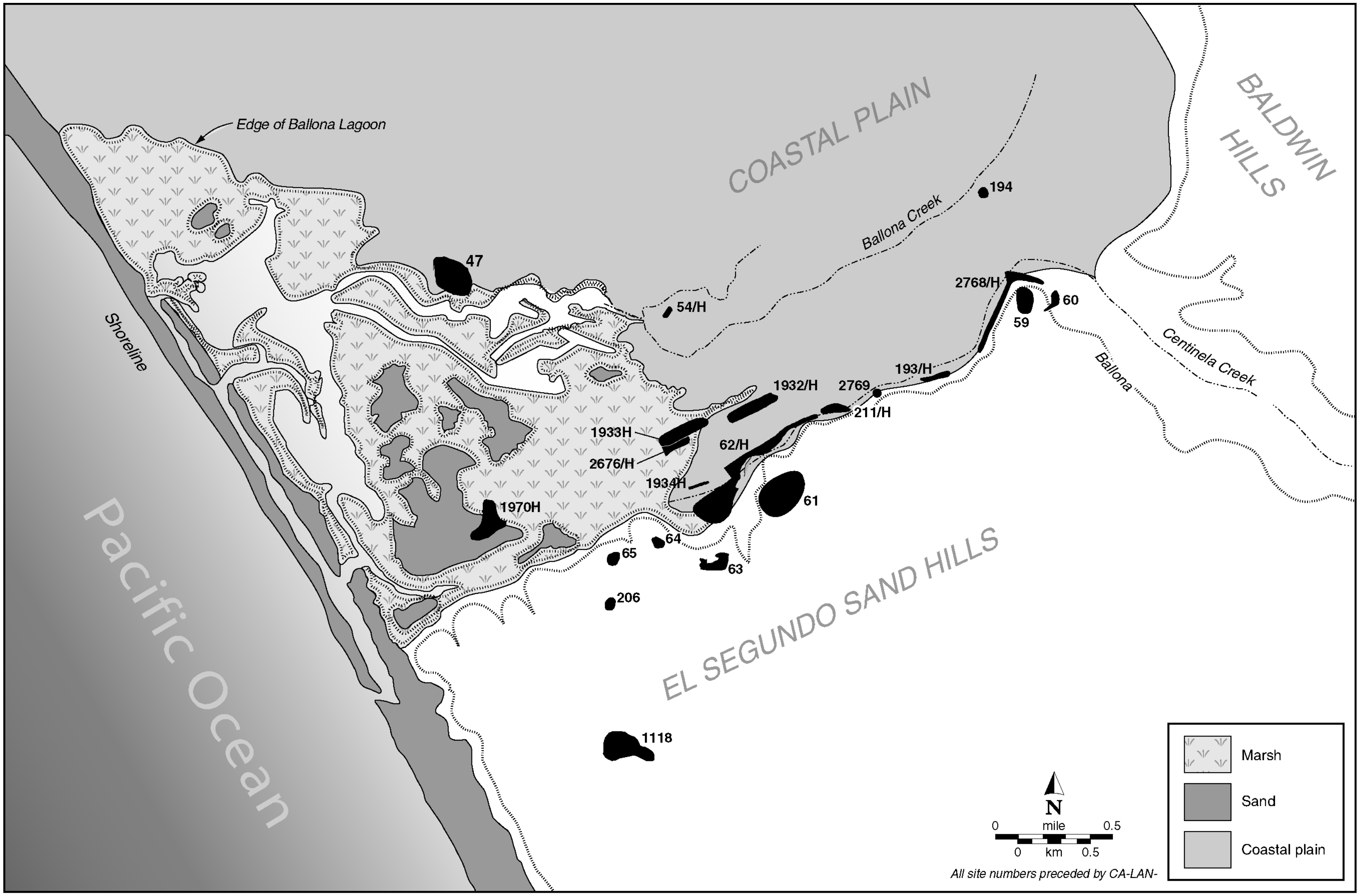


Figure 4.2. U.S. Coast survey map of the Ballona Lagoon in 1861 (adapted from Chase 1861). Sites LAN-63 and LAN-64 are in the West Bluffs project area.

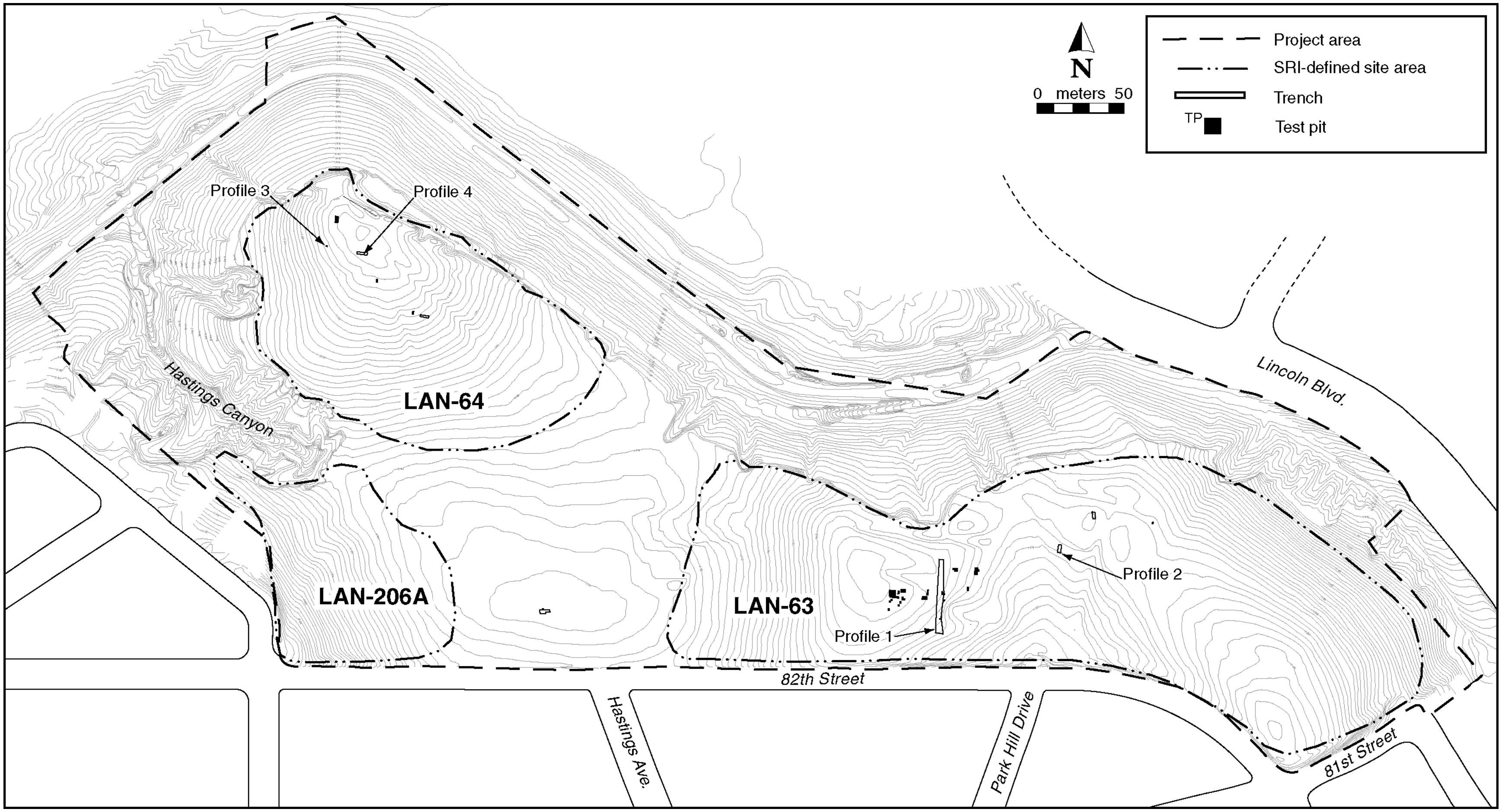


Figure 4.3. Site boundaries of LAN-63, LAN-64, and LAN-206A, as currently defined by SRI (based on 2003 fieldwork), and the locations of Van Horn's (1987) and SRI's excavation units and Profiles 1–7.

Figure 4.4. East view of the West Bluffs project area from the eastern part of LAN-206A. LAN-63 is on the low hill in the distance; Profile 7 is located next to the backdirt pile in the depression before the low hill; and 80th Street is on the right.

Figure 4.5. Northwest view of the Ballona Escarpment. LAN-64 is on the prominent hilltop overlooking the Ballona Lagoon to the right, and Cabora Road, which was built over the North Outfall Sewer line, is on the lower part of the bluff.

Figure 4.6. Grading and monitoring operations at West Bluffs in the summer of 2003. Heavy equipment includes two graders, a bottom-loading scraper used to load the earthen windrows, and a water truck used for dust control. Archaeologists monitored the grading operation for exposed cultural deposits, artifacts, and features.

Figure 4.7. Northwest view of Hastings Canyon from the headcut on the west side of the West Bluffs project area, with the Ballona Lagoon in the background.

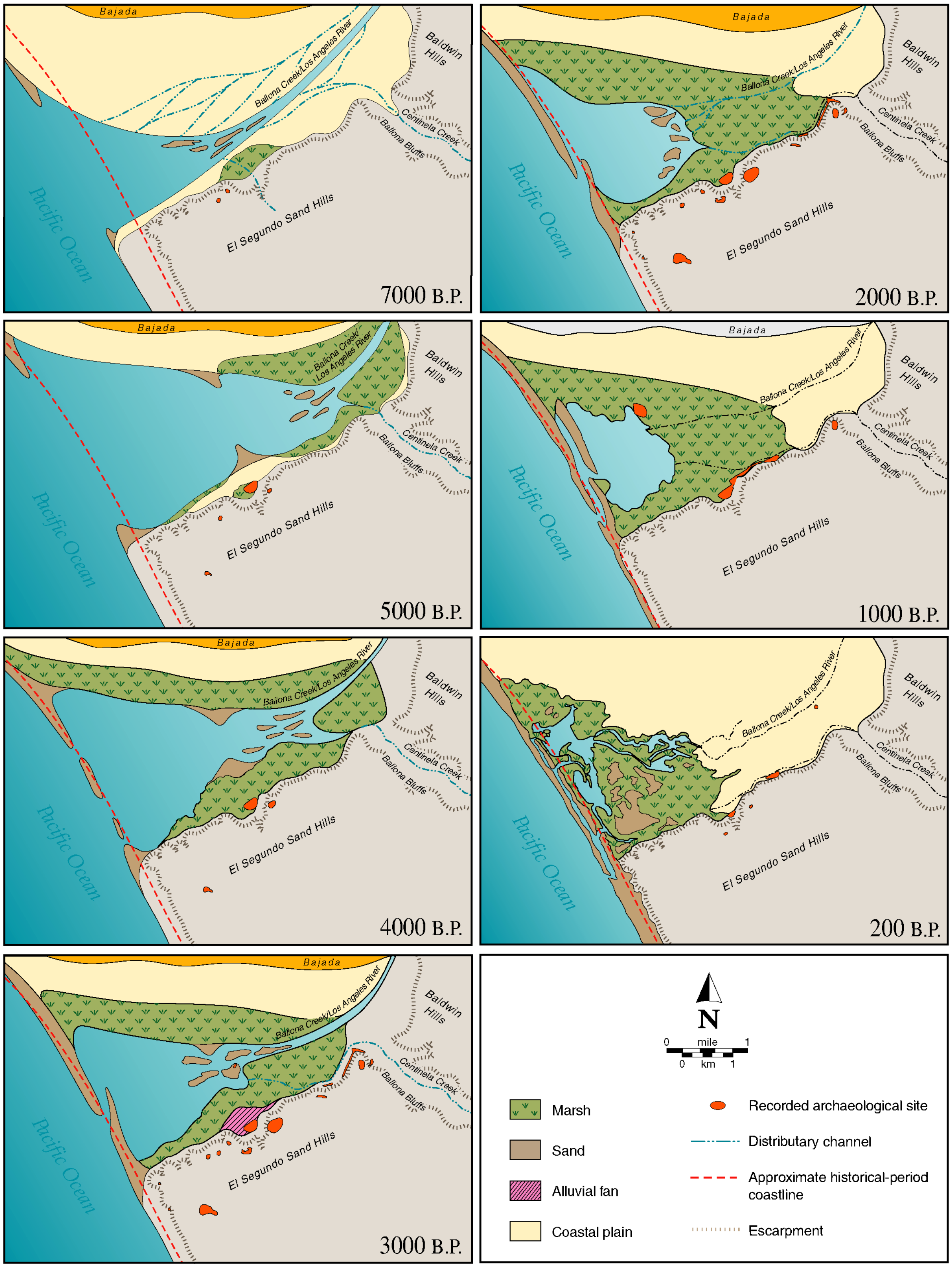


Figure 4.8. Holocene evolution of the Ballona Lagoon (after Shelley et al. 2003:Fig. 33).

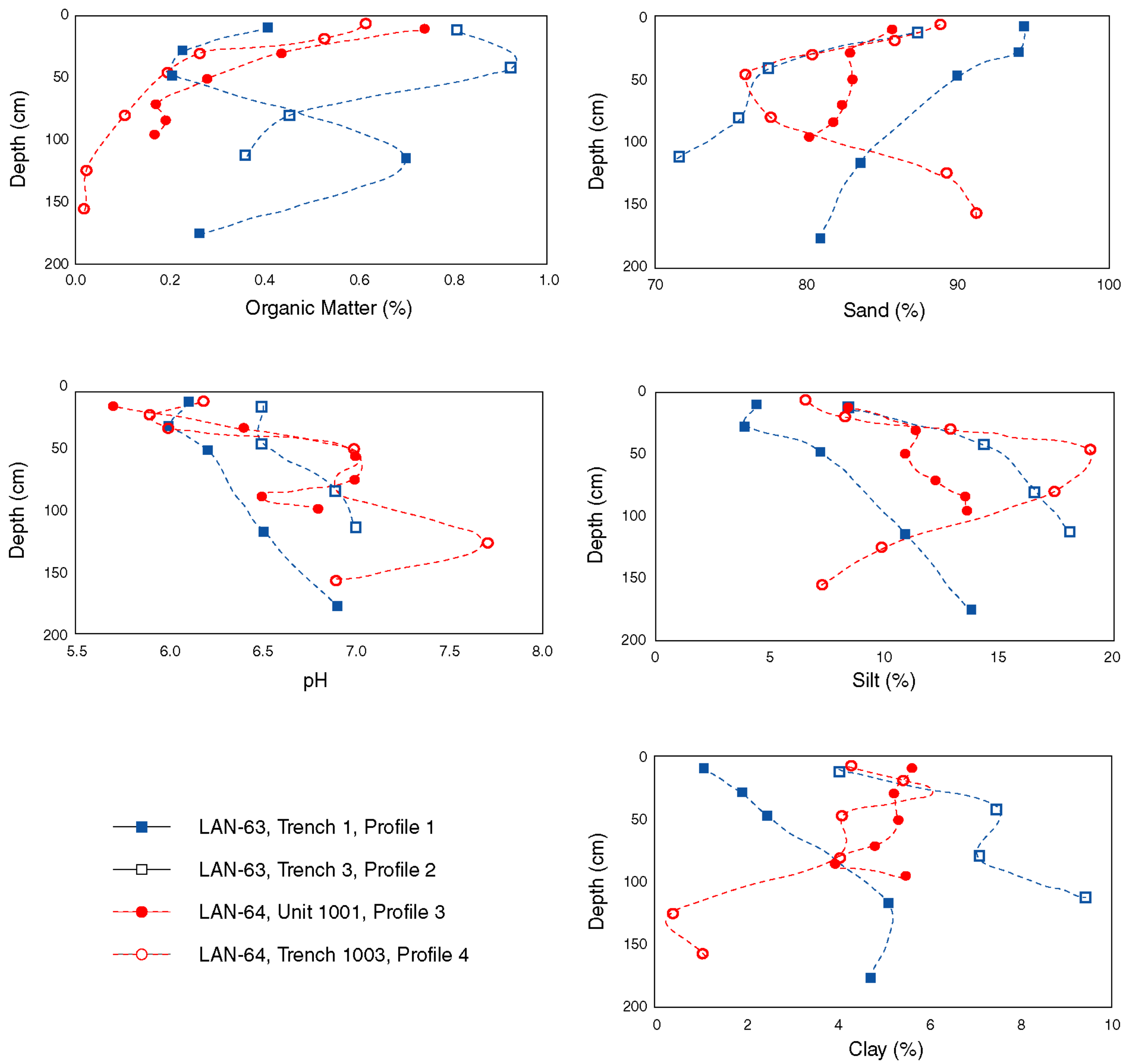


Figure 4.9. Soil data (organic matter, pH, sand, silt, and clay) for Profiles 1–4.

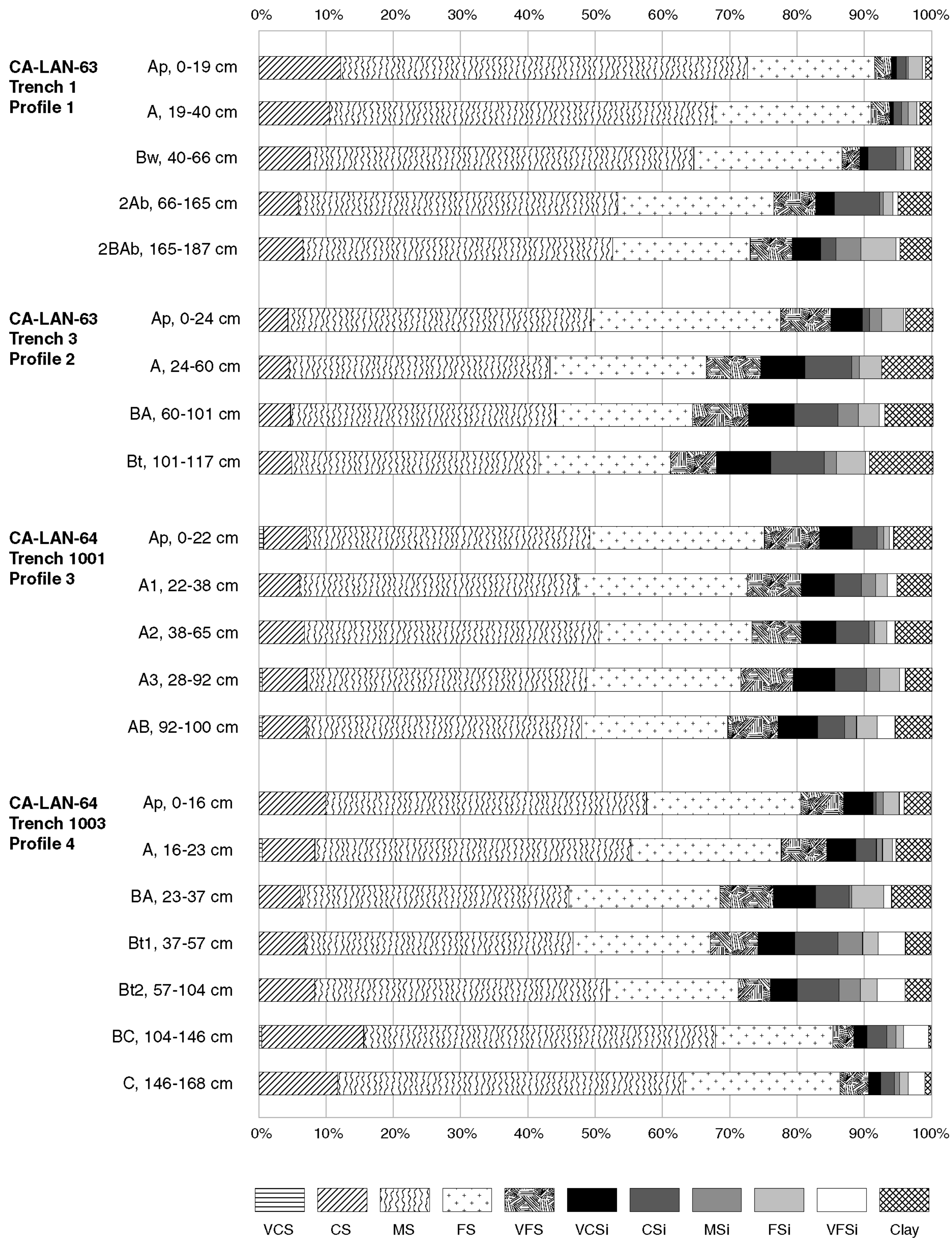
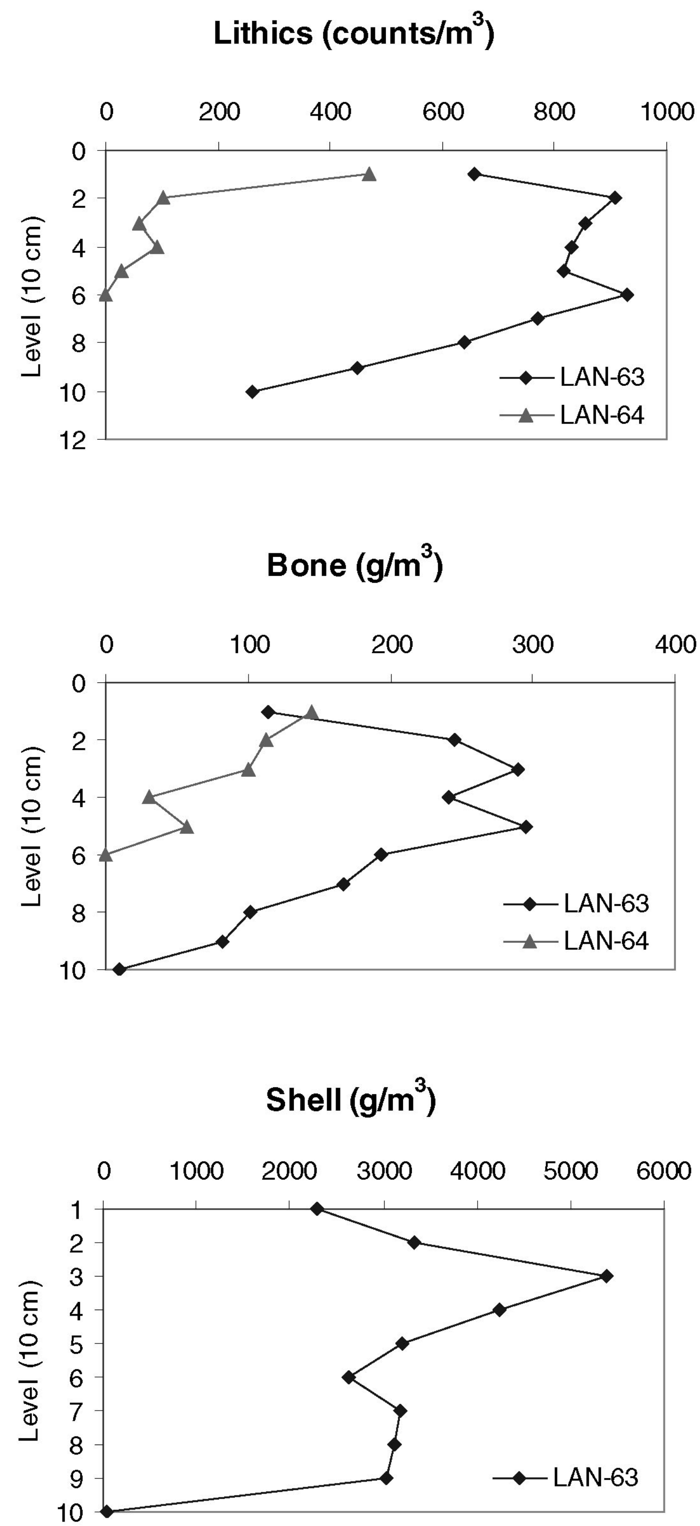


Figure 4.10. Stacked bar graphs showing the particle-size distributions for Profiles 1–4 (shown from top to bottom).



Note: There was no shell recovered from the sampled units of LAN-64

Figure 4.11. Lithic, faunal bone, and shell densities for LAN-63 and LAN-64.

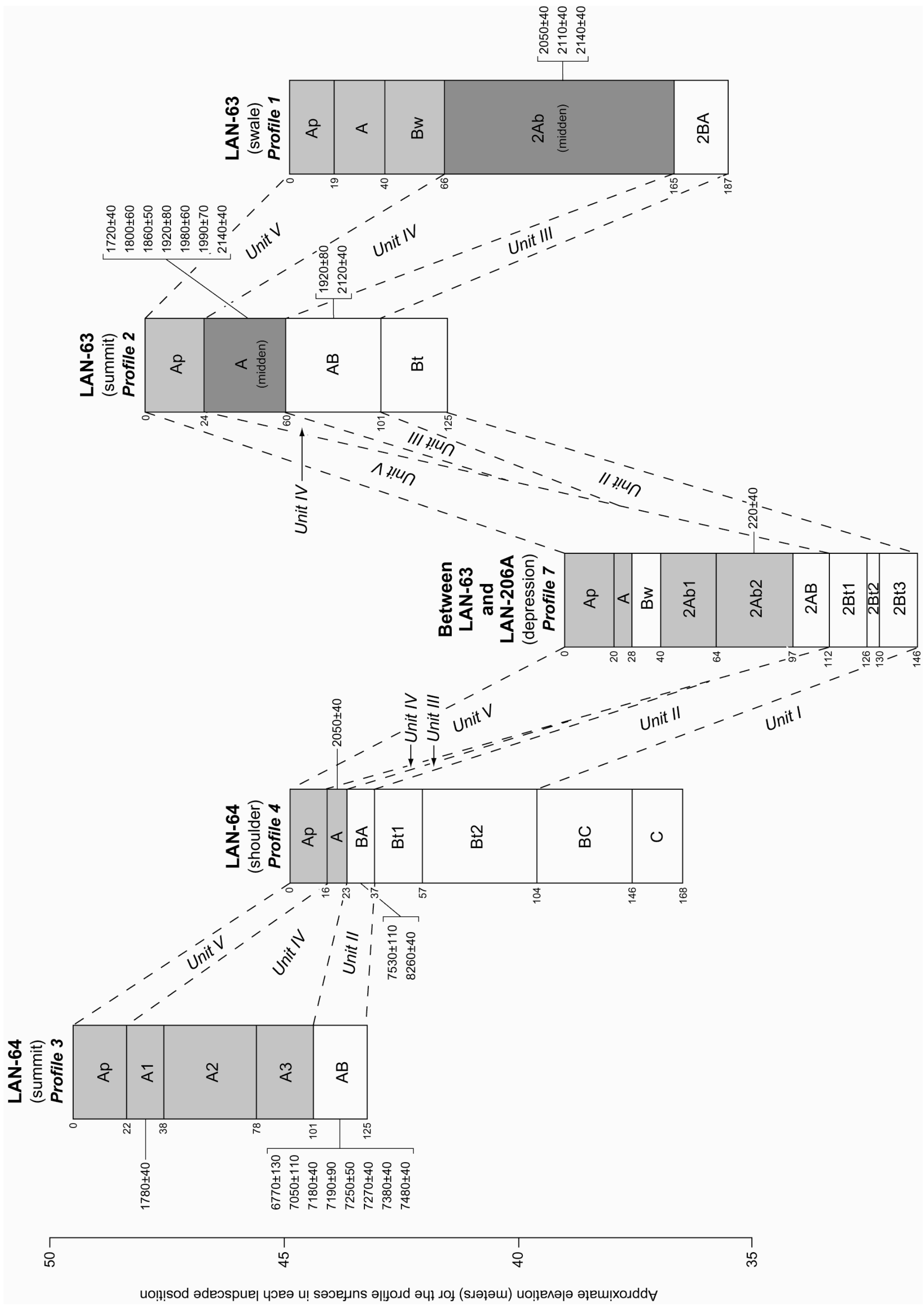


Figure 4.12. Composite drawing of the soil stratigraphy for the West Bluffs Project.

Figure 4.13. Dark shell midden exposed in the west wall of Trench 1 at LAN-63 below a lighter-colored sand sheet.

Figure 4.14. Midden and overlying sand sheet at Profile 1 in Trench 1 of LAN-63.

Figure 4.15. Extensive krotovina (infilled animal burrows) exposed by grading in the lower sand sheet at LAN-63.

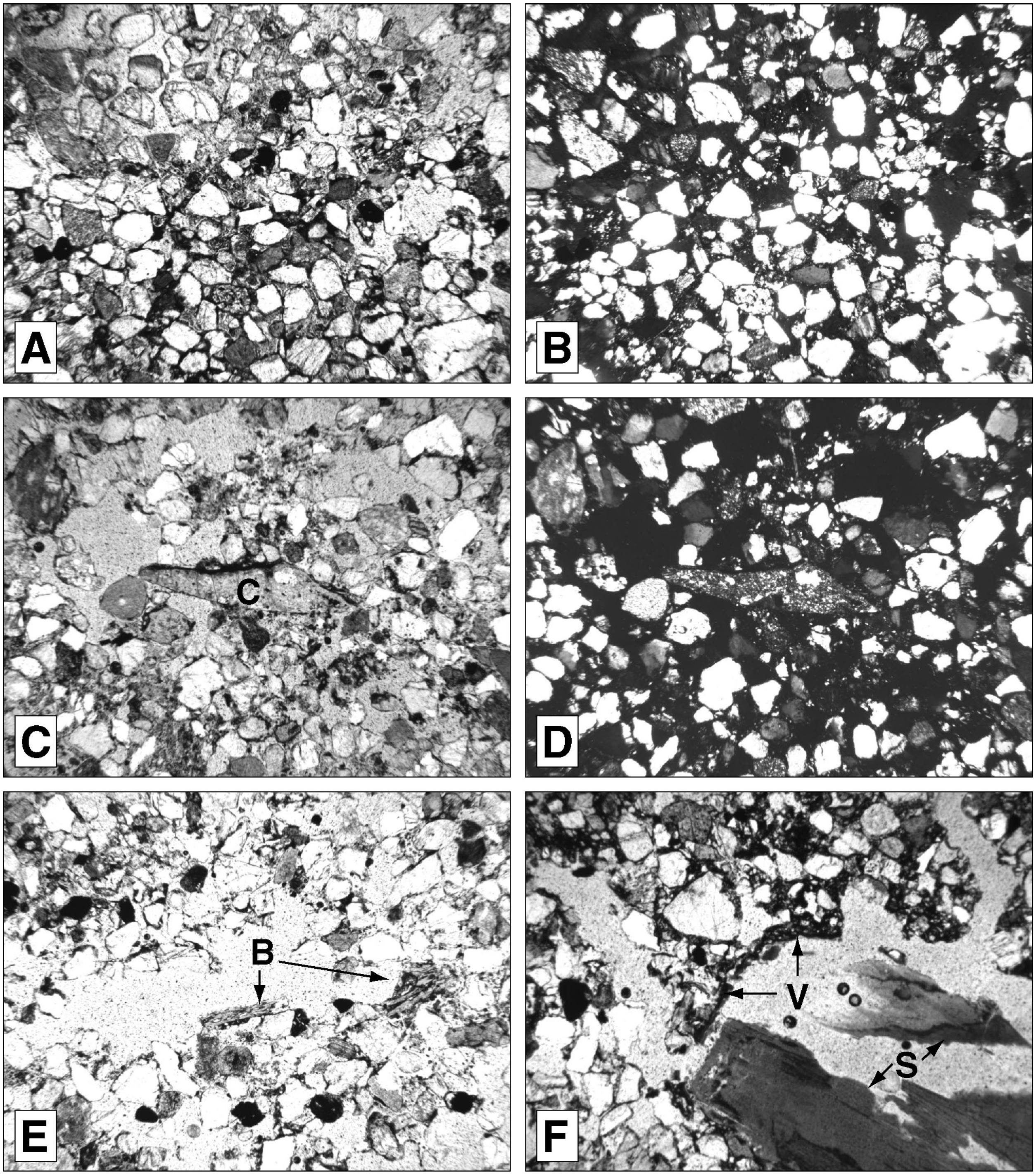


Figure 4.16. Selected photomicrographs of soil micromorphology slides from Profile 1 at LAN-63. A, 62–71 cm, horizon boundary between the Bw (top of image) and the 2Ab horizon (bottom of image). The 2Ab horizon shows more grain coat coatings and void infillings, as well as denser grain packing (PPL). B, same as Image A, but in XPL. C, 62–71 cm, 1.5-mm angular chert fragment interpreted as a microflake, "C" (PPL). D, same as Image C but in XPL. E, 62–71 cm, bone fragments, "B," in larger remnant void (PPL). F, large shell fragments, "S," showing evidence for dissolution. Note continuous void coatings, "V," where the shell is no longer in contact with the void wall. *Note:* PPL = plane-polarized light, XPL = cross-polarized light.

Figure 4.17. Stepped trench on the eroded summit of LAN-64, showing the ribbon-like clay lamellae that commonly underlie the cultural deposits throughout the West Bluffs project area.

Figure 4.18. Close-up view of clay lamellae exposed in a small gully on north side of LAN-64. This profile is about 50 cm wide and the individual clay lamellae are about 1 cm or less in thickness.

Figure 4.19. West wall of Profile 3 on the summit of LAN-64, with numerous clay lamellae in the lower part underlying the cultural deposits.

Figure 4.20. West wall of Profile 4 on the shoulder slope of LAN-64, with clay lamellae in the lower part underlying the cultural deposits.

Table 4.1. Soil Data for the West Bluffs Project

Site / Trench and Profile	Soil Horizon	Depth (cm)	pH	Organic Matter (%)	Sand (%)	Silt (%)	Clay (%)	Textural Class
LAN-63								
Trench 1, Profile 1								
	Ap	0–19	6.1	0.4	94	5	1	sand
	A	19–40	6.0	0.2	94	4	2	sand
	Bw	40–66	6.2	0.2	90	8	2	sand
	2Ab	66–165	6.5	0.7	84	11	5	loamy sand
	2BAb	165–187+	6.9	0.3	81	14	5	loamy sand
Trench 3, Profile 2								
	Ap	0–24	6.5	0.8	87	9	4	sand
	A	24–60	6.5	0.9	77	15	7	loamy sand
	BA	60–101	6.9	0.5	76	17	7	sandy loam
	Bt	101–117+	7.0	0.4	72	19	9	sandy loam
LAN-64								
Trench 1001, Profile 3								
	Ap	0–22	5.7	0.7	86	9	6	loamy sand
	A1	22–38	6.4	0.4	83	12	5	loamy sand
	A2	38–78	7.0	0.3	83	12	5	loamy sand
	A3	78–92	6.5	0.2	82	14	4	loamy sand
	AB	92–100+	6.8	0.2	80	14	5	loamy sand
Trench 1003, Profile 4								
	Ap	0–16	6.2	0.6	89	7	4	sand
	A	16–23	5.9	0.5	86	9	5	sand
	BA	23–37	6.0	0.3	80	13	6	loamy sand
	Bt1	37–57	7.0	0.2	76	20	4	loamy sand
	Bt2	57–104	6.9	0.1	78	18	4	loamy sand
	BC	104–146	7.7	0.0	89	10	0	loamy sand
	C	146–168+	6.9	0.0	91	8	1	sand

Table 4.2. Particle-size Distributions for Profiles 1 and 2 at LAN-63 and Profiles 3 and 4 at LAN-64

Site / Trench and Profile	Depth (cm)	Soil Horizon	Sand (%)					Silt (%)					Clay (%)
			Very Coarse (2–1 mm) 0ϕ	Coarse (1–0.5 mm) 1ϕ	Medium (0.5–0.25 mm) 2ϕ	Fine (0.25–0.125 mm) 3ϕ	Very Fine (0.125–0.063 mm) 4ϕ	Very Coarse (63–32 μ) 5ϕ	Coarse (32–16 μ) 6ϕ	Medium (16–8 μ) 7ϕ	Fine (8–4 μ) 8ϕ	Very Fine (4–2 μ) 9ϕ	(>2 μ) 10ϕ
LAN-63													
Trench 1, Profile 1													
	0–19	Ap	0.2	12.1	60.4	18.8	2.6	0.7	1.4	0.4	2.1	0.4	1.1
	19–40	A	0.3	10.2	56.8	23.5	2.9	0.4	1.3	1.0	1.2	0.5	1.9
	40–66	Bw	0.3	7.4	57.1	21.8	2.9	1.0	4.3	1.0	1.1	0.6	2.4
	66–165	2Ab	0.0	5.8	47.5	23.2	6.2	2.8	6.9	0.3	1.5	0.7	5.1
	165–187+	2BAb	0.2	6.5	45.8	20.5	6.2	4.2	2.3	3.7	5.2	0.7	4.7
Trench 3, Profile 2													
	0–24	Ap	0.2	4.2	44.9	28.2	7.5	4.7	1.0	1.9	3.1	0.3	4.0
	24–60	A	0.2	4.3	38.6	23.3	8.1	6.5	7.0	1.1	3.3	0.2	7.4
	60–101	BA	0.2	4.5	39.2	20.5	8.3	6.7	6.6	3.0	3.0	0.9	7.1
	101–117+	Bt	0.3	4.5	36.7	19.5	7.0	7.9	8.0	1.7	4.4	0.5	9.4
LAN-64													
Trench 1001, Profile 3													
	0–22	Ap	0.6	6.5	42.2	25.9	8.2	4.9	3.8	1.0	0.8	0.5	5.7
	22–38	A1	0.3	5.8	41.1	25.4	8.2	4.8	4.1	2.0	1.8	1.4	5.2
	38–65	A2	0.2	6.7	43.7	22.7	7.4	5.0	4.9	0.9	1.8	1.3	5.3
	78–92	A3	0.4	6.6	41.3	22.8	7.9	5.8	4.8	2.1	2.8	0.7	4.0
	92–100+	AB	0.4	6.8	41.5	22.0	7.7	5.9	4.1	1.8	3.1	2.7	5.5

Site Trench and Profile	Depth (cm)	Soil Horizon	Sand (%) Very Coarse (2–1 mm) 0ϕ	Sand (%) Coarse (1–0.5 mm) 1ϕ	Sand (%) Medium (0.5–0.25 mm) 2ϕ	Sand (%) Fine (0.25–0.125 mm) 3ϕ	Sand (%) Very Fine (0.125–0.063 mm) 4ϕ	Silt (%) Very Coarse (63–32 μ) 5ϕ	Silt (%) Coarse (32–16 μ) 6ϕ	Silt (%) Medium (16–8 μ) 7ϕ	Silt (%) Fine (8–4 μ) 8ϕ	Silt (%) Very Fine (4–2 μ) 9ϕ	Clay (%) (>2 μ) 10ϕ
Trench 1003, Profile 4													
	0–16	Ap	0.3	9.5	47.6	23.0	6.4	4.3	0.6	0.9	2.3	0.7	4.3
	16–23	A	0.4	7.7	47.2	22.2	6.9	4.2	3.3	0.7	1.5	0.5	5.4
	23–37	BA	0.3	5.9	39.8	22.6	8.0	6.0	5.2	0.4	4.6	1.1	6.1
	37–57	Bt1	0.0	6.8	39.8	20.4	7.2	5.1	6.6	3.8	2.2	3.9	4.1
	57–104	Bt2	0.1	8.1	43.6	19.4	5.0	3.8	6.3	3.1	2.6	4.1	4.1
	104–146	BC	0.4	15.2	52.2	17.5	3.2	1.8	3.0	1.5	1.0	3.7	0.4
	146–168+	C	0.1	11.4	51.6	23.2	4.3	1.6	2.2	0.8	1.3	2.4	1.1

Table 4.3. Artifact Counts or Weights per Cubic Meter

Site and Level	Volume Excavated (m^3)	Lithic (Count)	Historic (Count)	Worked Bone (Count)	Worked Shell (Count)	Bone (g)	Shell (g)
LAN-63							
1	7.6	658	0.5	1.3	0.3	114	2299
2	7.7	910	0.5	0.4	0.1	245	3327
3	4.6	857	0.9	0.2	1.1	290	5389
4	4.1	831	0.0	2.0	0.2	242	4248
5	3.3	816	0.3	1.2	0.6	295	3199
6	1.7	928	0.0	0.6	0.6	194	2638
7	1.1	772	0.0	0.9	0.9	167	3176
8	0.6	640	1.7	1.7	0.0	102	3108
9	0.5	448	0.0	0.0	0.0	82	3042
10	0.1	260	0.0	0.0	0.0	10	40
LAN-64							
1	2.6	470	1293	0.0	0.0	145	7
2	2.1	104	12.9	0.0	0.0	112	1
3	1.4	59	5.7	0.7	0.0	101	0
4	0.9	93	8.9	0.0	0.0	31	0
5	0.4	28	22.5	0.0	0.0	58	0
6	0.1	0	0	0	0	0	0

Note: Levels are in 10-cm increments.

Table 4.4. Summary of Selected Soil Micromorphological Properties for LAN-63

Depth (cm)	Void Space (%)	Remnant Voids (%)	Bone Fragments (n)	Range of Bone Length (mm)	Shell Fragments (n)	Range of Shell Length (mm)
62–71	15–20	5	5	0.4-0.8	2	1.5–20
103–112	20	< 2	1	0.5	0	n/a

Phase I: Geophysical Investigations

David Maki and Lewis Somers

Archaeo-Physics, LLC, was contracted by SRI to conduct a geophysical investigation of the West Bluffs project area, a 44-acre vacant site along the edge of the Westchester Bluffs in the Playa del Rey area of the city of Los Angeles, California. The methods employed during the investigation included magnetic field gradient survey and laboratory analysis of selected soil samples. Two sites were surveyed during the investigation, LAN-63 and LAN-64 (Figure 5.1).

The objective of the investigation was to locate, identify, and map subsurface cultural features. Expected cultural features included buried fire hearths or hearth clusters, caches of various materials such as ground stone tools, stone tools or shells, pit hearths, earth ovens, and shell middens (Altschul 1999; Altschul et. al. 2000, 2003). Laboratory analysis of soil magnetic properties was conducted to assist in magnetic field gradient data interpretation.

The geophysical field survey was conducted from September 7 to 14, 2000. Data processing and analysis took place at the Archaeo-Physics home office during September and November 2000. Laboratory analysis of soil samples was carried out at the Institute for Rock Magnetism, University of Minnesota on several occasions between 2000 and 2004.

Survey Design and Technical Parameters

The general procedure followed to perform these surveys was to divide each survey area into a series of squares, or survey "grids", measuring 20 by 20 m. Each grid was surveyed by taking readings at regular intervals along regularly spaced transects. Successive transects were surveyed until the grid was completed. The value and position of each data point was automatically recorded in digital format by the geophysical instruments.

The survey area at LAN-63 consisted of 53 20-by-20-m survey grids covering an area of 2.12 hectares. The survey area at LAN-64 consisted of 25.5 20-by-20-m survey grids covering an area of 1.02 hectares.

Magnetic field gradient survey was performed using a Geoscan Research FM36 fluxgate gradiometer (Figure 5.2). The FM36 has two fluxgate sensors, separated by 0.50 m. The recorded data are the difference between the two sensors. The instrument was operated in the 0.1 nanoTeslas (nT) sensitivity range. Data were collected using a transect spacing of 0.50 m, with 8 samples taken per meter along each transect (16 samples per m^2). Magnetic data transects were collected in a zigzag manner, meaning the first data transect was collected from south to north, the second data transect was collected north to south, and so on. Magnetic field gradient data are presented in nanoTeslas (nTs) in this report by convention. Multiplication by two is required to convert to International System (SI) units for the magnetic field gradient (nT/m).

Processing of magnetic data included:

- A zero-mean traverse filter, which compensates for defects caused by instrument drift and orientation.
- Interpolation to a uniform number of data points (4 per meter) in both the x and y directions.
- Lowpass filtering (2 data-point radius) to suppress small-scale noise and enhance the detectability of cultural patterning.
- Clipping the data used to construct imagery to a range that would best display cultural features.

A more detailed introduction to magnetic field gradient survey in archaeology is provided in Appendix B.

Site Setting and Field Conditions

At the time of geophysical investigation, the project area was a vacant parcel slated for development in the near future. Ground cover consisted of assorted grasses and annual weeds. The site was cleared of excessive vegetation by SRI personnel prior to the survey. Plow furrows were visible over the entire site. A moderate amount of modern trash was observed over the site. Much of this trash contained ferrous iron, a source of significant signal clutter. Prehistoric artifacts were also observed on the ground surface over much of the parcel. Many of these artifacts were volcanic or metavolcanic stones with considerable magnetic moments that also contributed to signal clutter. Bioturbation by rodent activity appeared to be quite heavy over the entire site. Turbation was severe enough that thermoremanent magnetization of consolidated soil within hearth features appeared to be highly unlikely.

Magnetic Mineral Properties of Soils within the West Bluffs Project Area

Laboratory tests were conducted on soil samples from the West Bluffs project area in an effort to understand the nature and intensity of the magnetic susceptibility contrast that might be expected in archaeological features at the site. Contrast in this intrinsic property can be caused by cultural processes including fire (often referred to as the burning mechanism) and pedogenic production of ferrimagnetic minerals by organic, and inorganic pathways.

High-temperature tests were conducted on soil samples from LAN-63 and from four additional archaeological sites that were included as control samples. The experiments indicated that the heating of soil from the West Bluffs project area resulted in a small initial enhancement (increase) in magnetic susceptibility, followed by a rapid reduction in values; whereas the four control samples experienced a more typical large enhancement, followed by relatively stable magnetic susceptibility levels (Figure 5.3).

Laboratory tests measured a reduction in West Bluffs project soil susceptibility to approximately 37 percent of the initial value after 3 hours at 750°C. Subsequent testing determined that a 20 percent enhancement occurred after firing at 650°C, but after 17 hours at this temperature the magnetic susceptibility had been reduced to below initial levels. The reduction in soil magnetic susceptibility observed during the laboratory experiments was thought to be the result of high-temperature oxidation of magnetite to maghemite, followed by the inversion of maghemite to hematite. These high-temperature transformations resulted in a net susceptibility decrease. The major implication of the study was that the magnetic properties of soil associated with hearths within the West Bluffs project area may cause a negative induced magnetic field—the opposite of what is normally expected from such a feature. The probability of a negative anomaly is greatly increased if bioturbation has randomized the thermoremanent component of the hearth.

The magnetic susceptibility of soil from the large shell midden identified in Trench 1 at LAN-63 was also evaluated. Nine soil samples were collected from the Trench 1 profile. Three of the nine samples came from within the midden deposits, three from non-cultural deposits above the midden, and three from non-cultural deposits below the midden. Testing determined that the magnetic susceptibility of shell midden soils was approximately 10 percent higher than the susceptibility of non-cultural soils above and below the midden (Figure 5.4).

Geophysical Survey Results

The approximate location of former excavation units and trenches are shown on the following pages as interpreted graphical overlays (the same maps without interpretations are presented in Appendix C). Each overlay was positioned by scaling and rotating a map of Van Horn's previous excavation areas until a best fit was achieved with anomalies that are believed to have originated with disturbed soil associated with previously back-filled excavation units and trenches. As the trenches and units were back-filled, soils from throughout the profile were mixed together resulting in some of the lower susceptibility material from deeper in the profile being repositioned close to the surface (Figure 5.5). This mixing, combined with an increased ratio of air voids in the solid-air-water mixture that comprises all soils, created the observed induced magnetic low. During excavation of the previous units and trenches, the first soil to be removed and placed in a backdirt pile was the original "A" horizon. Some of this soil is left behind during the back-filling process, leaving an increased concentration of highly magnetic soil immediately adjacent to the previous excavations. This may explain the many induced magnetic highs that could be observed adjacent to the previous excavations.

Undoubtedly, there was a degree of error in the scale and rotation of the overlay, nonetheless, an examination of the effect previously excavated areas had on the magnetic field gradient survey results was necessary for competent interpretation.

Interpretation of Geophysical Survey Results

The results of geophysical surveys of archaeological sites are generally presented graphically. This is done because anomalies of cultural origin are usually recognized by their pattern, rather than by their numeric values alone. When rendered graphically, we can better recognize cultural and natural patterns and visualize the physical phenomena causing the detected anomalies. Interpretation of survey data must be a cooperative process involving both archaeological geophysicists and archaeologists that are familiar with the specific cultural context of the site being studied. An understanding of the geological context of the survey area is also very important.

The interpretations offered in this report are to be considered preliminary, as they represent only the initial interpretations of the geophysical surveyor. Review by archaeologists familiar with the cultural context of the site and the range of expected feature types and intra-site patterning may result in different or elaborated interpretation.

LAN-63

Initial interpretations of the LAN-63 survey results are presented in Figure 5.6, in which an attempt has been made to identify anomalous regions that do not appear to be associated with previous excavations, topographic features, or modern surface debris. Possible prehistoric cultural sources for these anomalies are discussed below.

- A solid yellow line surrounds a region of slightly increased magnetism. This region, which is not well defined, may represent midden deposits or an ancient living surface, although some of these magnetic highs are almost certainly the result of previous excavations (see Appendix C).
- Dashed yellow lines surround regions of slightly better defined magnetic highs. These high gradient regions may represent midden deposits, artifact clusters, or hearths and ovens dispersed by plowing and/or rodent activity.
- A blue circle surrounds discrete magnetic lows that are not obviously associated with previous excavation units and trenches. These magnetic lows may represent buried hearths or ovens.
- A red circle surrounds discrete magnetic highs that are not obviously associated with back-dirt piles from previous excavations, modern iron fragments, or stone artifacts on the surface. These anomalies may represent trash pits or artifact caches. If hearths or ovens are intact (not distributed by plowing or rodents) the remanent component of the total magnetic field gradient may create these highs.

The effect of removing a portion of the non-cultural soil overburden was examined by resurveying selected areas after mechanical stripping. Figure 5.7 depicts survey data before and after mechanical stripping of a 30-by-30-m grid designated as LAN-63, stripped area No. 1 (southwest corner located at 1127 east, 1023 north). Although the magnetic highs previously identified in Figure 5.7 are now more pronounced, it is still not clear whether these represent archaeological features or more magnetic soil associated with backdirt piles from previous excavations. Perhaps more interesting are the distinct magnetic lows (circled in blue). Again, these may represent fire-altered soils such as found in a hearth or oven. The offset in anomaly location is due to changes in the slope distance over the grid caused by stripping.

Figure 5.8 depicts survey data before and after mechanical stripping of a 20-by-20-m grid designated as LAN-63, stripped area No. 2 (the southwest corner was located at 1169 east, 1040 north). Four discrete magnetic highs are circled in red. One circular magnetic low is circled in blue. A previous excavation unit is visible as a very distinct square magnetic low. The anomalies along the southern edge and in the southeast corner of the grid are caused by backdirt piles associated with mechanical stripping.

LAN-64

Initial interpretations of the LAN-63 survey results are presented in Figure 5.9. Possible prehistoric cultural sources for these anomalies are discussed below.

- A dashed yellow line surrounds regions of increased magnetism. These anomalous regions may represent midden deposits, ancient living surfaces, artifact clusters, or hearths and ovens dispersed by plowing and/or rodent activity.

- A blue circle surrounds discrete magnetic lows that are not obviously associated with previous excavation units or trenches. These magnetic lows may represent buried hearths or ovens.
- A red circle surrounds discrete magnetic highs that are not obviously associated with back-dirt piles from previous excavations, modern iron fragments, or stone artifacts on the surface. These anomalies may represent trash pits or artifact caches. If hearths or ovens are intact (not distributed by plowing or rodents) the remanent component of the total magnetic field gradient may create these highs.

The magnetic low forming a rectilinear pattern on the western edge of the survey area between 1180 and 1200 North was interpreted to be a modern feature, possibly a drain field or piping of another function.

Figure 5.10 depicts survey data before and after mechanical stripping of an irregularly shaped area. A 20-by-20-m grid was designated LAN-64, stripped area No. 1 and resurveyed (the southwest corner was located at 780 east, 1200 north). Removal of the plow zone significantly increased the signal-to-noise ratio of the data, increasing the definition of possible cultural anomalies. The limits of the stripped area are plainly visible in the image. A dashed yellow line surrounds large areas of increased magnetism, whereas a solid red line circles a small discrete region of increased magnetism. These may represent fire hearths, ovens, artifact caches, or trash pits. A solid yellow line surrounds discrete regions of lower magnetism, possibly representing fire hearths or ovens.

Figure 5.11 depicts survey data before and after mechanical stripping of an irregularly shaped area. A 10-by-20-m grid was designated LAN-64, stripped area No. 2, and resurveyed (the southwest corner was located at 780 east, 1230 north). The limits of the stripped area are plainly visible in the data. Removal of the plowzone did not significantly change interpretations in this region, although one discrete anomaly of lower magnetic field intensity is circled in blue (possible fire altered soil). The yellow dashed line surrounds a previously identified magnetic high. The amplitude of the signal has increased in the stripped area, but the spatial definition of the anomaly has not greatly improved.

Post-Survey Comparison of Feature Locations and Magnetic Anomalies

The locations of archaeological features from the 2003 excavation were compared with the magnetic field gradient survey results. A comprehensive comparison was not possible, as the two datasets overlapped only partially. The data were sufficient to determine that the correlation between archaeological features and magnetic anomalies was relatively poor, although some correlation between magnetic field gradient anomalies and archaeological features was observed. Several negative anomalies correlate with archaeological features. The intensity of many of these negative anomalies was relatively low, which would have made their identification rather difficult without prior knowledge of the feature locations. A few negative magnetic anomalies were of sufficient intensity to distinguish themselves from the signal noise and clutter. Several of these are presented in Figure 5.12.

In Figures 5.12a and 5.12b, relatively low intensity anomalies are visible in the vicinity of concentrations of fire-affected rock (marked with an “x”). In Figure 5.12c, several low intensity anomaly correlates are visible, as well as one very well-defined negative anomaly correlate. Additionally, several archaeological features with positive magnetic anomaly correlates were identified (not pictured), and numerous archaeological features had no discernable anomaly correlation.

Discussion

The magnetic field gradient survey of LAN-63 and LAN-64 appears to have resulted in a rather poor correlation between magnetic anomalies and archaeological hearths. This may have been primarily associated with two factors: (1) a relatively small initial enhancement of soil susceptibility associated with exposure to high temperatures (increase in c greater than 20 percent); and (2) a drop in susceptibility to below initial values associated with prolonged exposure to high temperatures—the result of inversion to relatively nonmagnetic hematite.

Other factors affecting the survey results included randomization of the thermoremanent magnetization component by bioturbation, and signal clutter created by bioturbation, agricultural plow furrows, disturbance from previous excavations, randomly oriented volcanic and meta-volcanic rock at or near the ground surface, and modern ferrous iron debris.

The correlation between some negative magnetic field gradient anomalies and archaeological hearths was significant. The source of the negative anomalies appeared to be soil with a lower magnetic susceptibility than the surrounding matrix, the susceptibility having been lowered by high-temperature oxidation and inversion. High-temperature oxidation and inversion is a phenomenon that should be carefully considered while interpreting magnetic survey results from archaeological sites with soils similar to those found in the West Bluffs project area; for example, at sites containing soils with a relatively high concentration of primary (lithogenic) multidomain magnetite.

Laboratory testing results also indicated that a susceptibility contrast did exist between shell midden soils and noncultural soils; however, the magnetic field gradient survey did not reliably detect these midden deposits. The lack of correlation between magnetic field gradient anomalies and midden deposits was most likely associated with the nature of the magnetic fields induced by this positive contrast. The middens probably induced large and uniform magnetic fields. Magnetic field gradient surveys record the difference between two sensors. In the case of the FM36, the sensors were separated by 50 cm. If the anomalous magnetic field is large and uniform, the values recorded by the top and bottom sensor may be very similar and the difference between them negligible. In such cases, the anomalous signal is effectively filtered out and the cultural feature remains undetected.

The high-temperature inversion of highly magnetic magnetite to relatively non-magnetic hematite, combined with the scale and geometry of the midden deposits, created unusually challenging conditions for magnetic field gradient survey techniques. The results of this survey point out the importance of applying multiple geophysical methods while assessing prehistoric archaeological sites. The application of high sample density ground penetrating radar or EM magnetic susceptibility (for example, survey by the EM38 in the in-phase mode) survey methods would very likely have resulted in an improved correlation between geophysical anomalies and archaeological features. This interpretation is due, in part, to laboratory analysis conducted subsequent to field work; data from the laboratory analysis was not available during fieldwork.

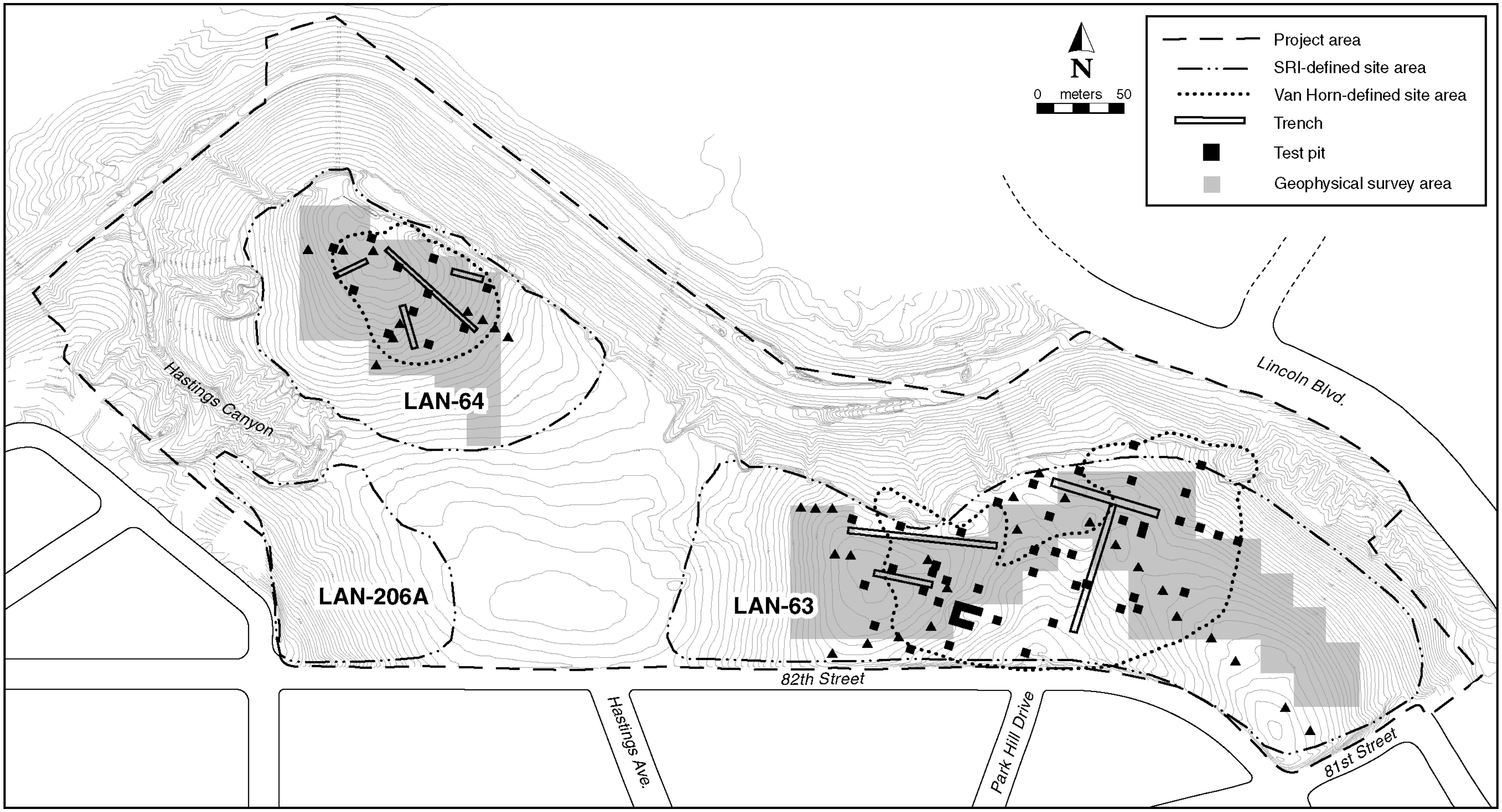


Figure 5.1. Location of geophysical survey areas, site boundaries, and excavation units at LAN-63 and LAN-64.

Figure 5.2. Magnetic field gradient survey at LAN-63 using the FM 36 fluxgate gradiometer.

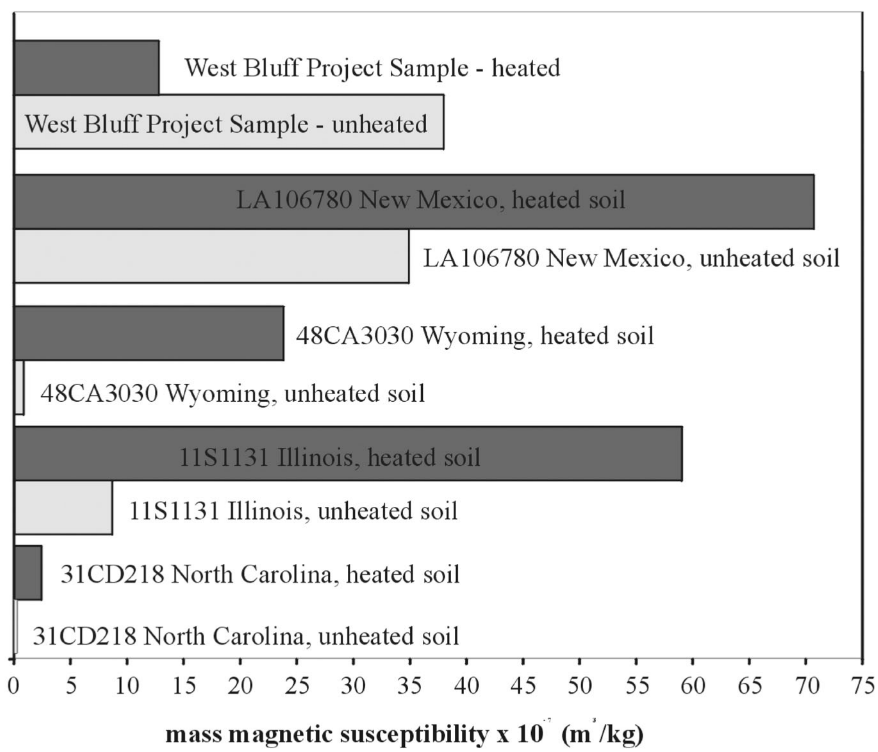


Figure 5.3. Magnetic susceptibility levels before and after exposure to high temperatures.

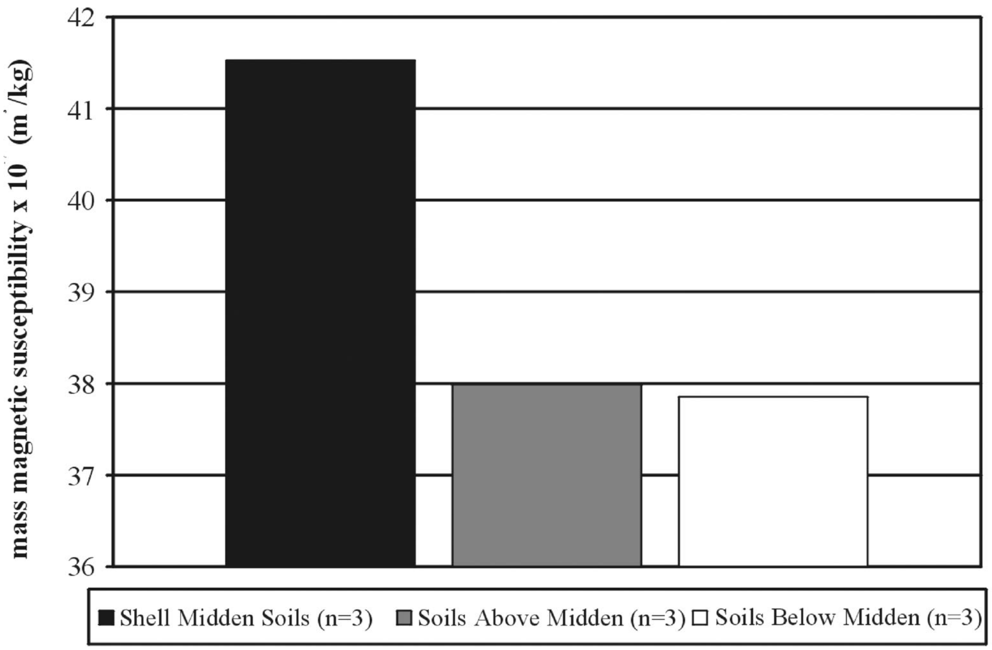


Figure 5.4. A comparison of shell midden soils and noncultural soils from Trench 1, LAN-63.

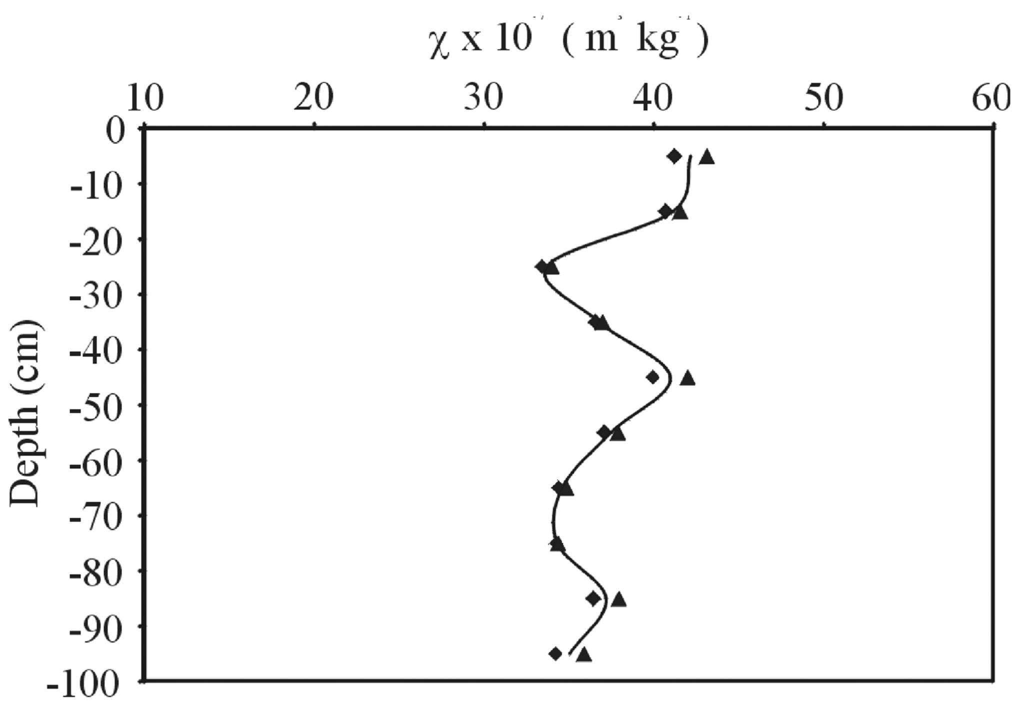


Figure 5.5. A typical magnetic susceptibility profile from LAN-64.

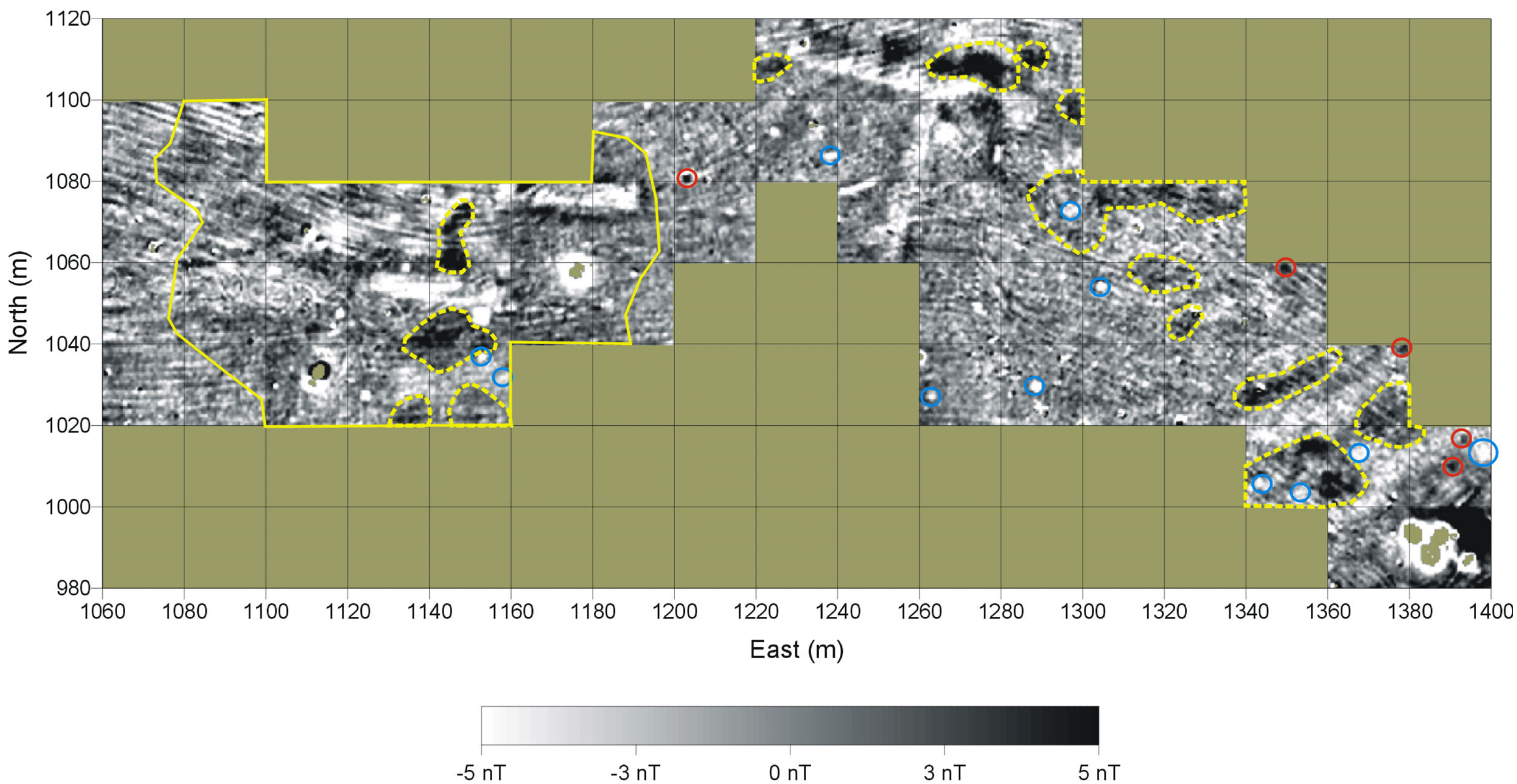


Figure 5.6. Initial interpretations of the magnetic field gradient survey results at LAN-63. In Figures 5.6–5.11, darker shades represent positive deviations from the mean or zero gradient, whereas lighter shades represent negative deviations. A scale bar shows the range of data used in each display and a 20-m-grid interval was superimposed on each image.

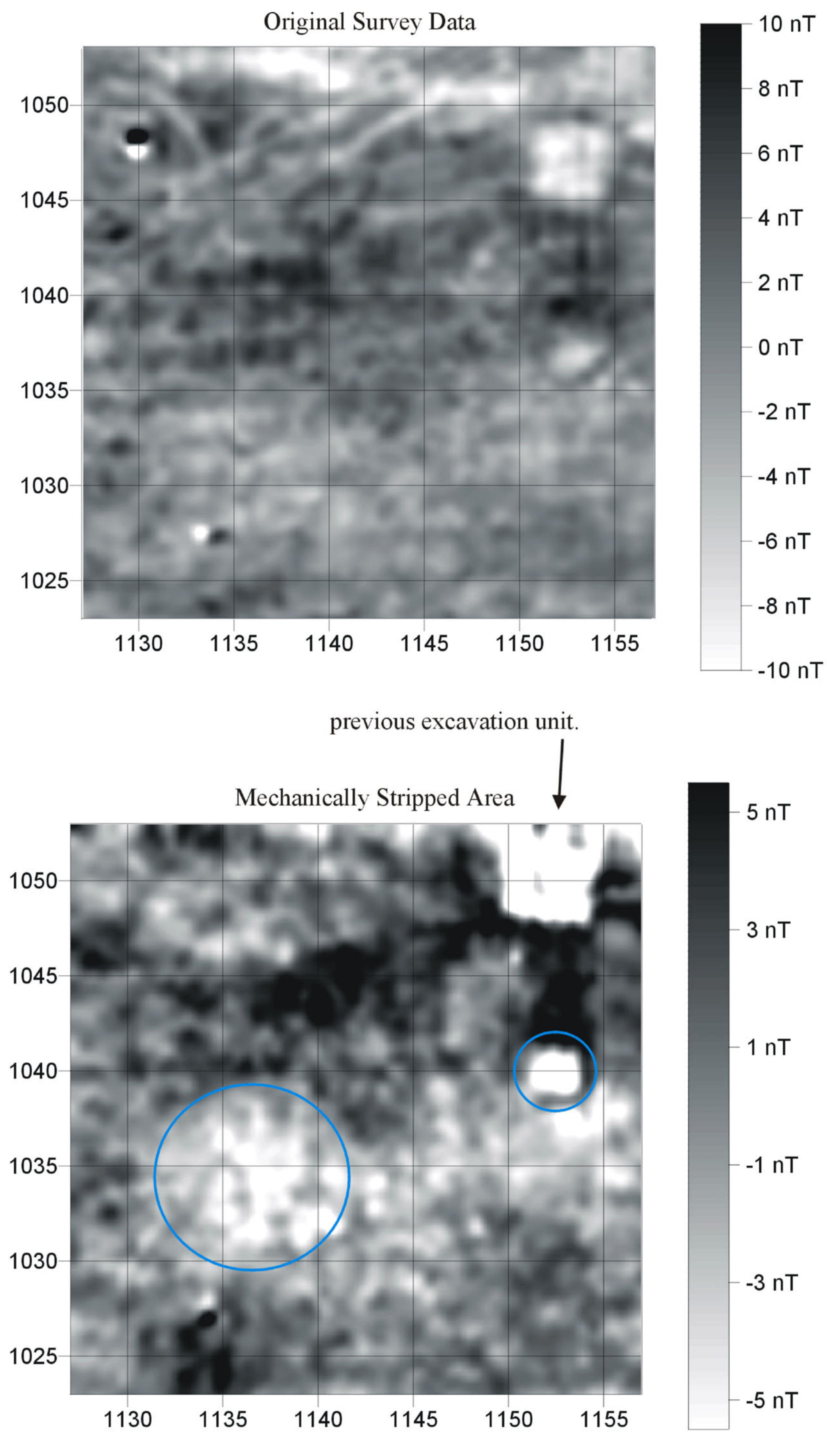


Figure 5.7. Survey results before and after mechanical stripping (LAN-63 Stripped Area 1).

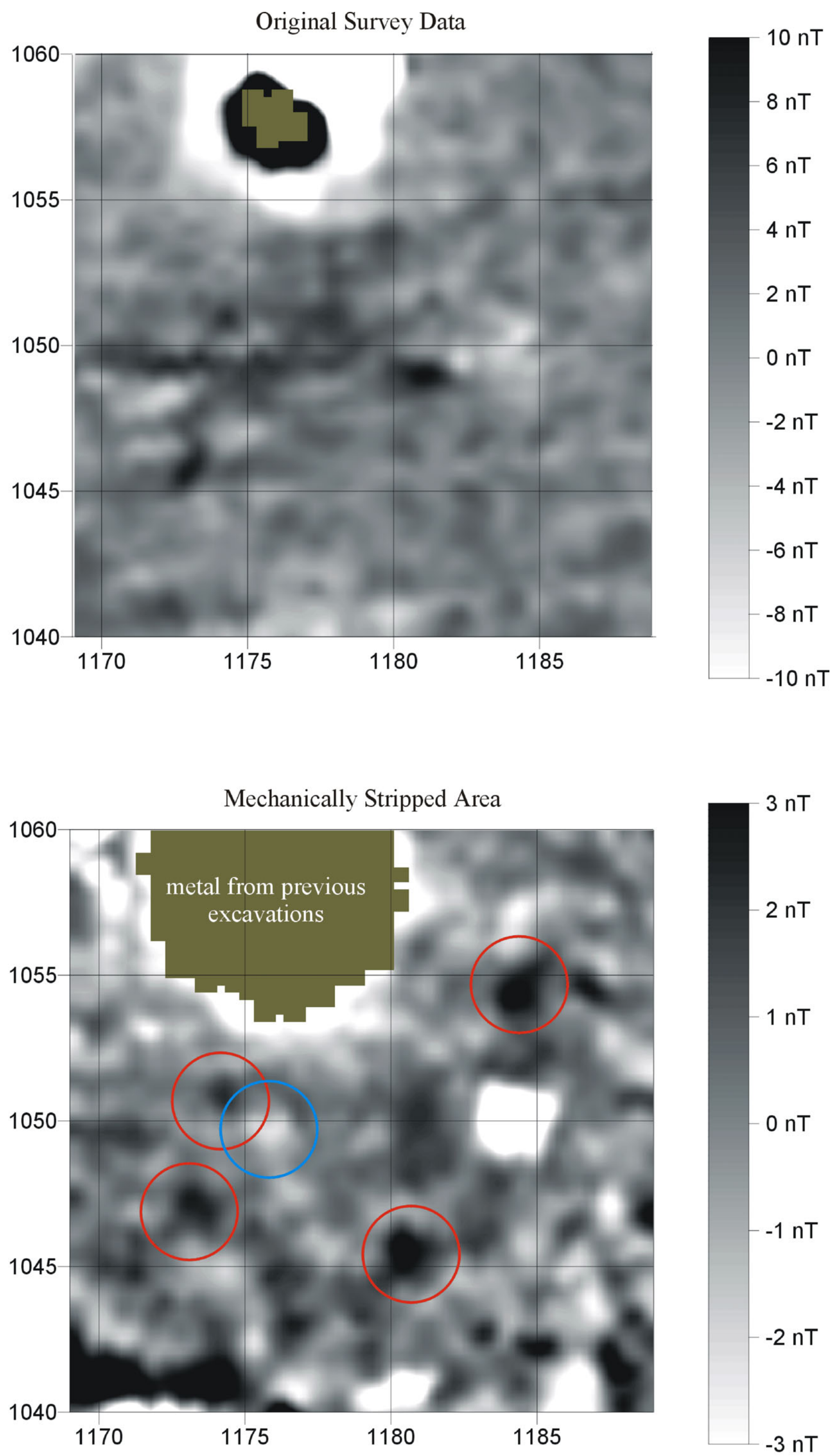


Figure 5.8. Survey results after mechanical stripping (LAN-63 Stripped Area 2).

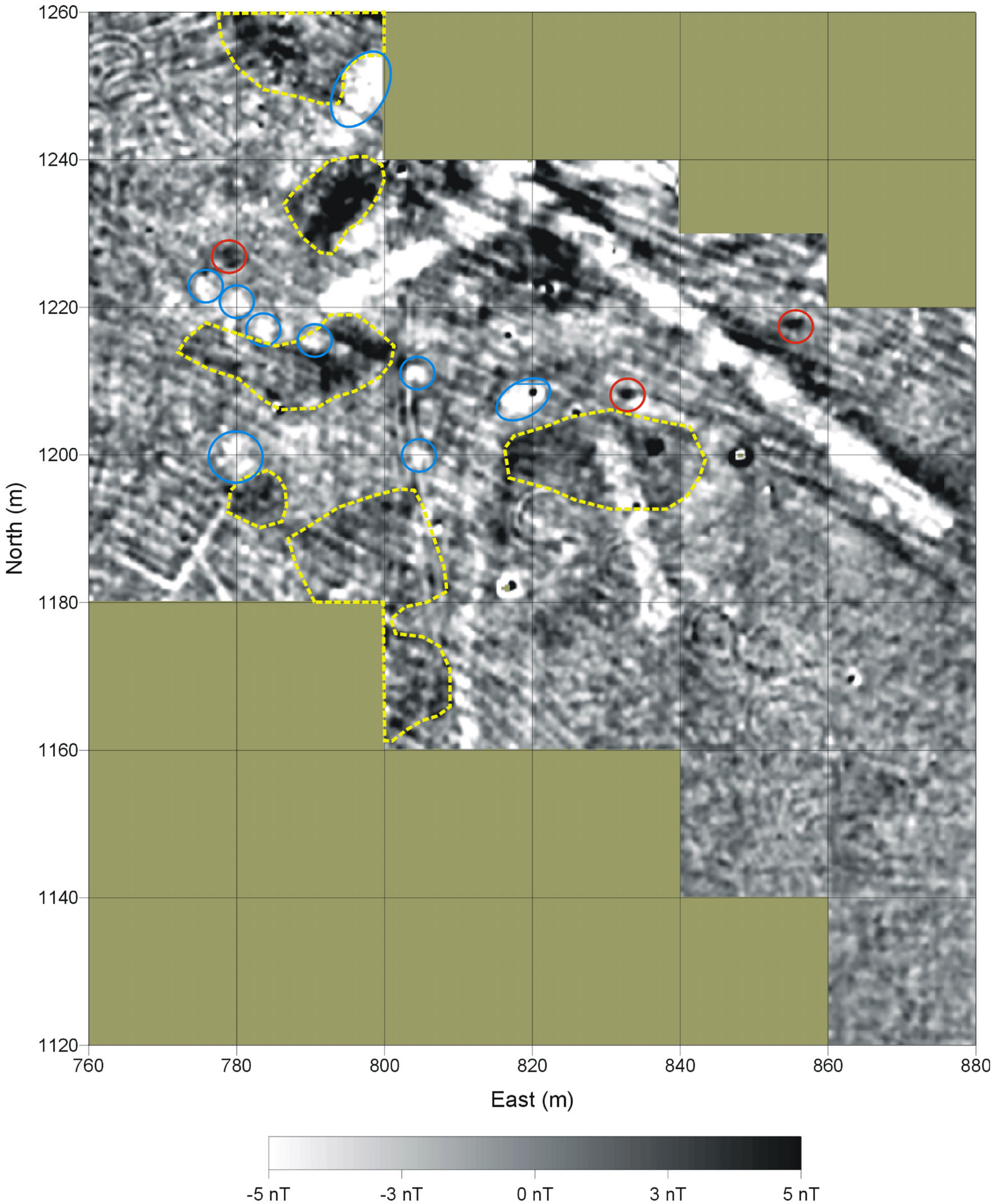


Figure 5.9. Initial interpretations of the magnetic field gradient survey results at LAN-64.

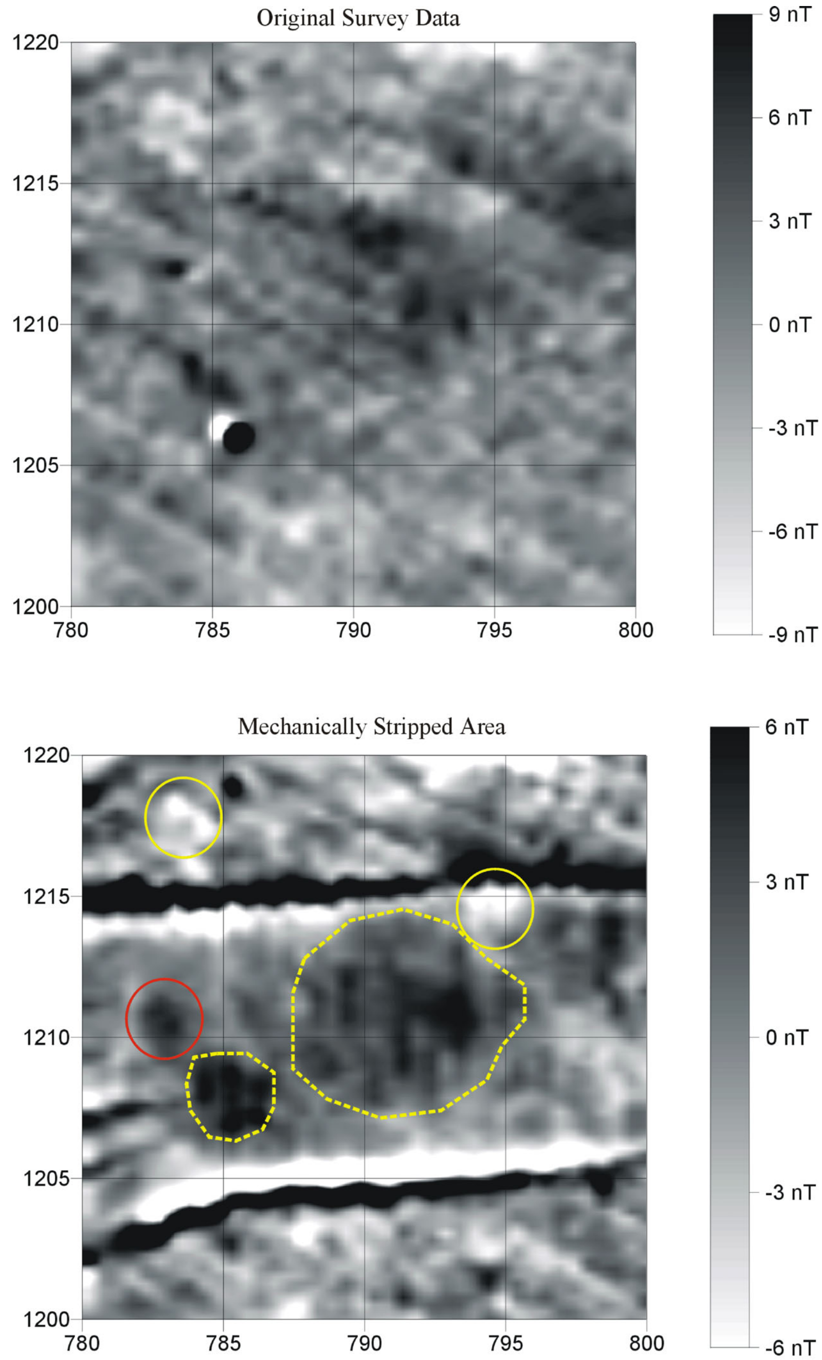


Figure 5.10. Survey results after mechanical stripping (LAN-64 Stripped Area 1).

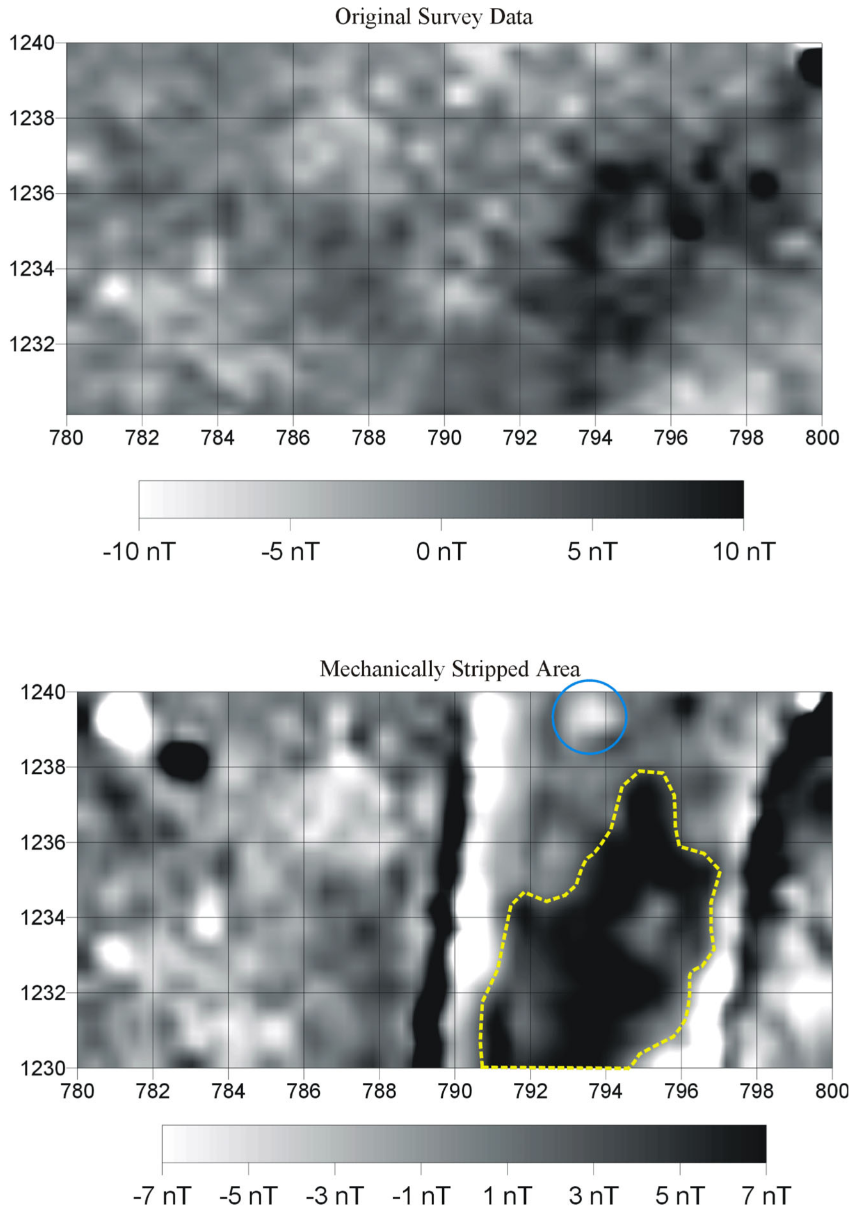


Figure 5.11. Survey results after mechanical stripping (LAN-64 Stripped Area 2).

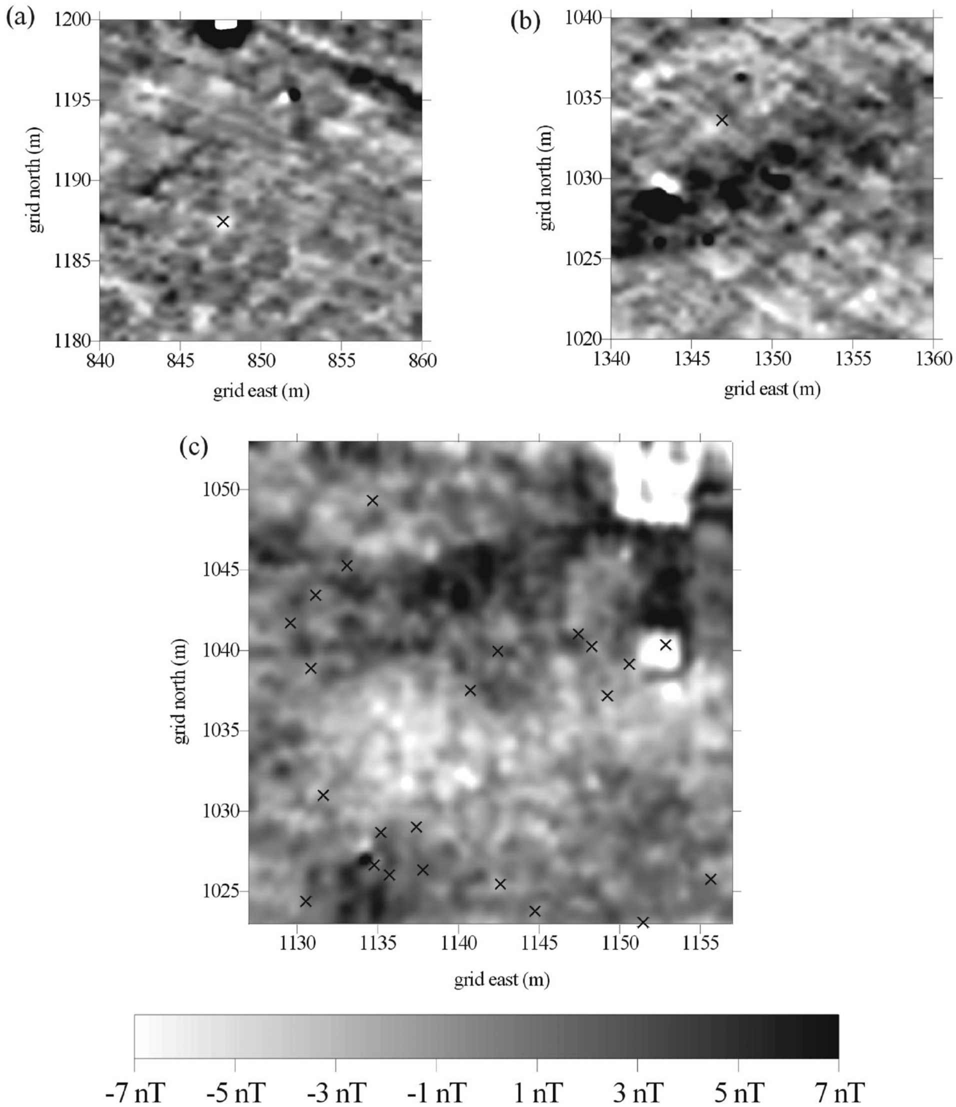


Figure 5.12. Several examples of archaeological features with negative magnetic field gradient anomaly correlates.

Phases II and III: Data Recovery Methods and Summary Results

John G. Douglass

Field and laboratory methods for SRI's West Bluffs Phase II and III data recovery and intensive monitoring project, as well as summary results, are described in this chapter. Descriptions of analyzed features can be found in Chapter 7. Procedures for completing the various tasks were outlined in the HPTP (Altschul et al. 2000), in consultation with the Corps. Because previous work on the property (Van Horn 1987) indicated that important archaeological features might have been present, data recovery investigations were divided into three separate phases. These phases were also designed to meet not only requirements set forth by the Corps under Section 106 of the NHPA, but also conditions of approval by the City of Los Angeles under CEQA.

The methods described below are similar to those outlined in the HPTP, with one major exception. In the HPTP, one priority in sampling and analysis was to study the physical artifacts collected by Van Horn during his work in the 1980s in the project area. Unfortunately, these artifacts were not available to SRI for examination. Although SRI was not able to physically examine the Van Horn artifacts, however, analysts working for SRI were able to use the published data on various artifact classes to compare to the current results. As a result, the basic principle of comparative research and analysis was adhered to.

Phase I consisted of geophysically mapping portions of LAN-63 and LAN-64 through the use of resistivity and magnetic surveys to identify possible features; these activities are described in Chapter 5. Phase II consisted of investigating a sample of these anomalies using hand excavations. These first two phases of data recovery were conducted in August and September of 2000.

There were three primary goals of the Phase II data recovery: (1) excavate a sample of intact features and activity areas; (2) identify temporal relationships between the features; and (3) define distinct activity areas. Achieving these primary goals required a different strategy than the one usually applied to coastal shell middens. Traditionally, archaeologists have treated middens as massive, largely uniform deposits. Some archaeologists have argued that occupation took place at one time, with activities distributed evenly throughout the site. Others have argued that regardless of how many occupations took place or where the activities were distributed, by excavating enough of the midden, all past activities should be represented. These assumptions have led to strategies that rely on excavating units that are distributed through some form of probabilistic or systematic sampling technique. Archaeologists, then, generalize the results from the sample to the entire site.

Given the extent of previous archaeological excavation at LAN-63 and LAN-64, SRI recognized that gathering more midden samples would provide little additional information. For example, it is doubtful that we would learn that the residents used a lithic technology fundamentally different from one already documented at the sites on the property. Similarly, estimating the total number of obsidian artifacts at all three sites would be largely meaningless, but knowing that obsidian is restricted to certain types of occupation or perhaps certain areas within the site is crucial for evaluating the settlement and site structure models proposed in Chapter 3.

How does one recognize and isolate activity areas in a midden? Middens by definition are accretionary formations. Residents would have lived on a surface, conducted activities, dug pits, buried family members, and discarded refuse. They would have perform these actions over a continual span of time or in repeated occupations of the same location. Once abandoned, middens would have become attractive habitats for plants and burrowing animals, which move artifacts and ecofacts from where they were initially discarded to new locations within the midden.

There is no simple strategy for finding activity areas; in some middens, it may be impossible. However, many middens do exhibit internal structure. As a result, SRI focused on hearths as the centers of activity areas. Hearths and, more generally, features, are critical to investigate, because many of the artifacts in them are less likely to have been moved by postdepositional activities such as rodent burrowing because large artifacts are less liable to be moved from their original position due to rodent activity. To understand individual activity areas, however, and how they relate to one another (i.e., intrasite spatial patterns), it was necessary to excavate large areas or blocks. This, in combination with Phase III monitoring and recording, allowed SRI to gather a large amount of data for analysis.

After the initial data recovery (Phases I and II) was complete, SRI conducted the final phase (Phase III) of data recovery between May and September 2003. During Phase III, referred to as a data recovery/intensive monitoring program, heavy machinery was used for the controlled removal of the three archaeological sites on the property. During this phase, a large team of archaeologists and Native Americans documented hundreds of features and artifacts.

The methods and results of the Phase I work, which consisted of exploration and discovery, are detailed in Chapter 5.

Phase II Feature Recovery

Fieldwork for Phase II was conducted between September 11 and 29, 2000, at LAN-63 and LAN-64. Because LAN-206A was found to be not eligible for listing in the NRHP, this site did not undergo data recovery. Phase II field investigations had three primary objectives: (1) locate and excavate a sample of intact features and activity areas such as those discussed by Van Horn at LAN-63, (2) identify temporal relationships between features, and (3) define distinct activity areas. In addition, SRI wanted to update the paleoenvironmental reconstruction of the bluffs to better understand the physiographic setting of the sites. Hand excavation focused on digging 1-by-1-m units in large block excavations to search for possible features identified in Phase I.

Fieldwork Methods

Phase II data recovery required determining the nature and condition of features and artifact distributions. To recover relevant data effectively, large hand-excavated blocks were opened around suspected features within mechanical-stripping units. In addition, smaller excavations were placed around other areas of interest, based on trenching or other means. Excavation units were placed, in part, where remote sensing revealed discrete areas representing midden deposits or features.

A total of 71 1-by-1-m excavation units, 5 0.50-by-0.50-m control columns, 9 mechanical trenches, and 8 mechanical-stripping units were placed in midden locations within the project area. At LAN-63, there were 59 excavation units, 4 control columns, 5 trenches, and 4 mechanical-stripping units (Figure 6.1; Table 6.1). At LAN-64, there were 12 excavation units, 1 control column, 4 mechanical trenches, and 4 mechanical-stripping units (Figure 6.2; see Table 6.1). Hand-excavation units were dug in large blocks whenever possible to ensure full excavation of suspected features identified during Phase I. Fieldwork entailed several tasks: (1) placing, excavating, and screening hand units; (2) data recording; and (3) recovering specialized samples. Procedures involved with these tasks are described below.

Excavation, Data Recording, and Screening

Phase II excavation units were typically 1-by-1-m units placed over anomalies located using remote sensing. To ensure complete feature recovery, most of these units were placed within larger block-excavation areas. Because the site lacked a complex stratigraphic profile, units were excavated in arbitrary 10-cm levels until the bottom of the cultural deposit was reached, generally the A-B-horizon contact. In some cases, however, excavation units were terminated well before the base of the cultural deposit for a number of reasons, including extensive disturbance. If there were subtle changes in the soil stratigraphy within the unit before the bottom of the cultural deposit was reached, the excavation level was completed with less than a 10-cm level or levels were subdivided into natural stratigraphic units.

At LAN-63, there was a stratum of aeolian (windblown) sterile sand overlying the cultural deposit on its western flank. As a result, a backhoe was employed to mechanically strip areas for feature recovery in four locations. Trenches of various lengths also were placed in five locations across LAN-63 to aid in our study of the soil stratigraphy and to help us find additional features (see Figure 6.1 and Table 6.1). Because of the unique information that can be gained from features, they were treated with special consideration. When features were found in excavation units, they were drawn in plan view, photographed, and fully excavated, and samples were collected for paleobotanical and chronometric analysis. In all features, the fill was removed in natural or cultural levels. All feature fill was processed in the field as a flotation sample according to the procedures stated below and wet-screened through $^{1}/_{16}$-inch mesh.

At LAN-64, there was no need to strip away windblown sand prior to placing excavation units; the prevailing wind had already stripped away the upper portion of the site over time. Four mechanical-stripping units were placed in the central portion of the site to search for features (see Figure 6.2). Two large stripping units was placed in the western portion of the site, and two additional smaller blocks were placed in different parts of the site's center. There were three excavation blocks: one in the northwest corner of the site and two smaller blocks within the two small mechanical-stripping units in the center of the site. A total of four trenches was also excavated for the study of soil stratigraphy; these were placed across the center of the site. Another trench (Trench 1002) was placed to the south of the site boundaries, in a depressed area between LAN-63 and LAN-64.

A location away from the two sites was designated the water-screening area; the material was moved there in 5-gallon (about 20-liter) buckets labeled with the appropriate provenience information. After removal of the matrix, all remaining material was dried in the sun and then placed in plastic bags. Bags then were taken to the SRI laboratory in Redlands. All bags were carefully packed to prevent the various samples from being damaged or mixed during transport.

Crew chiefs and the project director checked project notes and organized them appropriately. At the end of each day, all artifact bags and specialized items were collected and stored in a secure facility. At the end of the week, these items were organized and prepared for transport to the Redlands laboratory. A special-item list, provenience list, gab list, unit and feature list, and photographic log were maintained by crew chiefs and the project director.

The field crew recorded unit and feature information for individual excavations. Completed forms bore data on unit location, provenience, depths, soil characteristics, artifact and samples taken, disturbances noted, and associated units and features, among many other things. Plan drawings were done at the base of any level in which artifacts were exposed. Selected trench walls were faced, profiled, recorded on appropriate forms, and photographed.

Specialized Samples

Pollen samples were collected from underneath some of the ground stone and other rocks found during excavation, as well as from selected areas within the excavated matrix, such as control columns at both sites. Roughly 2 cups of soil from each sample was collected with a clean trowel for this purpose. The soil was put into plastic bags and sealed before being sent to the laboratory. Samples were stored in the laboratory until it was decided which ones would be sent out for further analysis. When ground stone was collected in the field for pollen washes, it was wrapped in aluminum foil.

In addition, four column samples (25-by-25-cm units) were collected to be floated in 10-cm levels (three column samples at LAN-63, one at LAN-64). Flotation samples were processed using standard SRI procedures. A No. 45 screen (approximately 1/64-inch mesh) was used to capture light fractions. This screen size was chosen to retrieve an adequate macrobotanical sample while avoiding the capture of silt or clay particles. Heavy fraction was captured using a 1/16-inch screen. Flotation samples were processed using a Dausman Flote-Tech machine (Model A), a self-contained, recirculating system consisting of two adjoining chambers with screen boxes (one for heavy fraction, one for light fraction), a water pump (for recirculating water), and a sludge pump (to pump off sediment and excess water). This system offers several advantages over other methods. First, it is efficient, allowing 20-liter samples to be processed in 15 minutes. Second, it can handle very large sediment samples. Third, potential variations in agitation and light-fraction collection are minimized. Agitation is accomplished by pressurized water, and, thus, the potential for damaging macrobotanical remains is minimized. Finally, the self-contained unit can be used both indoors and outdoors, and it conserves water compared to other systems.

Phase III Data Recovery and Intensive Monitoring: Field Methods

Phase III was conducted between May 12, 2003, and September 5, 2003. This final phase of archaeological investigation was a combination of feature data recovery and intensive monitoring. Rather than being a simple program of data recovery, during Phase III, the sites were graded in a controlled manner (in 1–2-inch [3–5-cm] "lifts," or levels) to about 3 feet (0.9 m) below the base of archaeological deposits. As a result, although features were excavated in this phase of the project, we used different methods than were used in Phase II. With few exceptions, features were not excavated in 1-by-1-m excavation units, but rather were more expediently documented and collected. All features identified by SRI personnel were completely excavated and recorded.

Personnel

In accordance with the conditions of approval by the City of Los Angeles, at least one Native American monitor was on site during the work day to monitor grading. When grading machines were used on more than one site simultaneously, there were two Native Americans monitoring grading activities. In addition to these monitors, there was at least one Most Likely Descendent (MLD)–designated representative on site daily beginning June 16, 2003, to monitor the excavation of possible human burials. Robert Dorame, a member of the Gabrielino Tongva Indians of California, was named the MLD for the West Bluffs project by the Native American Heritage Commission (NAHC) on June 12, 2003, after it was notified of human remains at LAN-64 by SRI and the Los Angeles Coroner's office on June 11, 2003. A complete list of Native American monitors and MLD representatives can be found in Appendix D.

The size of the archaeological team assembled was a proportional response to the amount of heavy equipment used for grading and the density of prehistoric features identified. This team, which fluctuated in size during the project, consisted of several mappers (a dedicated total-station mapper and one or two prism-rod operators), at least one monitor who walked behind each piece of grading equipment looking for artifacts, and a number of feature-recovery personnel. During the latter portion of the project, a wet-screen crew processed collected soil. Over the course of the project, the number of archaeologists fluctuated from a low of 7 to a high of 25, with an average crew size of 15.

Fieldwork Methods

During the last phase of the data recovery/monitoring program, similar field methods were used at all three sites (LAN-63, LAN-64, and LAN-206A). Prior to fieldwork, the site was mowed by the client, previous datums were relocated, and site boundaries were staked. The monitoring protocol was designed to identify all significant features and all human remains. SRI took a conservative approach in defining features so as to ensure identifying all of them, including those containing human remains. All features were excavated, not just those that were considered unique.

Grading of site deposits was conducted with a combination of at least one set of machinery: a motor grader (a "blade") paired with a paddle-wheel belly scraper. The blade would make single passes over an area, cutting 1–2-inch lifts of soil. The windrow produced by the blade would be subsequently collected by a paddle wheel. Ideally, the equipment would make a single pass over a large portion of the site before returning to begin the next pass. This grading continued to roughly 3 feet (0.9 m) below the site deposit to ensure that all prehistoric remains were identified.

Monitors followed a safe distance behind each piece of heavy equipment to identify prehistoric and historical-period remains. When a possible artifact was identified, an ice pick or other probing device was placed in the ground in the immediate area to mark the area where we needed to search for additional artifacts. If a lone artifact was identified, a single pin flag was placed near it to alert a prism-rod operator to map it with a unique provenience number and collect it. If a possible feature was identified by the monitor, two pin flags were placed at either end of the feature. These two pin flags both identified it as a potential feature to other archaeologists and ensured that machine operators avoided the immediate area.

Possible features were given unique provenience and feature numbers, and their locations were mapped. One or more archaeologists would then excavate and document the feature. In some cases, artifacts tentatively identified by monitors as features turned out to be isolated artifacts. In these cases, the unique feature number was deleted and any artifacts collected were recorded using the corresponding provenience number. All diagnostic isolated artifacts (such as ground stone, utilized flakes, tools, and projectile points) were point-provenienced.

Excavation, Data Recording, and Screening

When a feature, such as a rock concentration, was identified, it was excavated as a unique entity. When necessary, an area around the feature was staked and flagged with caution tape to help ensure the safety of excavators when heavy machinery passed nearby. The actual excavation techniques used in Phase III were similar to those used in Phase II (see above), with a few exceptions detailed below.

At all three sites on the West Bluffs property, excavation units were used almost exclusively for examining burials and related deposits surrounding burials (Figures 6.3–6.5; Table 6.2). Five excavation units were dug around burials at LAN-63; 16 units at LAN-64; and 2 units at LAN-206A. In addition to the burials, Feature 587, a ritual cache containing scattered cremated human bone, also was excavated with a total of 25 units (see Table 6.2).

During Phase III, soil excavated around features was normally not collected for wet screening (except in the case of unit excavations, such as those used in and around burials, in which all levels were wet-screened). Most features were not sectioned because rodent disturbance was acute at all three sites, and there was little soil differentiation within features in midden deposits. In the case of the excavation of units, all soil from arbitrary 10-cm levels was collected in 5-gallon buckets and wet-screened. Excavation units were faced, profiled and recorded on appropriate forms, and photographed using a digital camera. Upon completion of the excavation, whether a feature or a unit, a total station was used to precisely and three-dimensionally map its location within the site.

During this final phase of data recovery, several locations were designated water-screening areas. Material was moved to these areas in 5-gallon (about 20-liter) buckets labeled with the appropriate provenience information. After removal of the matrix, all remaining material was dried in the sun and then placed in plastic bags. Bags were then taken to the SRI laboratory in Redlands. All bags were carefully packed to prevent the various samples from being damaged or mixed during transport.

Field Methods for Human Remains

Human remains were identified in the field only during Phase III work. When human burials were identified during grading, SRI followed specific guidelines written by the MLD (Appendix E). The MLD offered initial, verbal guidelines to Catellus and SRI on June 13, 2003; written guidelines were received by Catellus and SRI on June 19. Discussions with the MLD throughout the project, and especially on June 20, 2003—a day after SRI received the MLD written guidelines—clarified the guidelines and led to the subsequent refining of SRI's methods and protocol for dealing with human burials. When bone was identified by a monitor, an archaeologist trained in human osteology examined the bone. If the remains were identified as human, a 50-foot radius around the burial was roped with stakes and caution tape to protect the area. All Native Americans on-site (the Native American monitors and MLD representatives) were notified, as were the NAHC, Catellus, SRI, and, when appropriate, Roderic McLean, staff archaeologist of the Corps. For the first possible burial found (Feature 32), which subsequently was determined to be faunal remains, SRI also notified the Los Angeles Police Department (LAPD), which immediately contacted the Los Angeles County Coroner. By our second possible human burial at LAN-64 (Feature 43), SRI was instructed by both the LAPD and Coroner's office not to contact those agencies in the future. Any isolated pieces of probable or possible (including indeterminate) human bone identified in the field were collected in cloth bags and secured with the burial remains. These isolated pieces of bone, along with the human burials, were sent to Dr. Philip Walker at the University of California, Santa Barbara, for laboratory macroscopic examination and positive identification, in accordance with the MLD's guidelines (see Chapter 13 for details).

Examination and removal of burial remains involved several stages. Any major decisions related to these procedures were discussed and approved by the MLD or his representatives, who were on-site daily during the work week between June 16 and September 3, 2003. All excavations were done by, or under the supervision of, archaeologists trained in human osteology. (These archaeologists included personnel from the bioarchaeological consulting firm Bioarch, LLC.) The burials were drawn, documented, and excavated. As part of excavation, in-field identification data were collected and recorded for future reference in the laboratory. All burial remains were placed in cotton bags, and the soil from the immediate burial area was collected for flotation and later reburial of the remains. After the burial was removed, a 1-by-1-m or 1-by-2-m unit was placed over the area and excavated to sterile matrix, with all soil collected for water-screening (see Table 6.2; see Figures 6.2 and 6.3). Fifteen feet of windrow (grader spoil) associated with the burial was collected for water-screening. Next, a 10-by-10-m area surrounding the burial was shovel-scraped, and any large disturbances or features located within this area were excavated with 1-by-1-m units. During the last several burials at LAN-63, this procedure changed, with the approval of the MLD; rather than shovel-scraping the 10-by-10-m area, the entire 50-foot- (about 15 m) radius safety area was mechanically scraped to sterile matrix with a flat-bladed backhoe. During the project, all possible human remains were transported to SRI's Redlands office and stored in a building secured with an alarm.

Reburial of Human Remains

In accordance with Public Resources Code 5097.98, all human remains, burial-related soil, and associated grave goods were reburied at an undisclosed location on the West Bluffs property on April 30, 2005. This reburial was done in consultation with the MLD, Catellus, and SRI. An initial, on-site meeting was held on April 16, 2005, by the MLD, Ken Hassett of Catellus, and John Douglass of SRI. At this meeting, a reburial location was agreed upon by Catellus and the MLD.

On April 29, 2005, a large area was excavated with a backhoe for reburial at the agreed-upon location. This work was monitored by John Douglass of SRI and Greg Dorame, a representative of the MLD. Early in the morning of April 30, 2005, all remains to be reburied were transported to the West Bluffs property from SRI's Redlands office. Once on-site, all remains were placed in the excavated burial area that conformed to written and verbal requests by the MLD. This work was supervised by John Douglass of SRI and representatives of the MLD. A private ceremony was held by the MLD and his invited guests as part of the reburial process. Upon completion of the reburial ceremony, the human remains, burial-related soil, and associated grave goods were capped with concrete.

Phase II and III Summary Results

In Phases II and III of data recovery, analyzed features were broken down into seven categories, and unanalyzed features were organized into three additional, more general, categories. Analyzed features were categorized as (1) thermal features associated with processing activities, (2) processing features, (3) ritual caches, (4) lithic tool manufacture features, (5) artifact caches, (6) burials, and (7) shell dumps. Although some of the unanalyzed features from Phase III work were able to be identified as one of the above feature types, many were classified more generally into one of three categories: artifact concentration, artifact scatter, and historical-period feature. The first two of these more-general feature types were necessary because of the lack of precise data collected in the field. During analysis, it became clear that general classes of artifacts were misidentified as a result of field conditions. This happened with ground stone artifacts. In the field, large numbers of artifacts were classified as ground stone; however, once they were analyzed, it became clear they were not ground, but, rather, smooth river cobbles. As a result, observations of features in the field may have substantially overestimate ground stone or misidentified other artifact classes. As a result, we took a conservative approach to classifying unanalyzed features at West Bluffs. Classifications of these feature types are as follows:

> *Thermal feature associated with processing activities*: concentration of fire-affected rock associated with ground stone, flaked stone, or both.
>
> *Processing feature*: concentration of ground stone, flaked stone, or both, possibly including small amount of debitage.
>
> *Ritual feature or cache*: presence of large amounts of steatite; may include abalone, purposefully broken tools or other artifacts, ochre, and cremated human remains; and may be burned.
>
> *Artifact cache*: concentration of particular classes of artifacts that appear to have been purposefully buried.

Lithic tool manufacture feature: concentration of formal tool or tools with evidence of manufacture.

Shell dump: concentration of shell with few other artifacts present.

Burial: purposefully buried human individual.

Historical-period feature: feature that probably dates to the historical period (pre-1950).

Artifact concentration: a general category for an unanalyzed feature that contains a concentration of different classes of artifacts; many were presumed to be thermal features associated with processing activities.

Artifact scatter: a general category for an unanalyzed feature that contains a scatter of different classes of artifacts; many are presumed to be disturbed thermal features associated with processing activities.

These feature classifications are generally comparable to Van Horn's (1987) previous work at West Bluffs. However, there are some differences between the classifications used here and Van Horn's. In some cases, for example, Van Horn did not find features similar to those identified by SRI. Burials and historical-period features are two such examples. In addition, some features that Van Horn classified may have been interpreted differently than similar ones found by SRI. Van Horn's earth oven category, for example, may be similar to Feature 587, which was found by SRI and interpreted as a ritual cache (see Chapter 7 for a feature description and discussion of Feature 587). Finally, SRI's feature classifications may be more functional than some of Van Horn's. SRI's two processing feature categories, for example, may be similar to Van Horn's hearth and artifact scatter categories, but SRI's interpretation is more functional.

In Phase II, 21 features (Features 1–21) were found at LAN-63, but none was found at LAN-64. Overall, features were classified into five categories. During Phase III, features were identified at all three sites (Figures 6.6–6.8). At LAN-63, 286 additional features were found; 60 features were identified at LAN-64, and 10 were found at LAN-206A. During this phase, features were classified into 10 general categories, with some distinctions made within individual categories. Appendixes F–H include lists of each feature identified at each site during Phases II and III and its classification. All told, a total of 307 features was identified at LAN-63, 60 features were found at LAN-64, and 10 features were located at LAN-206A. A summary of the categories of features identified at each site on the West Bluffs property is found in Table 6.3.

In the final report, electronic files will be included as an appendix to this chapter. These electronic files will include photographs of selected features, as well as unit, level, and feature data, including horizontal and vertical location, size, and artifact-class quantities and densities.

Phase II and III Laboratory Procedures for All Collected Materials

During fieldwork, materials were transported to SRI at the end of each workweek. Once they arrived, the laboratory director assumed responsibility for them. An initial inventory was completed, and a basic artifact catalog database was created. This and other tasks relating to sampling, sorting, transporting, cataloging, and curation are described below. Analytical methods for various artifact classes and paleo-environmental studies are detailed in individual chapters.

Washing, Sorting, Sampling, and Inventorying

During Phase II, materials, except for special items, arrived in SRI's Redlands laboratory already washed. As noted above, wet-screening was done in the field for some proveniences, and, therefore, artifacts generally arrived ready for inventory. During Phase III operations, however, only a portion of the material (those related to burials, for example) was water-screened in the field. As a result, much of the material from Phase III work had to be washed once it arrived in the laboratory.

Most special items (unless wrapped for pollen wash or otherwise noted) and all grab-samples and other field-collected items that were not water-screened were cleaned in the laboratory prior to their inventory. During the sorting of wet-screened materials, if laboratory technicians noticed any extremely dirty items, they were also washed. For durable items, such as glass, ceramics, lithics, and shell, this cleaning was accomplished by water-screening accompanied by light hand rubbing as necessary. Brushing was avoided. For fragile items, such as bone and rusted metal, dry brushing was used to remove soil deposits. If laboratory technicians identified any fragile materials or residues (such as ochre or asphaltum) that might have been damaged during washing, they did not clean the item and notified the laboratory director.

After artifacts arrived in the laboratory, all Phase II material was sorted by broad classes. Materials from Phase II work were sorted by size in a series of four nested screens (2, 1, $^1/_2$, and $^1/_4$ inch). The basic categories used were bone, charcoal, modern/historical, lithic (which includes FAR), other, shell, worked bone, and worked shell. For all lithics and FAR, the material type was listed as lithic and the artifact categories as flaked stone, ground stone, or FAR. Laboratory technicians were instructed to show any materials from the "other" category (seeds, wood, asphaltum, ochre, etc.) to the laboratory director prior to inventorying. Fragile items, such as beads and bone tools, were placed in plastic vials and wrapped in cotton for their protection. Most artifact classes were counted during this process, and the data were added to the catalog database. Shell and charcoal were weighed. All materials were bagged separately by provenience, size class, and material type and boxed by material type. To ensure that materials were consistently sorted, selected laboratory personnel checked forms and the database for accuracy. After completion of these basic tasks, artifacts were ready for distribution to individual specialists. However, because of a stop in the project after Phase II by the client, analysis of these materials was done as part of Phase III work.

Sorting during Phase III was generally accomplished using the same procedures outlined for Phase II, with some exceptions. Sorting categories similar to those used in Phase II were also used in Phase III. Unlike the Phase II sorting, however, only about a quarter of the Phase III material was fully size-sorted using a series of four nested screens (2, 1, $^1/_2$, and $^1/_4$ inch). The rest were sorted for formal tools only. Because artifacts from most features were individually bagged and collected in the field, in many cases, only heavy-fraction materials were sorted.

Upon completion of fieldwork, it was clear that the amount of collected artifacts was well beyond what could be completely analyzed. As a result, a sampling strategy was created prior to analysis. Because of the different field methods for feature excavation, different sampling strategies were used for Phase II and Phase III features. The nature of excavation during Phase II, which included 71 1-by-1-m test excavation units, offered a more complete collection method than Phase III; as a result, all features from Phase II were analyzed. Because of the large number of features documented in Phase III, a sample of the best examples of each feature type present at LAN-63, LAN-64, and LAN-206A were sorted, and a smaller number analyzed. Artifact density and diversity, size, type, completeness, disturbance, and horizontal and vertical position on-site were all criteria used for selecting which features and levels were included in the analysis samples. Please see the analysis chapters (Chapters 8–13) for discussions on the rationale for sampling each type of material.

Laboratory Treatment of Human Remains

Treatment of human remains was guided by MLD guidelines and applicable state and federal statutes. All human remains, from the time they arrived in SRI's Redland office, were secured in a locked cabinet or cage, within a locked building. When transported to and from Dr. Phillip Walker's laboratory at the University of California, Santa Barbara, a complete inventory of remains was included with the materials to account for all remains.

As per MLD guidelines, and as discussed in Chapter 13, all soil removed from human remains for identification was collected and stored in cloth bags. This soil was inventoried and then reburied with all human remains on-site (see Reburial of Human Remains, above).

To ensure that all human remains were identified, human osteologists sorted through the entire faunal collection from Phase II and III work to identify any possible or probable remains. These remains were studied by Dr. Walker and his staff. If the remains were identified as human, they were inventoried as such and stored with other human remains until they were reburied. The reader is referred to the chapter on human remains (Chapter 13) for complete details.

Sample Delivery

Analysis was conducted for materials collected from both Phase II and Phase III after Phase III fieldwork was completed. Analyses were conducted according to the HPTP (Altschul et al. 2000), either by specialists on SRI's staff or by others who maintain their own laboratories. The laboratory director was responsible for delivering samples to the appropriate specialists. A complete, up-to-date, accurate inventory of the artifacts and samples maintained at the SRI office and those shipped out for analyses was kept. Artifacts were counted by laboratory sorters and individual specialists to improve the data's reliability and to ensure the complete transfer of collections to the analysts. The analyzed collections were later entered as updates into the computerized catalog record.

Specialists were responsible for their portions of the laboratory work. Each specialist was provided with an inventory of all materials submitted to him or her for analysis along with the appropriate contextual data to provide the background information necessary for the analysis. Upon completion of the analyses, the specialist returned the samples to the SRI laboratory. A small number of carbon and shell samples were taken for radiocarbon dating and were destroyed as part of the analytical procedure.

Cataloging and Curation

A simple cataloging and storage procedure was designed to enable easy access to the collection, as well as to facilitate final preparations for curation. Artifacts were stored in 4-mil, reclosable plastic bags with provenience and catalog data recorded on paper tags placed within the bags. These bags were then put in standard cardboard storage boxes by material type. Bag and box numbers were used to track materials until they were further sorted and assigned catalog numbers by the individual analysts. This strategy facilitated the maintenance of the materials database. It also assisted in the retrieval of specific items that had to be examined during the analysis stage. A final inventory will be completed following finalization of this report, in preparation for curation.

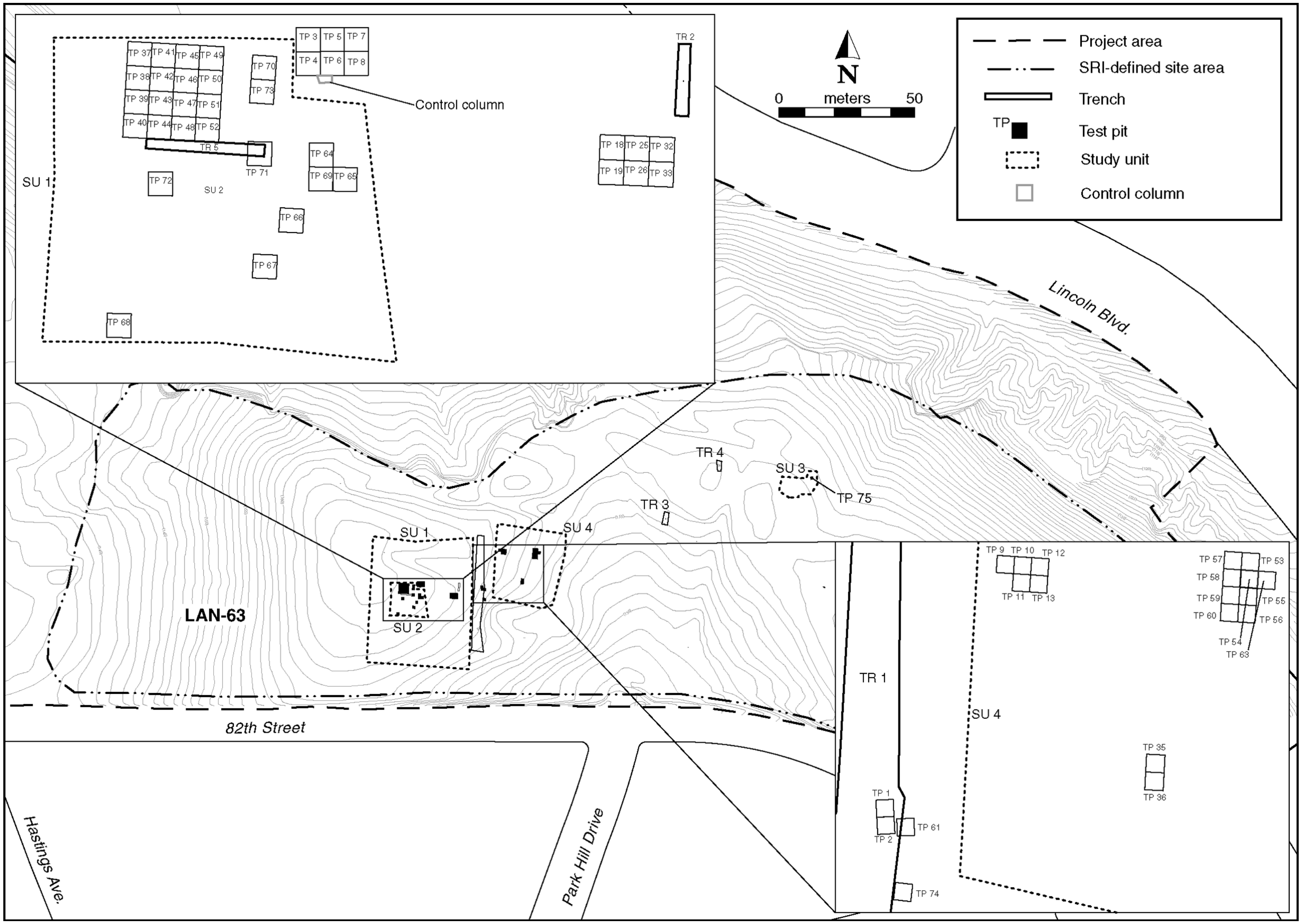


Figure 6.1. Location of excavation units, control columns, trenches and stripping units, LAN-63, Phase II.

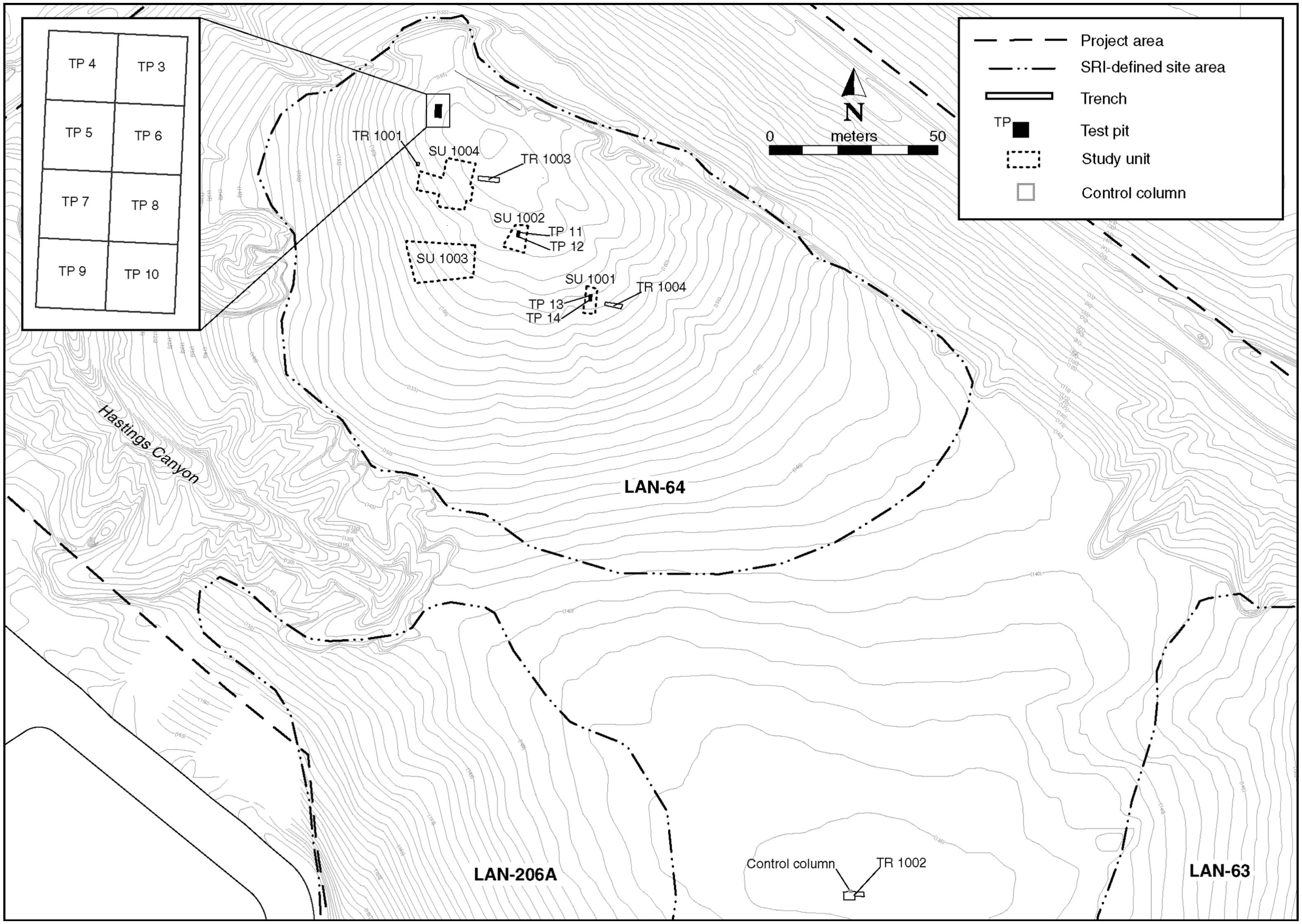


Figure 6.2. Location of excavation units, control column, trenches, and stripping units, LAN-64, Phase II.

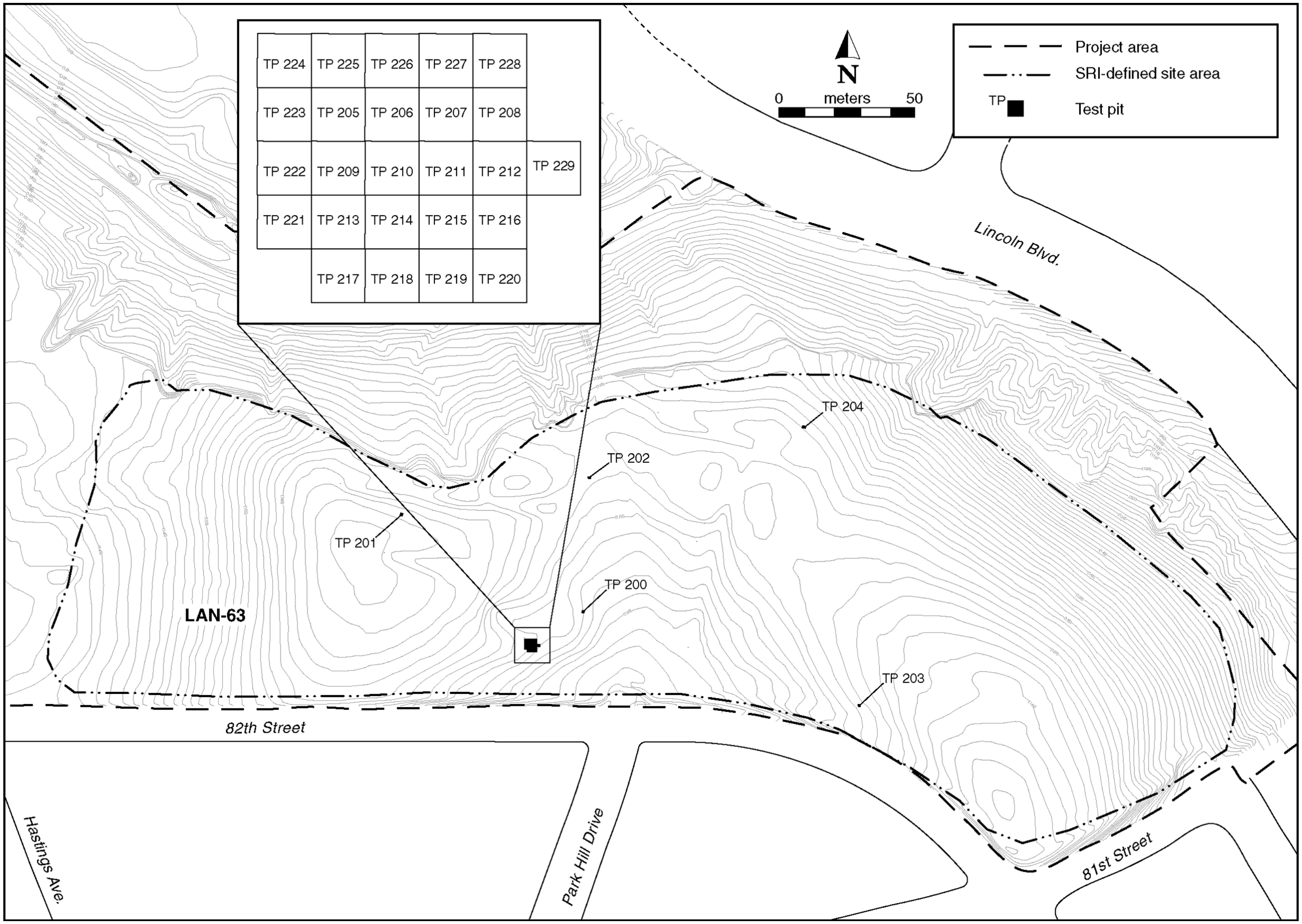


Figure 6.3. Location of units, LAN-63, Phase III.

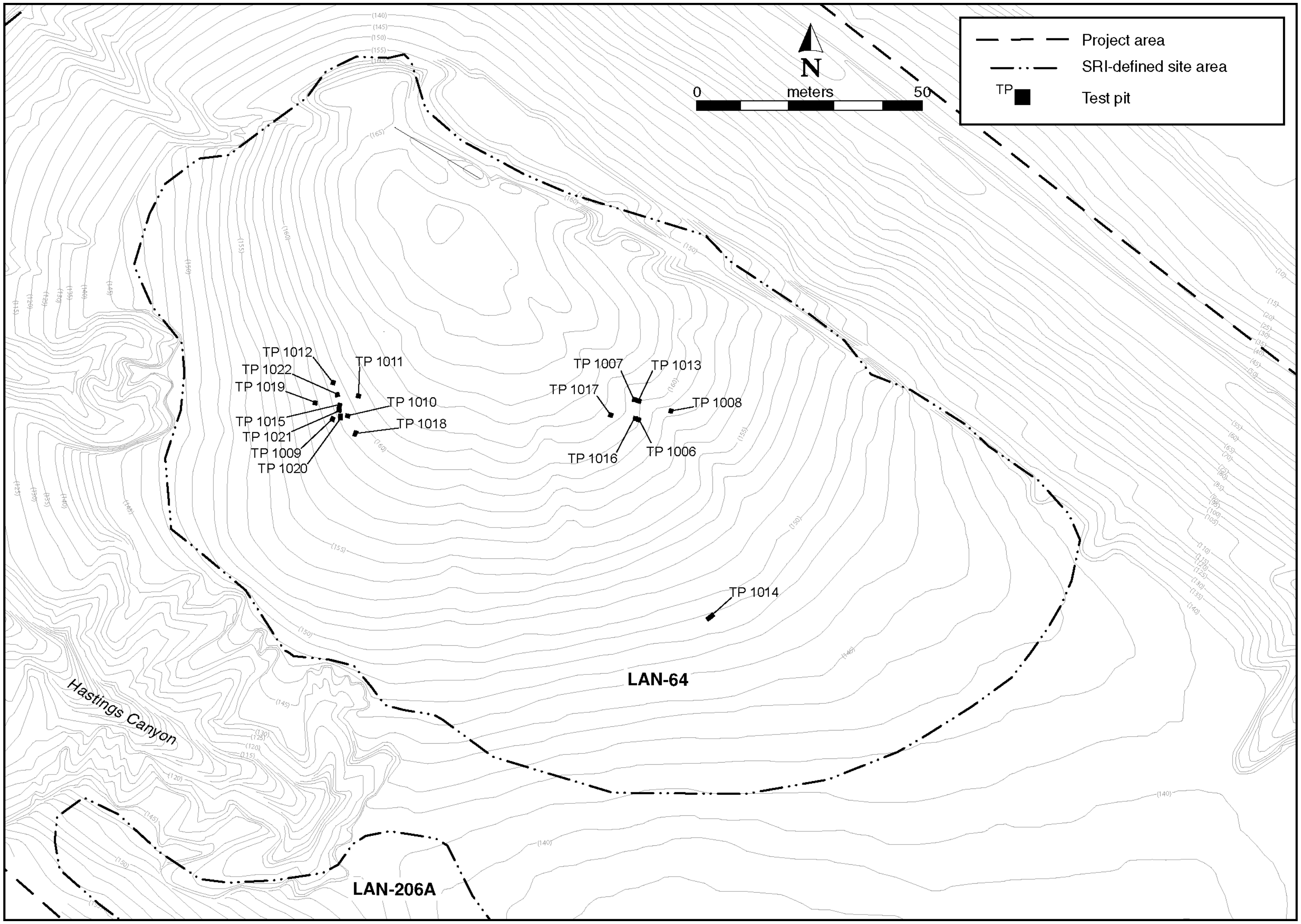


Figure 6.4. Location of units, LAN-64, Phase III.

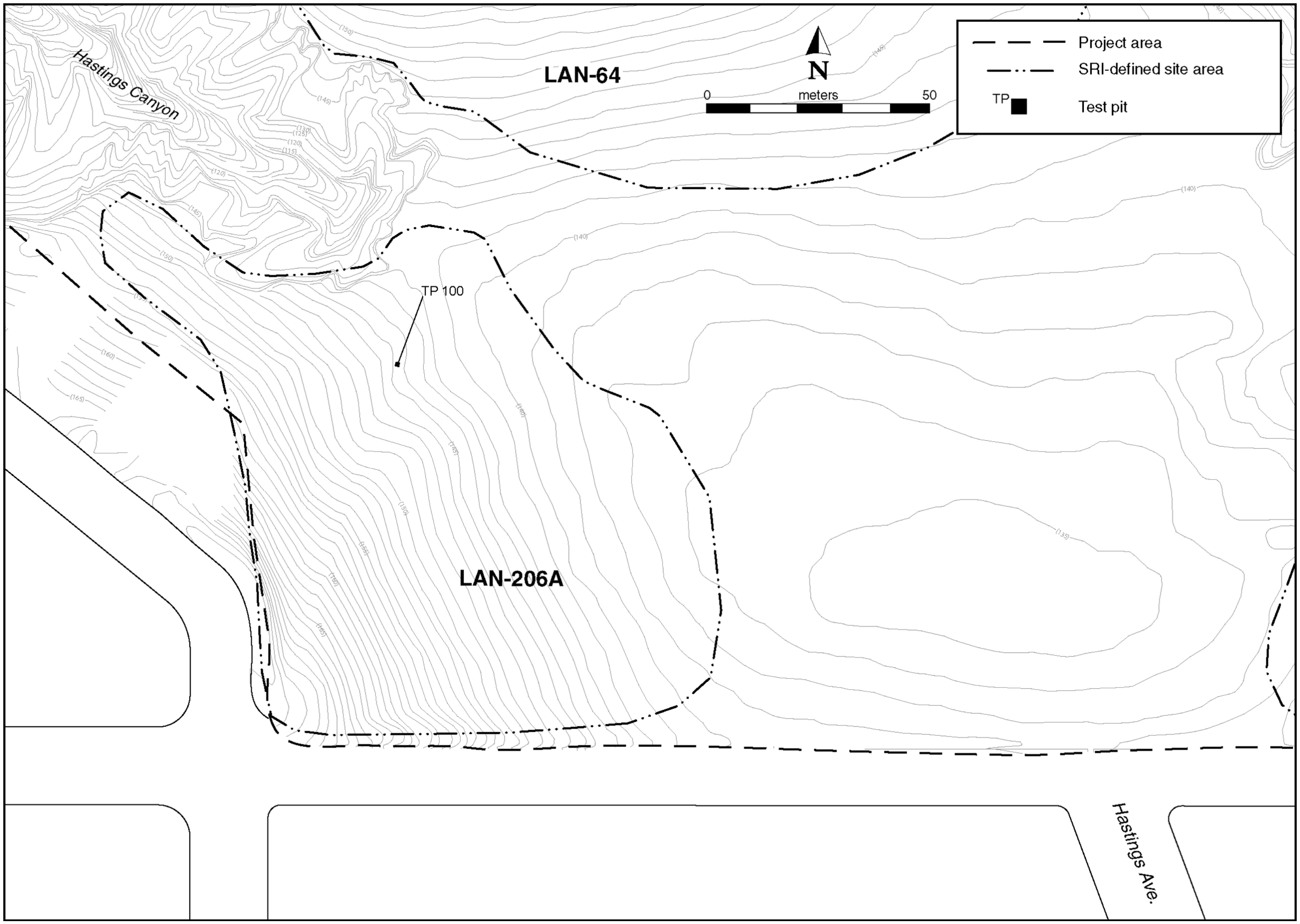


Figure 6.5. Location of units, LAN-206A, Phase III.

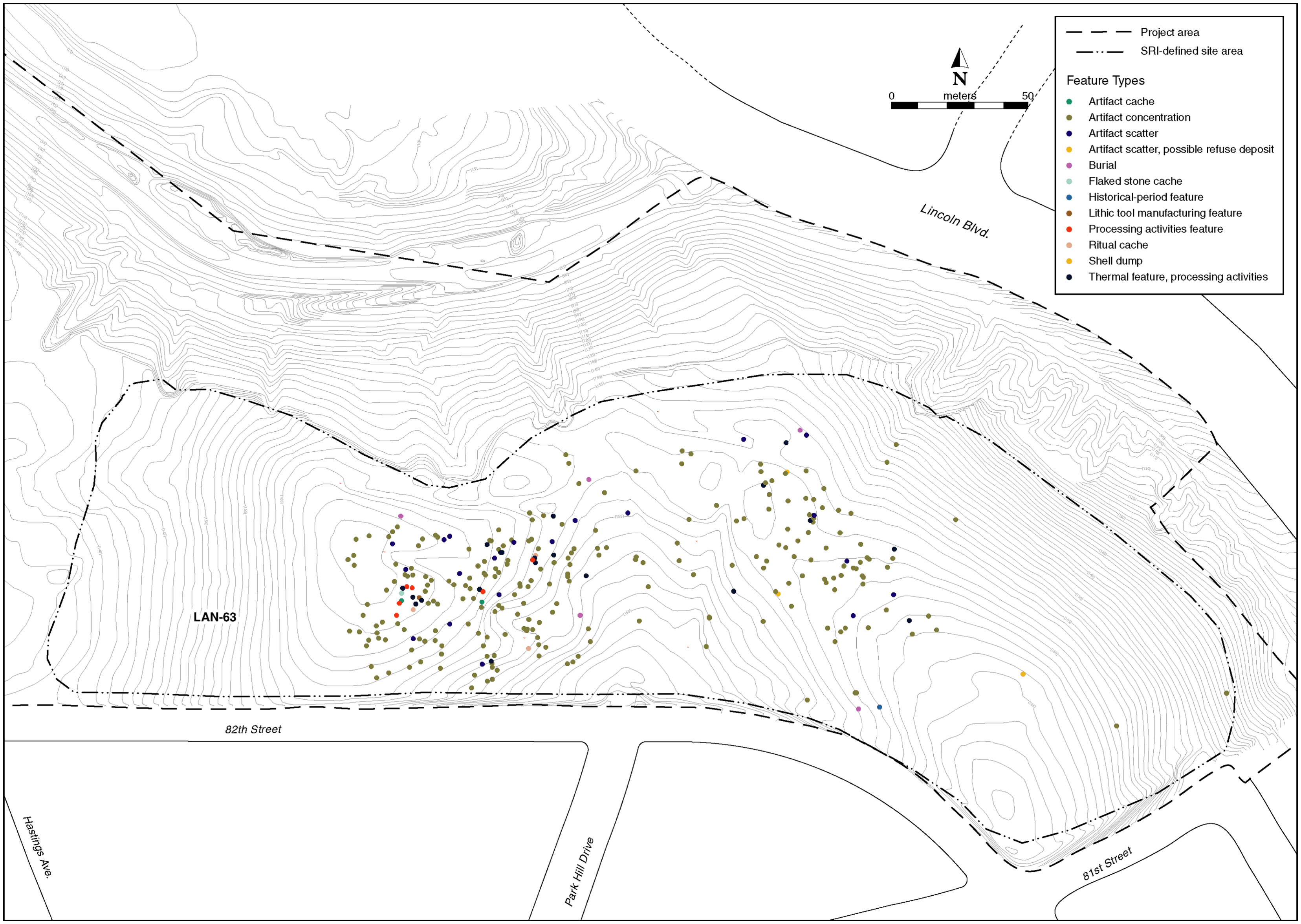


Figure 6.6. Feature type locations, LAN-63, Phases II and III.

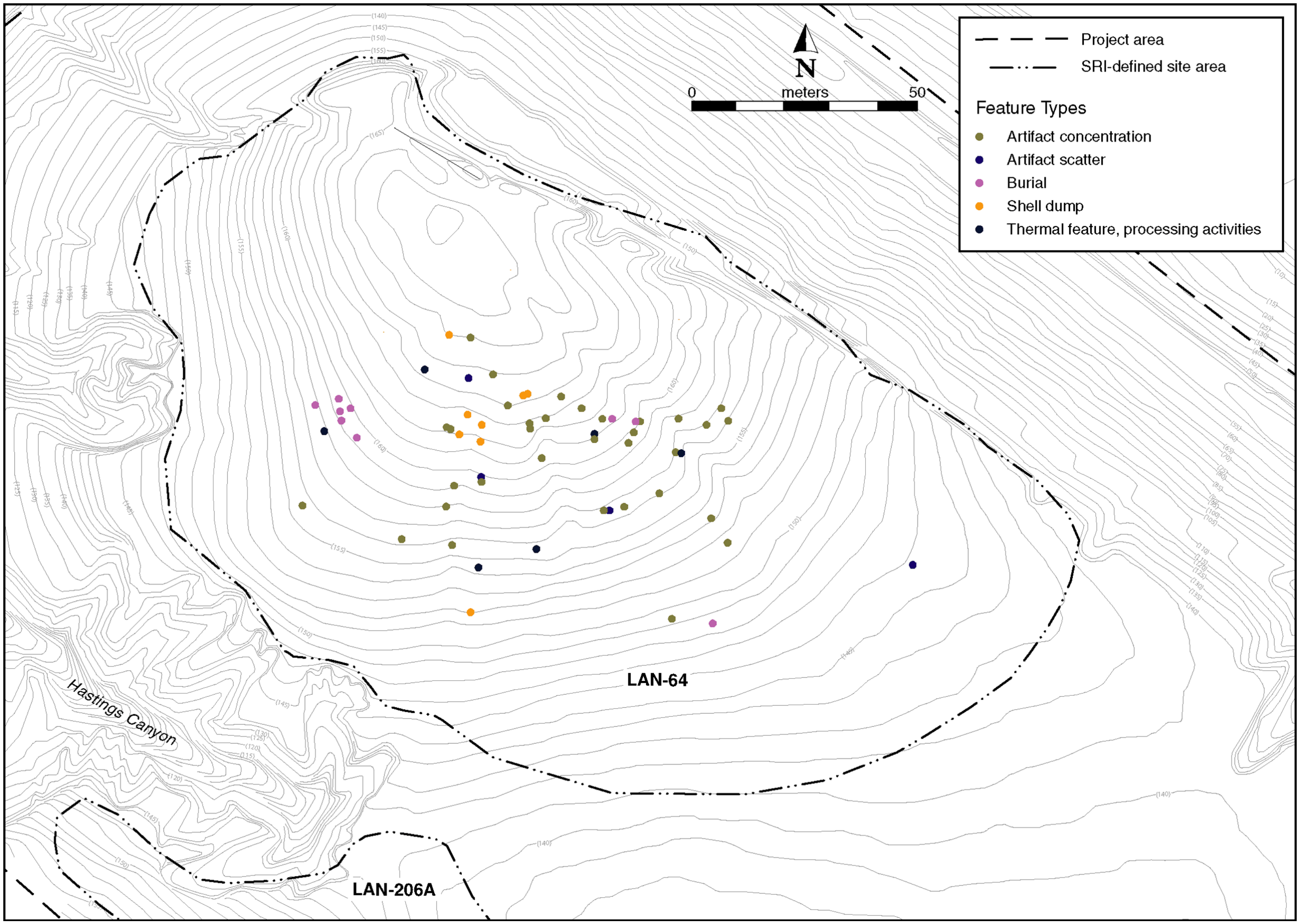


Figure 6.7. Feature type locations, LAN-64, Phases II and III.

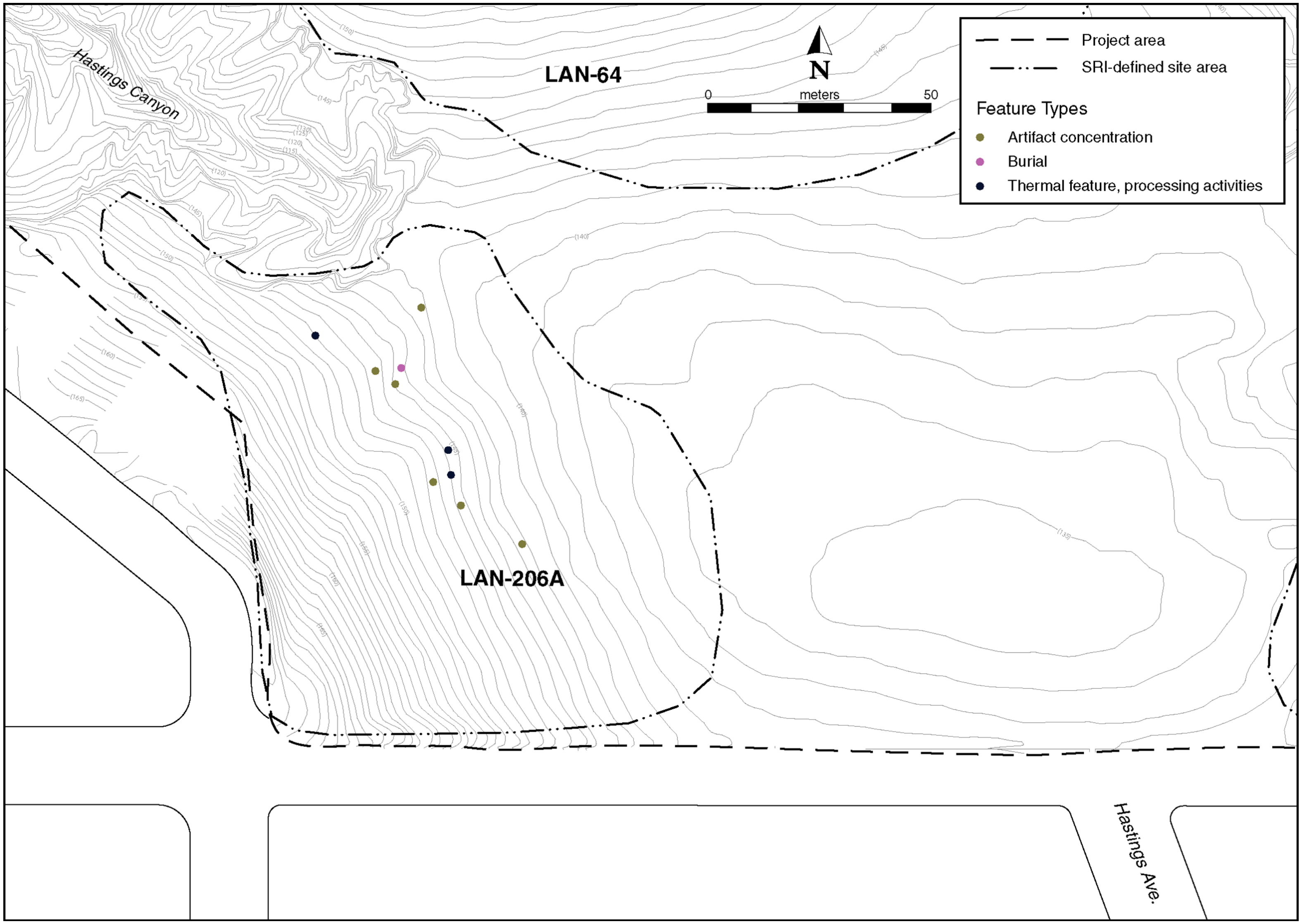


Figure 6.8. Feature type locations, LAN-206A, Phase III.

Table 6.1. List of Trenches, Mechanical-Stripping Units, and Hand-Excavation Units from Phase II

Unit	Dimensions
LAN-63	
Trench no.	
1	44 m
2	3 m
3	5 m
4	4 m
5	5 m
Mechanical-stripping no.	
1	1,895 m^2
2	166 m^2
3	100 m^2
4	734 m^2
Excavation units no.	
1–13, 18, 19, 25, 26, 32, 33, 35–61, 63-75	
LAN-64	
Trench no.	
1001	1 m
1002	6.5 m
1003	6.6 m
1004	5.25 m
Stripping no.	
1001	29 m^2
1002	42 m^2
1003	233 m^2
1004	173 m^2
Excavation unit no.	
3–14	

Table 6.2. List of Hand-Excavation Units from Phase III

Feature No., by Site	Feature Type	Hand-Excavation Unit Nos.
LAN-63		
Feature 475	burial	200
Feature 480	burial	204
Feature 492	burial	201
Feature 587	ritual cache	205–229
Feature 600	burial	202
Feature 617	burial	203
LAN-64		
Feature 43	burial	1006, 1017
Feature 52	burial	1009, 1010, 1011, 1012, 1015
Feature 56	burial	1014
Feature 61	burial	1008, 1013, 1016
Feature 62	burial	1019
Feature 64	burial	1018
Feature 65	burial	1022
Feature 66	burial	1020, 1021
LAN-206A		
Feature 100	burial	18, 100

Table 6.3. Summary Results for Phases II and III

Feature Types	Classification Traits	Number of Features			Total
		LAN-63	LAN-64	LAN-206A	
Thermal feature, associated with processing activities	concentration of fire-affected rock associated with ground stone and/or flaked stone	21	6	3	30
Processing feature	concentration of ground stone and/or flaked stone, possibly including small amount of debitage	6	—	—	6
Ritual cache or feature	presence of large amounts of steatite, may include abalone, purposefully broken tools or other artifacts, ochre, or cremated human; remains may be burned	3	—	—	3
Artifact cache	concentration of particular classes of artifact that appear to have been purposefully buried	4	—	—	4
Lithic tool manufacture feature	concentration of formed tool or tools with evidence of manufacture	2	—	—	2
Shell dump	concentration of shell with few other artifacts present	1	8	—	9
Burial	purposefully buried human individual	5	9	1	15
Historical-period feature	feature that dates to the historical-period (pre-1950)	1	—	—	1
Artifact concentration	general category for unanalyzed feature containing concentration of different types of artifacts	245	33	6	284
Artifact scatter	general category for unanalyzed feature containing a scatter or artifacts	19	4	—	23
Total		307	60	10	377

Chapter 7

Analyzed-Feature Descriptions

John G. Douglass

As noted in the methods and summary results chapter, Chapter 6, the methods for the excavation of features from the 2000 data recovery and the subsequent 2003 data recovery and intensive monitoring program were different from one another. Features in the 2000 season were identified in either block or individual unit excavations. The location of these primarily 1-by-1-m units resulted from the identification of possible subsurface features using nondestructive methods, as David Maki described in Chapter 5. The methods used during the 2000 season included excavating by unit and level and then collecting all fill from each level for subsequent water screening. All 21 features identified during the 2000 data recovery were from LAN-63; none of the unit excavations at LAN-64 produced features. Because LAN-206A was found to be not eligible for inclusion in the NRHP, there were no data recovery excavations at this third archaeological site on the property during the Phase II (2000) work. The Phase III work in 2003, however, treated LAN-206A like the other sites, and features were identified and documented.

During the 2003 data recovery and intensive monitoring program, features were generally exposed not through the use of excavation units but by mechanical stripping. Data recovery was undertaken at all three sites on the property, using the same methods, during the 2003 grading work. During this final phase of data recovery, SRI was responsible for documenting features exposed during the controlled demolition of the sites on the property in preparation for development. As a result, the methods employed in Phase III were different than those used during the previous two phases of data recovery (see Chapter 6 for detailed information on the different methods). Rather than being excavated by unit and level, these features were only excavated within and immediately surrounding the feature. Floatation and pollen samples were taken from the feature for analysis, but only in rare occasions (see below) were additional materials, such as feature fill or soil outside the feature, collected for water-screening. As a result, while compatible, these data are not completely similar. Although this is the case, there is more than enough information from all analyzed features to assess their qualities and interpret their possible functions.

In total, 48 features are described in this chapter. These features are only those that were analyzed. Because slightly different samples were picked for separate artifact-class analysis, not all features described below will correspond to each analysis chapter. For example, the shell dump features at LAN-64 (Features 45, 49, 50, 55, and 60) were not used as part of the lithics sample (Chapter 8) but were sampled for invertebrate faunal remains (Chapter 11). In addition, feature descriptions for human burials are found in the human remains chapter, Chapter 13. As described in the methods and summary results chapter, Chapter 6, it was difficult to choose which sample of features to analyze. The sample of features picked for analysis, as described in Chapter 6, was a difficult to choose. In the end, feature size, density and diversity of artifacts, and horizontal and vertical placement within the different sites were underlying factors in determining what features to pick for analysis.

LAN-63

In total, 34 features that were excavated from LAN-63 in both Phase II and Phase III of data recovery are described in this section (Figure 7.1; Table 7.1).

Feature 1

Feature 1 was located in Units 1 and 2 and consisted primarily of a tight concentration of lithics, with some shell and faunal bone noted during excavations (Figure 7.2). The main concentration of artifacts in this feature measured approximately 0.40 m long, 0.40 m wide, and 0.20 m deep. This feature extended from 0.29 to 0.46 m below the ground surface. Over 30 artifacts and manuports were mapped in this feature, some of which appeared to be fire affected. Based on lithic analysis, there was a combination of fire-affected rock, ground stone, flaked stone, manuports, and battered stone in this feature. No charcoal was identified during excavation. The dark brown, silty sand matrix (site midden), in which the feature sat, was indistinguishable from the feature fill. The excavation of the feature, however, revealed that, whereas the top layer of stones was relatively wide, a second layer of stones beneath was much smaller in diameter and centrally placed below the top level. This indicates that the feature was possibly created in a cone-shaped pit. A flotation sample was collected, as well as the remainder of the feature fill for water-screening. This feature was interpreted as a thermal feature associated with processing activities.

Feature 2

Feature 2 was located in Units 9 and 10 and consisted of three broken and burnt cobbles (Figure 7.3). Shell and faunal bone were present in the matrix. None of the cobbles was modified, and they were therefore determined to be manuports. Feature 2 was identified during monitoring of backhoe work during initial excavation at the site and may have been disturbed by the backhoe. As a result, the excavator noted that it was unclear if the three stones actually were in situ when excavated. This feature measured 0.20 m long, 0.27 m wide, and 0.07 m deep. This featured extended from 0.03 to 0.09 m below the current ground surface, which had been mechanically stripped of wind-blown sand prior to hand excavation. The dark brown, silty sand matrix surrounding the feature was very similar to the feature fill. Because of uncertainty as to the nature of this feature, no flotation or pollen samples were collected. Rather, the contexts of the units were collected for subsequent water-screening. This feature was interpreted as a thermal feature associated with processing activities.

Feature 3

Drawings and notes are unavailable for this feature. Based on lithic analysis, there was a combination of flaked stone, ground stone, fire-affected rock, and manuports found in this feature. This feature was interpreted as a thermal feature associated with processing activities.

Feature 4

Feature 4 was located primarily in Unit 10 but was in the center of an excavation block of Units 9–13. It consisted of a dense lithic scatter, with small amounts of shell and faunal remains found in the matrix (Figure 7.4). Numerous bowl and ground stone fragments were included in this feature assemblage, as discussed in the lithic analysis chapter, Chapter 8. Based on analysis, lithics in this feature included fire-affected rock, ground stone, flaked stone, and manuports. The main concentration of artifacts, which ran northwest to southeast, measured 1.25 m long, about 0.40 m wide, and 0.28 m deep. The feature, including scattered artifacts outside this main concentration, measured 1.25 m long and 1.20 m wide. This feature was about 0.15–0.43 m below ground surface. The soil surrounding the feature, a dark brown, silty sand (site midden), was indistinguishable from the feature fill. Floatation samples, as well as the matrix in and surrounding the feature, were collected for analysis and wet-screening. This feature was interpreted as a thermal feature associated with processing activities.

Feature 5

Feature 5, a concentration of lithics, shell, and faunal remains, was excavated in Units 43 and 44 in three levels. Containing manuports, ground stone, flaked stone, and fire-affected rock, the principal feature concentration measured 0.55 m long by 0.30 m wide on its upper surface (Figure 7.5). In addition, shell and faunal bone were present in the matrix. Including scattered lithics nearby, this feature measured at maximum 0.55 m long by 0.70 m wide on its upper surface. This feature was 0.25 m deep. Like Feature 76 at LAN-64, a fair number of artifacts exhibited asphaltum or other black residue. As with Feature 1, the depth and decreasing width and length of artifacts in the feature suggests the feature was a pit, although there did not appear to be any difference in soil color or texture (a dark brown, silty sand) between the feature fill and surrounding matrix. A soil sample was collected for flotation, and the remainder of the feature fill was collected for water-screening. Excavators noted that the fire-affected rock was generally found only in the upper portion of the feature. This feature was interpreted as a flaked stone cache feature associated with processing activities related to asphaltum.

Feature 6

Feature 6 consisted of a scatter of lithic artifacts found in a circular pattern. Based on analysis, this feature contained a mixture of ground stone, flaked stone, and a single manuport (Figure 7.6). In addition, shell and faunal bone were present in the matrix. Feature 6 measured approximately 0.55 m by 0.60 m and was approximately 0.10 m deep. Soil within the interior of the feature, a dark brown, silty sand, was similar to the surrounding midden matrix. No pit outline was identifiable. A soil sample was taken for flotation and the rest of the feature fill for water-screening. This feature was interpreted as being associated with processing activities.

Feature 7

Feature 7 was identified in Units 41, 42, 45, and 46. This feature, based on lithic analysis, contained a combination of fire-affected rock, ground stone, flaked stone, manuports, and battered stone (Figure 7.7). In addition, shell and faunal bone were present in the feature matrix. Because there was no discernable difference between the soil surrounding the lithic artifacts (a dark brown, silty sand) and the surrounding matrix, the boundaries of the feature were defined by the artifacts. Feature 7 consisted of a cluster of artifacts in the northeastern portion of the feature (within Unit 45) and a semicircular artifact scatter to the southwest of the cluster (within Units 41, 42, and 46). The entire feature measured approximately 1.50 m by 0.80 m, whereas the cluster within the feature measured approximately 0.40 m by 0.30 m. The feature was approximately 0.20 m deep and was approximately 0.30–0.50 m below the top of the midden. Soil was collected for flotation and the rest of the feature fill for water-screening. This feature was interpreted as a thermal feature associated with processing activities.

Feature 8

Feature 8 was a tight cluster containing primarily lithics, with shell and faunal remains in the matrix. This feature measured approximately 0.20 m by 0.20 m and was approximately 0.10 m deep (Figure 7.8). Based on lithic analysis, ground stone was the predominant lithic type in the feature assemblage, although flaked stone and two manuports were also present. This feature was identified primarily in Unit 56 but was also documented in portions of Units 55, 59, and 60. Some bowl fragments were burned. There did not appear to be any difference in soil color or texture (a dark brown, silty sand) between the feature and surrounding site matrix. Soil was collected for flotation and the rest of the feature fill for wet-screening. This feature was interpreted as a feature associated with processing activities.

Feature 9

Feature 9, found within Unit 55, consisted of a tight concentration of lithic artifacts, with some shell and faunal bone in the matrix. This feature measured approximately 0.20 m by 0.15 m and was approximately 0.15 m deep (Figure 7.9). Based on lithic analysis, Feature 9 contained a combination of fire-affected rock, ground stone, flaked stone, and a single manuport. There was no discernable difference in soil color or texture (a dark brown, silty sand) between the feature and the surrounding matrix. A soil sample was taken for flotation and the rest of the feature fill for wet-screening. This feature was interpreted as a thermal feature associated with processing activities.

Feature 10

Feature 10, excavated within Unit 61, consisted primarily of a cluster of lithics, with some shell and faunal bone in the matrix. This feature measured at maximum 1.10 m by 0.60 m and was approximately 0.20 m deep (Figure 7.10). Although there were no observed differences between the feature matrix (a dark brown, silty sand) and the surrounding site matrix, the discovery of this feature in two layers suggested that the artifacts we recovered had been placed in a shallow pit. Based on lithic analysis, the majority of the larger stones found in the feature were manuports rather than artifacts. Soil was collected for flotation and the remaining feature fill for water-screening. This feature was interpreted as being associated with processing activities.

Feature 11

Feature 11 was a large cluster of artifacts identified in Unit 54. This featured measured approximately 1.00 m by 0.80 m and was approximately 0.30 m deep (Figure 7.11). This feature contained faunal bone, shell, and numerous lithic artifacts. Based on lithic analysis, many of the ground stone artifacts, some covered in ochre, appeared to have been either never or only slightly used and then intentionally broken.

Several pieces of sea mammal bone were found in the northeastern portion of the feature. Based on lithic analysis, there was a high concentration of steatite debris within this feature. Although there was no discernable difference between the feature fill (a dark brown, silty sand) and surrounding site matrix, it is assumed that this feature had been placed in an oval-shaped pit based on the tight concentration of artifacts and their layering within the feature. A flotation sample and the feature fill were collected for water-screening. This feature was interpreted as a ritual cache.

Feature 12

Feature 12 was located in Units 64 and 65 and consisted of a sparse lithic scatter, with small amounts of shell and faunal bone found in the matrix. Feature 12 measured approximately 0.55 m long, 0.22 m wide, and 0.20 m deep (Figure 7.12). Based on lithic analysis, the feature contained flaked stone, ground stone, fire-affected rock, and two manuports. The soil containing the feature, as with many features at LAN-63, did not have any qualities (color, texture) that distinguished it from the surrounding midden, a dark brown, silty sand. A floatation sample was collected for analysis and the soil from the unit was water-screened. This feature was interpreted as a lithic-tool-manufacture feature.

Feature 13

Feature 13 consisted of a single layer of lithics found in a tight cluster (Figure 7.13). Small amounts of shell and faunal remains were found in the matrix. Feature 13 was identified in Unit 65 and measured 0.35 m long, 0.32 m wide, and about 0.10 m deep. This feature was located approximately 0.20 m below ground surface. Based on lithic analysis, we discerned that the feature primarily consisted of manuports and fire-affected rock, with only small amounts of flaked stone, battered stone, and ground stone present. A flotation sample was collected and soil from the feature fill was water-screened. This feature was interpreted as being a thermal feature associated with lithic-tool manufacture and processing.

Feature 14

Feature 14, identified in Unit 66, was a dense concentration of lithics in an area that measured at maximum 0.30 m long, 0.25 m wide, and about 0.12 m deep (Figure 7.14). This feature was approximately 0.20 m below the ground surface. In the matrix within and surrounding the feature, sparse amounts of shell and faunal remains were collected. Analysis of lithic tools from this feature suggests that, as with Feature 13, many of the rocks were manuports or ground stone and a small amount of tools, consisting of 3 choppers. A single core was also identified in the assemblage. There was no discernable differentiation in soil color or texture between the feature itself and the surrounding matrix (a dark brown, silty sand). The feature, based upon layers of artifacts, appeared to have been placed in a pit, with the lower layer supporting the upper. The lower layer of artifacts primarily contained fire-affected rock, suggesting that this feature was a thermal feature with scattered artifacts associated with it. Flotation samples collected from the feature and soil from the unit excavation were wet-screened. This feature was interpreted as a thermal feature associated with processing activities.

Feature 15

Feature 15 consisted of 2 abalone shells stacked together with a manuport and ground stone fragment located nearby (Figure 7.15). Identified in Unit 67, Feature 15 was a sparsely scattered feature. The ground stone fragment and stacked shells together formed the core of the feature and measured 0.30 m long, 0.15 m wide, and about 0.05 m deep. The feature was located approximately 0.40 m below the top of the midden. There did not appear to be any differentiation in either texture or color between the feature itself and the midden soil surrounding it; excavators noted a large amount of rodent disturbance surrounding the feature. A flotation sample was taken and the soil within the unit was wet-screened. This feature was interpreted as a ritual cache.

Feature 16

Feature 16 was identified close to the surface in Unit 70. The lithics in this feature were scattered but generally were found in a line in the western side of the unit. The feature measured 1.0 m long, about 0.40 m wide, and approximately 0.07 m deep (Figure 7.16). Beyond lithics, there were small amounts of shell and faunal bone in the matrix. The top of this feature was about 0.21 m below the ground surface. Lithic tools analyzed from this feature indicated that manuports were the predominant type of rock found in the feature, with single examples of a chopper, core, scrapper, and an unidentifiable ground stone fragment also identified. None of the mapped artifacts appeared to be fire affected. There did not appear to be any distinctive color or texture that distinguished the feature from the surrounding dark brown, silty sand of the site midden. A flotation sample was collected for analysis and the soil in the unit was wet-screened. This feature was interpreted as a feature associated with processing activities.

Feature 17

Feature 17 was identified in Unit 72 very close to the ground surface. This feature consisted of a sparse lithic scatter, with small amounts of shell and faunal remains also found in the matrix (Figure 7.17). This feature measured 0.60 m long, 0.40 m wide, and 0.15 m deep. The top of this feature was identified about 0.02 m below the top of the midden. Based on analysis, lithics in this feature included fire-affected rock, ground stone, flaked stone, and battered stone. Excavators noted that much of the artifacts found in this feature were heavily fire affected and that there was some sparsely scattered charcoal seen in the surrounding matrix. Even with the heavily fire-affected nature of the artifacts, there was no noted difference in color or texture between the feature fill and the surrounding matrix, a dark brown, silty sand. A flotation sample was collected and soil from the unit was water-screened. This feature was interpreted as a thermal feature associated with processing activities.

Feature 18

Feature 18 was identified in the first level of Unit 72. Feature 18 consisted of a sparse lithic scatter, with small amounts of shell and faunal remains in the matrix (Figure 7.18). It measured 1.0 m long by 1.0 m wide by 0.05 m deep. The top of the feature was identified within five centimeters of the top of the midden. Lithic tools collected from the feature included ground stone, flaked stone, manuports, and battered stone. The single ground stone artifact was a phallic effigy. None of the lithics appeared to be fire affected. There were numerous intrusive rodent burrows throughout the unit containing Feature 18 that may have obscured any differences in soil color or texture that may have been present; the feature fill and surrounding site matrix were both a dark brown, silty sand. Given the highly dispersed nature of the artifacts mapped as Feature 18, it is unlikely that there was any type of pit associated with the feature. Soil from the feature was water-screened, but due to a large amount of rodent disturbance and the scattered nature of artifacts, no flotation sample was collected. This feature was interpreted as an artifact cache.

Feature 19

Feature 19 consisted of two small clusters of lithics in Unit 68 (Figure 7.19). This small feature measured at maximum 0.50 m long, 0.25 m wide, and 0.05 m deep. Based on analysis, lithic tools from this feature consisted of a mixture of manuports, ground stone, and flaked stone. In addition to lithics, shell and faunal remains were also identified in the feature fill and surrounding matrix. There did not appear to be any differences observed between the color and texture of the feature fill and that of the surrounding site matrix, a dark brown, silty sand. Soil from the unit was water-screened, but due to the sparse nature of the feature, a flotation sample was not collected. This feature was interpreted as being associated with processing activities.

Feature 20

Feature 20 consisted of a sparse lithic scatter, with small amounts of faunal bone and shell in the matrix (Figure 7.20). Identified in Unit 74, Feature 20 measured 0.80 m by 0.90 m and was approximately 0.10 m deep. Based on analysis, lithic artifacts in this feature were fire-affected rock, ground stone, a pendant, and a manuport. The color and texture of the soil surrounding the feature (a dark brown, silty sand) was similar to the surrounding site matrix; no discernable pit was associated with Feature 20. Soil was collected to be water-screened. This feature was interpreted as an artifact cache.

Feature 21

Feature 21 consisted of a lithic scatter, with small amounts of faunal bone and shell in the matrix (Figure 7.21). Identified in Unit 75, Feature 21 measured 0.80 m by 0.70 m and was approximately 0.10 m deep. Based on analysis, lithic artifacts in this feature were ground stone, flaked stone, fire-affected rocks, and manuports. There was no identifiable difference between the soil within the feature and that surrounding it in the site matrix (a dark brown, silty sand). No charcoal was observed. Soil samples were collected from the feature for water-screening. This feature was interpreted as being associated with processing activities.

Feature 318

This oval-shaped feature was a highly concentrated collection, the majority of which consisted of manuports, with fire-affected rocks, ground stone, and flaked stone appearing in smaller quantities (Figure 7.22). Feature 318 measured 2.5 m long, 1.5 m wide, and about 0.25 m deep. The majority of the artifacts and stones in the feature were fire affected. Small amounts of shell and faunal bone were present in the feature matrix. Evidence of rodent disturbance, including a rodent burrow on the north side of the feature, was also present. Although there was some scattering of material within the limits of the feature, the vast majority of the collection was concentrated in the center of the feature in a dense concentration, indicating a lack of significant disturbance to the feature. Flotation and pollen samples and artifacts were collected for analysis. This feature was interpreted as a thermal feature related to processing activities.

Feature 337

This feature primarily consisted of a highly concentrated collection of manuports, fire-affected rock, ground stone, and flaked stone (Figure 7.23). Measuring 1.1 m long, 0.7 m wide, and about 0.35 m deep, Feature 337 contained one of the densest concentrations of artifacts of any feature identified at LAN-63. Nearly all of the components of this feature exhibited signs of thermal alteration, especially in the feature's central, deeper portions. Many of the components of this feature, especially those from its deeper, central area, were covered in a black, sootlike substance. This central area of the feature was four layers of stone thick in some places. Charcoal may have been present in the feature, but it was indistinguishable from the granulated fire-affected rock found throughout the deposit. Shell and small amounts of faunal bone were found in the feature matrix, as were visible rodent disturbances. The soil in the feature was a dark brown, silty sand (Munsell 10YR 4/3). Flotation and pollen samples and artifacts were collected. This feature was interpreted as a thermal feature associated with processing activities.

Feature 340

This feature consisted of a tight concentration of manuports, fire-affected rocks, ground stone, and flaked stone located south of a light linear scatter of additional artifacts (Figure 7.24). This feature primarily consisted of flaked stone and ground stone, with some shell and faunal bone found in the surrounding matrix. Feature 340 measured 1.5 m long, 1.2 m wide, and 0.2 m deep. The majority of the manuports (non-artifact rocks) and ground stone appeared to have been fire affected. Rodent disturbance was apparent in both the feature and surrounding soil. The top of the feature was cut by mechanical stripping. The feature matrix was a dark brown, silty sand (10YR 4/3). No charcoal was observed. Flotation and pollen samples and artifacts were taken for analysis. This feature was interpreted as a thermal feature related to processing activities.

Feature 409

This feature consisted of several small clusters of manuports, fire-affected rocks, ground stone, and flaked stone located within three meters of one another (Figure 7.25). Feature 409 measured about 4.60 m long, 2.40 m wide, and approximately 0.30 m deep across the entire feature. The largest and densest artifact cluster measured about 0.70 m long by 0.65 m wide. In addition to this primary cluster, there were two additional clusters, which were more scattered, located to the northeast and northwest. As observed in the field, many of the components of the feature appeared to have been fire affected, especially on their underside. Few charcoal piece were identified during excavation, however. Small amounts of faunal bone and shell were present in the feature matrix. The feature fill was a dark brown to dark reddish brown silty sand (5YR 5/2) that contained rodent disturbance. Flotation and pollen samples were collected for analysis. This feature was interpreted as a thermal feature related to processing activities.

Feature 444

This feature consisted of a tight concentration of manuports, fire-affected rock, ground stone and flaked stone artifacts surrounded by multiple areas of light-density scatters that contained various artifacts, manuports, and fire-affected rock (Figure 7.26). The principal cluster in this feature measured 0.60 m long, 0.50 m wide, and about 0.20 m deep, whereas the scattering of peripheral artifacts and manuports extended for a distance of more than 2.0 m to the east and west of the principal cluster. There were small amounts of shell and faunal bone in the surrounding matrix, which was a brown silty sand (10YR 3/2). Flotation and pollen samples were collected for analysis. This feature was interpreted as a thermal feature associated with processing activities.

Feature 446

This feature consisted of a tight, linear cluster of small, rounded pebbles, with a scatter of ground stone, flaked stone, and fire-affected rock located to the south (Figure 7.27). This feature measured approximately 0.80 m long, 0.60 m wide, and approximately 0.10 m deep. Several of the small, rounded pebbles, as well as one piece of ground stone, had asphaltum adhered to them, suggesting that the small stones were either tarring pebbles or were originally planned to be used as such. The brown silty sand (10YR 3/2) surrounding this feature contained sparse amounts of shell and faunal bone, as well as evidence of rodent disturbance. Several of the artifacts in the feature were damaged by the mechanical stripping used to uncover the feature. Flotation and pollen samples were collected for analysis. This feature was interpreted as a thermal feature associated with processing activities, possibly related to working with asphaltum.

Feature 462

This feature consisted of a tight concentration of manuports, fire-affected rocks, ground stone, and flaked stone, surrounded by a lighter-density scatter of similar materials (Figure 7.28). Measuring 1.05 m long, 1.00 m wide, and about 0.25 m deep, this feature was primarily composed of thermally altered ground stone and manuports stacked up to three layers deep. Many of the ground stone artifacts and manuports were heavily cracked from thermal activity. The top of the upper-most layer was disturbed by mechanical stripping during its discovery and was found to be further disturbed by rodent activity. There was some shell and faunal bone in the feature fill, which was a brown silty sand (10YR 4/3). Flotation and pollen samples and artifacts were collected for analysis. This feature was interpreted as a thermal feature associated with processing activities.

Feature 468

This feature consisted of a tight concentration of flaked stone, ground stone, fire-affected rocks, and one manuport (Figure 7.29). This feature measured approximately 0.85 m long, 0.70 m wide, and approximately 0.10 m deep. This feature was tightly concentrated, with a few scattered pieces of fire-affected rock laying around its outer edges. The feature fill was a loosely to moderately compacted medium to dark brown silty sand. Shell and faunal bone were present in the feature matrix, but no charcoal was visible . Soil from this feature was collected for pollen and flotation samples. This feature was interpreted as a thermal feature associated with processing activities.

Feature 509

This feature consisted of a single concentration of manuports, fire-affected rock, ground stone, and flaked stone surrounded by a dispersed amount of similar types of material (Figure 7.30). The single concentration of artifacts was 0.50 by 0.40 m and 0.10 m deep; the surrounding scatter extended for approximately 1.0 m in all directions. Many of the ground stone artifacts, which included several broken pestles and bowl fragments, as well as many of the manuports, were thermally altered. Small amounts of charcoal, shell, and faunal bone were identified in the feature matrix, a brown (10YR 3/2) silty sand containing rodent burrows. Flotation and pollen samples were collected for analysis. This feature was identified as a disturbed thermal feature associated with processing activities.

Feature 521

Feature 521 was a single concentration of manuports, flaked stone, ground stone, and fire-affected rock (Figure 7.31). The majority of the artifacts in the feature were fire affected. No charcoal was identified in the matrix. Measuring 1.20 m by 0.50 m, this feature was approximately 0.17 m deep. Small amounts of shell and faunal bone were in the feature matrix. At the south end of this feature, a fire-affected bowl and pestle were found. Numerous rodent burrows were present throughout the excavation area. Flotation and pollen samples were collected for analysis. This feature was interpreted as a thermal feature associated with processing activities.

Feature 587

Feature 587 was the largest and most complex feature identified by SRI during data recovery at West Bluffs (Figures 7.32 and 7.33). This feature contained a mixture of shell and bone, flaked stone, ground stone, and fire-affected rocks. Measuring approximately 5 m long, 5 m wide, and 0.5 m deep, this feature contained tens of purposefully broken artifacts, including many pieces of ground stone. The feature fill was a dark brown silty sand, indicative of the surrounding site matrix. The densest artifact concentration, which was primarily made up of broken ground stone and manuports, was found in the central portion of the feature. More scattered and dispersed artifacts were found surrounding this feature core. Some of the artifacts were covered in ochre. Cremated human remains were scattered throughout the feature fill. This feature contains steatite debris, which was only found in two other analyzed features. Whereas there was no identifiable pit during excavation of the feature, the south wall soil profile suggests that this feature, found within the lower portion of the A horizon, was placed in a shallow pit, about 0.15 m deep, dug into the B horizon, a lighter, yellowish brown silty sand. This feature was interpreted as a ritual cache.

Feature 594

This feature consisted of a loose cluster of manuports, fire-affected rocks, ground stone, and flaked stone (Figure 7.34). Measuring 1.0 m long, 0.65 m wide, and about 0.10 m deep, this feature included a high percentage of fire-affected rock. There was a small amount of shell and faunal bone in the feature matrix. Two pestles found in the southeast corner of the feature during field analysis appeared to be placed in a shallow pit, about 0.08 m deep, dug into the underlying soil. The feature matrix was a brown silty sand (10YR 4/3). There was heavy rodent disturbance present throughout the feature. Flotation and pollen samples were collected for analysis. This feature was interpreted as a thermal feature associated with processing activities.

Feature 601

This feature consisted primarily of a mixture of manuports, fire-affected cobbles, ground stone and flaked stone (Figure 7.35). Feature 601 measured at its margins 3.0 m long by 2.6 m wide. The majority of the artifacts in this feature were concentrated in an area that measured 2.0 m long by 2.1 m wide. Some components of the feature were spread out as far as a meter from the central concentration. Even though the feature's depth varied, its deepest point was about 0.30 m below the ground surface. The matrix surrounding the feature contained a moderate amount of shell, a small amount of faunal bone, and a scattering of charcoal. The top of the feature was truncated by mechanical stripping, which cracked some of the stones in the feature. Rodent disturbance was heavy in some portions of the feature. Flotation and pollen samples were collected from the feature for analysis, as were artifacts. This feature was interpreted as a thermal feature associated with processing activities.

LAN-64

In total, 11 analyzed features are described in this section (Figure 7.36 and Table 7.2).

Feature 12

Feature 12 was a sparse lithic scatter that included ground stone, flaked stone, and fire-affected rock (Figure 7.37). These artifacts were found in a single horizontal layer. This feature measured 1.15 m by 1.00 m and was approximately 0.25 m deep. The soil surrounding the feature was a dark orangish brown silty sand, which the excavator noted was slightly darker than the surrounding matrix. Despite this observation, there were neither pit outlines nor defined boundaries to the feature based upon soil color or texture. Some shell, faunal bone, and charcoal were also noted during the excavation of the feature. Soil was collected for pollen and macrobotanical analysis, and all artifacts were also collected. This feature was interpreted as a thermal feature associated with processing activities.

Feature 17

Feature 17 was a concentration of ground stone, flaked stone, manuports, a tarring pebble, and a large amount of fire-affected rock (Figure 7.38). Three artifacts were found beneath the top layer of stone, but the feature generally appeared to be a single horizontal layer of artifacts. This feature measured 0.90 m by 0.80 m and was approximately 0.25 m deep. There was no pit outline apparent during excavation, since the feature fill was a dark orangish brown silty sand similar to that found in the surrounding site matrix. Small amounts of shell and faunal bone were noted in the feature fill. Pollen and flotation samples were collected from the feature, as were artifacts. This feature was interpreted as a thermal feature associated with processing or repairing activities.

Feature 23

Feature 23 was a sparse concentration of ground stone, fire-affected rock, and a manuport (Figure 7.39). This feature measured 0.30 m by 0.16 m, was approximately 0.10 m deep, and consisted of a single course of artifacts. There were sparse amounts of faunal bone and shell in the surrounding site matrix. There was neither a pit outline nor any other way to distinguish the feature from the surrounding orangish brown, silty sand except for the artifacts themselves. Pollen and flotation samples were collected. The majority of the stones in this feature were fire affected, leading to the interpretation that this feature was a thermal feature associated with processing activities.

Feature 33

Feature 33 consisted of a sparse concentration of ground stone, fire-affected rock, and a manuport (Figure 7.40). This feature measured 1.00 m by 0.60 m, was approximately 0.11 m deep, and consisted of a single course of artifacts. There was neither a pit outline nor any other way to distinguish the feature from the surrounding dark brown silty sand except for the location of the artifacts themselves. There were small amounts of shell and faunal bone in the surrounding site matrix. Pollen and flotation samples were collected. The majority of the artifacts, including some of the ground stone, were fire affected, leading to the interpretation that this was a thermal feature associated with processing activities.

Feature 36

Feature 36 consisted of a concentration of ground stone, flaked stone, manuports, and fire-affected rock (Figure 7.41). This feature measured 0.70 m by 0.60 m, was approximately 0.10 m deep, and consisted of a single course of stone. There were sparse amounts of faunal bone and shell in the site matrix. There was no pit outline, and the feature fill was the same dark brown, silty sand as the surrounding site matrix. Pollen and flotation samples were collected for processing. The majority of the stones in the feature were fire affected, indicating that this was a thermal feature associated with processing activities.

Feature 45

Feature 45 consisted of a cluster of small concentrations of shell and several small pieces of debitage (Figure 7.42). This feature was identified at the bottom of the A horizon and appears to have been dug into the B horizon. This feature measured approximately 1.00 m long, 1.60 m wide, and was approximately 0.12 m deep at its deepest spot. Although this feature was amorphous in general appearance, the excavator noted a saucer-shaped pit outline that was marked by shell deposits. The surrounding B horizon was a brown silty sand. Pollen and flotation samples were collected. This feature was interpreted as a shell dump.

Feature 49

Feature 49 consisted of a dense cluster of shell, with one small locus of charcoal staining (Figure 7.43). This feature was found at the A/B horizon transition and appeared to have been dug into the B horizon. Feature 49 measured approximately 0.80 m long, 0.40 m wide, and approximately 0.15 m deep at its deepest. The feature's soil was a medium brown silty sand, but the feature was dug in an amorphous shape into the surrounding light-brown to tan colored surrounding matrix. The excavators did not note any discernable shape to the pit in which the shell was placed. Rodent disturbance was present within the feature. Pollen and flotation samples were collected. This feature was interpreted as a shell dump.

Feature 50

Feature 50 consisted of a small, but concentrated, scatter of shell that was mixed in with small amounts of faunal bone (Figure 7.44). The primary concentration of shell was found in the center of the feature, with some smaller concentrations of shell found in the outlying portions of the feature. This feature, found at the A/B horizon transition, measured approximately 0.60 m long, 0.80 m wide, and approximately 0.15 m deep. Soil within the feature was a lightly compacted, medium-brown, silty sand, which was surrounded by a lighter-colored brown, silty sand. Pollen and flotation samples were collected. This feature was interpreted as a shell dump.

Feature 55

Feature 55 consisted of an oval-shaped, shallow pit containing a small, sparse concentration of shell and a shaped stone (Figure 7.45). This feature, found at the A/B horizon transition, measured approximately 1.5 m long, 1.2 m wide, and approximately 0.10 m deep. The feature's soil was a mixture of dark brown, silty sand and surrounding lighter-colored brown silty sand. This mixture of soil may suggest that there was rodent activity which disturbed part of the feature. Whereas no formal pit was identified by the excavator, this feature was dug into the upper portion of the B-horizon from the upper A-horizon. Flotation and pollen samples were collected. This feature was interpreted as a shell dump.

Feature 60

Feature 60 consisted of an amorphous-shaped pit containing a moderate density of shell and a scatter of flaked stone artifacts (Figure 7.46). This feature, found at the A/B horizon transition, measured approximately 1.70 m long, 1.15 m wide, and approximately 0.08 m deep. The soil within the feature was a brown, silty sand, similar in appearance and texture to the midden soil, whereas the feature itself was dug into the surrounding B horizon, a lighter-colored silty sand. Excavators noted rodent disturbance to the feature. Pollen and flotation samples were collected. This feature was interpreted as a shell dump.

Feature 76

Feature 76 consisted of a dense concentration of flaked stone, ground stone, manuports, fire-affected rock, shell, and animal bone (Figure 7.47). Some of these artifacts exhibited asphaltum. This feature measured about 1.0 m long, 0.90 m wide, and approximately 0.15 m thick. Various fragments of both burnt and unburnt bone were present in the feature matrix, as were small fragments of charcoal. There was no obvious burning of the soil directly within the feature, although there were some clusters of oxidized soil noted in the matrix surrounding the feature. There was a heavy amount of rodent disturbance noted within the feature. The presence of fire-affected rock, artifacts exhibiting asphaltum, and oxidized soil led to the interpretation that the feature was a thermal feature associated with processing activities, possibly related to working with asphaltum.

LAN-206A

In total, three analyzed features are described in this section (Figure 7.48 and Table 7.3).

Feature 105

Feature 105 consisted of a concentration of flaked stone, ground stone, and fire-affected rock (Figure 7.49). This feature measured 0.75 by 0.75 m, was approximately 0.13 m deep, and consisted of a single layer of artifacts. Neither shell nor faunal bone was observed during the excavation of the feature. There was neither a pit outline nor any other indication of a difference in soil color or texture between the feature fill and the surrounding matrix. Pollen and flotation samples were collected. The high concentration of fire-affected rock in this feature in a tight concentration suggests that this was a thermal feature associated with processing activities.

Feature 106

Feature 106 consisted of a concentration of flaked stone, ground stone, fire-affected rock, and a manuport (Figure 7.50). This feature was smaller than Feature 105 and measured 0.55 by 0.50 m and was approximately 0.10 m deep. This feature consisted of a single layer of stone. The majority of the stones in this feature were fire affected. There was neither a pit outline nor any difference in the color or texture of soil between the feature fill and the surrounding matrix. Pollen and flotation samples were collected. No faunal bone, shell, or charcoal was observed in the feature during excavation. This feature was interpreted as a thermal feature associated with processing activities.

Feature 107

Feature 107 was a large concentration of flaked stone, ground stone, manuports, tarring pebbles, and fire-affected rock (Figure 7.51). This feature was the largest analyzed feature at site LAN-206A, measuring 1.00 by 0.90 m and approximately 0.15 m thick. Unlike the other analyzed features at this site, Feature 107 had very sparse amounts of shell and charcoal in the feature fill. Like many other features, there was neither a discernable pit outline nor any characteristics in the feature fill which would have distinguished it from the surrounding matrix. Pollen and flotation samples were collected for analysis. This feature was interpreted as a thermal feature associated with processing activities, possibly related to working with asphaltum.

Discussion

Overall, there was a fair amount of diversity in the feature types described above. Although a number of the features at all three sites were generally thermal features associated with processing activities (such as cooking, processing vegetal material, heating material, and the like), there were other more-specific activities identified, such as caching behavior, ritual activity, and likely using asphaltum for waterproofing or repairing items. It is interesting to note that many of these activities, including processing activities and using asphaltum, were identified at all three sites.

One of the most unusual types of features identified were those related to ritual activity. This activity was only found within the central portion of LAN-63. Generally, there were two particular types of artifact classes associated with ritual activity: steatite objects, including debris, and abalone shell. In the cases of Features 11 and 587, there were large numbers of purposefully broken steatite objects, broken ground stone, and other objects, some of which appeared to have been only slightly used and covered with ochre. In the case of Feature 587, there were scattered, cremated human remains throughout the feature fill. Whereas these types of features are generally rare across Southern California, there are archaeological examples that are similar. Cairns of purposefully broken milling stones, for example, have been documented at the Little Sycamore site (VEN-1) (Wallace 1954), the Stone Bowl site at Big Tujunga Wash (Walker 1952), and the Walker Cairn Site in Chatsworth (LAN-21) (Walker 1952; see also Tartaglia 1980), and most recently, at Hellman Ranch in Seal Beach (Andy York, personal communication 2005). In all of these examples, large amounts of intentionally broken ground stone were placed in a central location, or cairn. In some cases, such as those of the Walker Cairn site and Hellman Ranch, cremated human remains were found within the deposit.

One possible explanation for this type of behavior, as has been alluded to in several chapters in this report, is that this type of activity is a prehistoric ritual similar to the ethnographically documented Mourning Ceremony of various southern Californian Native American groups, including the Gabrielino, Luiseño, Serrano, and Cahuilla. In these ceremonies, which varied from group to group, those who had passed in the previous year were mourned and commemorated. As part of the ceremony, particular items of the recently dead were purposefully broken and at times burned. In some cases, the event was held in a ceremonial area, often built for the ceremony and then burned afterwards. Many personal belongings, as well as other offerings, such as representations of the dead, were disposed of during the ceremony in a circular pit and burned (see Kroeber 1925:626 for discussion). Among the Cahuilla, during the mourning ceremony, practiced annually or biannually, all the possessions of the person who had passed were destroyed or burned (Strong 1929:15). The belongings were not destroyed in all cases, however. In the case of the Serrano, for example, many of the possessions of the departed were dispersed among other community members (Benedict 1924:378).

Activities at LAN-63 appeared to be formalized. Ritual behavior, especially in light of the previous work of Van Horn (see Chapter 3), was focused in the central portion of the site to the west of the shell midden. Indications of caching behaviors were also found in the core area of the site. Some of the largest thermal features associated with processing activities, such as cooking, are found on the margins of the site, especially to the east, where the prevailing winds would have taken smoke away from the core area of the site. Trash disposal was generally centralized in the slough, which divided the eastern and western sections of LAN-63. A further discussion of these patterns is presented in subsequent chapters.

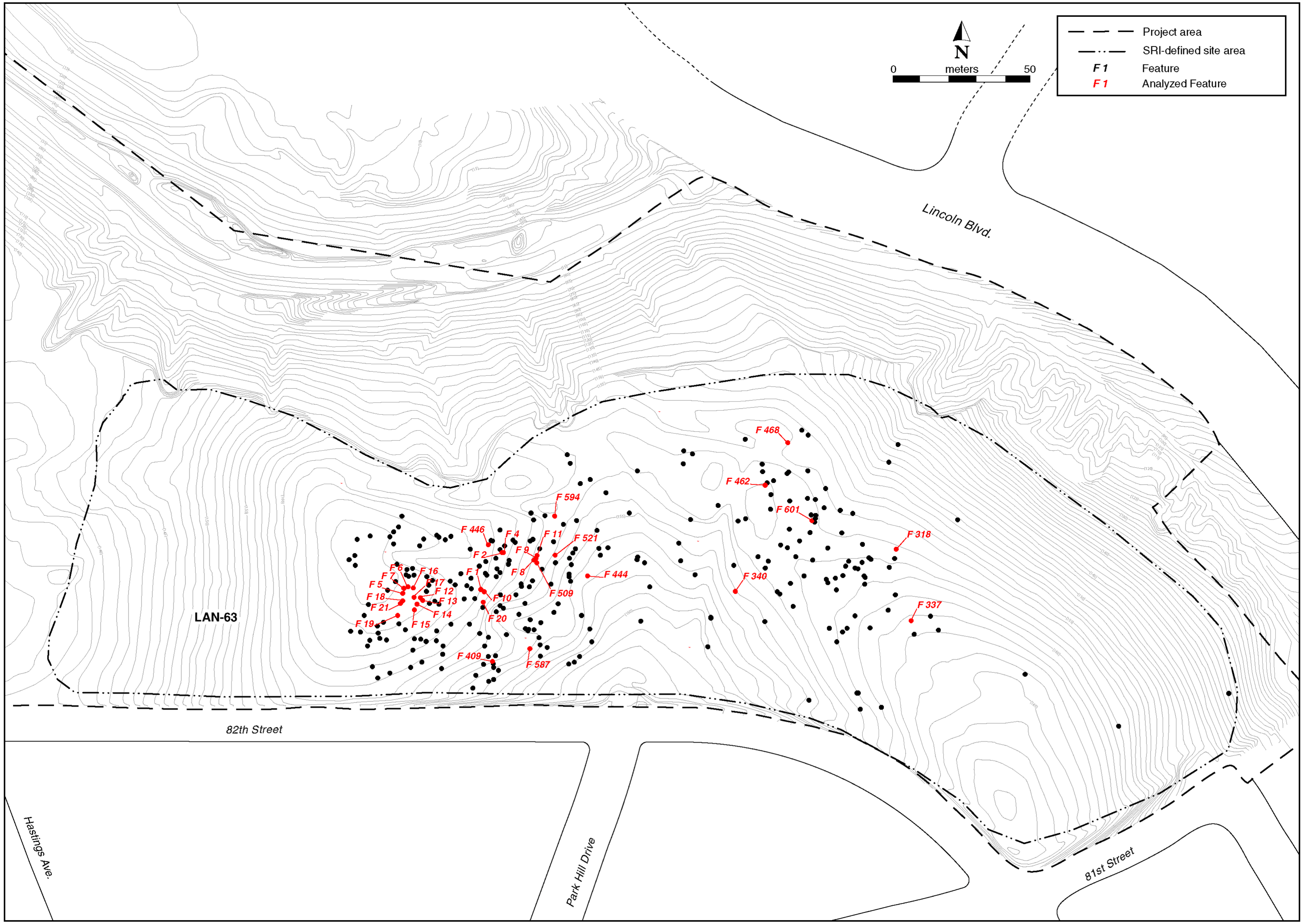


Figure 7.1. Location of analyzed features at LAN-63.

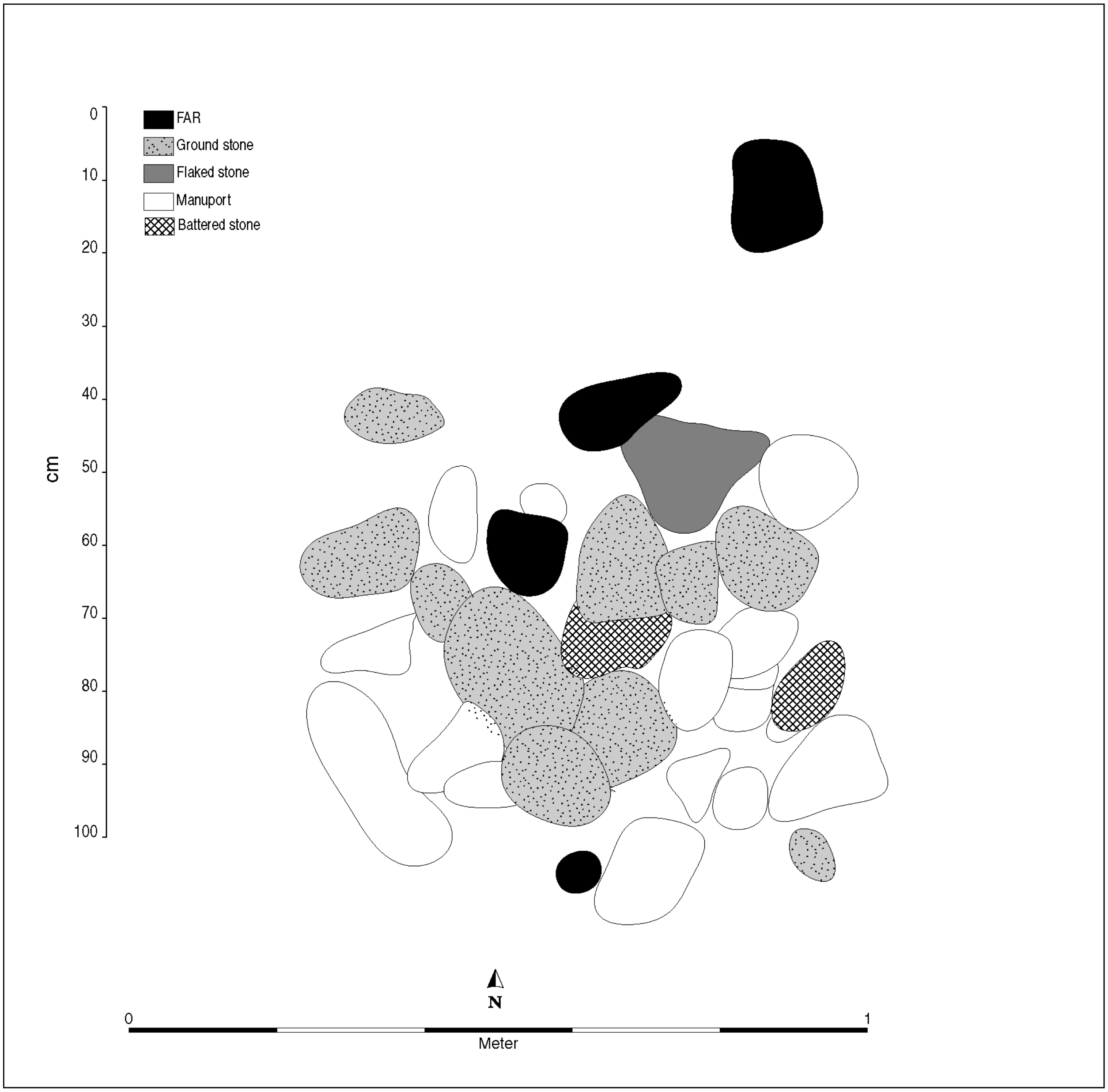


Figure 7.2. Plan map of Feature 1 at LAN-63.

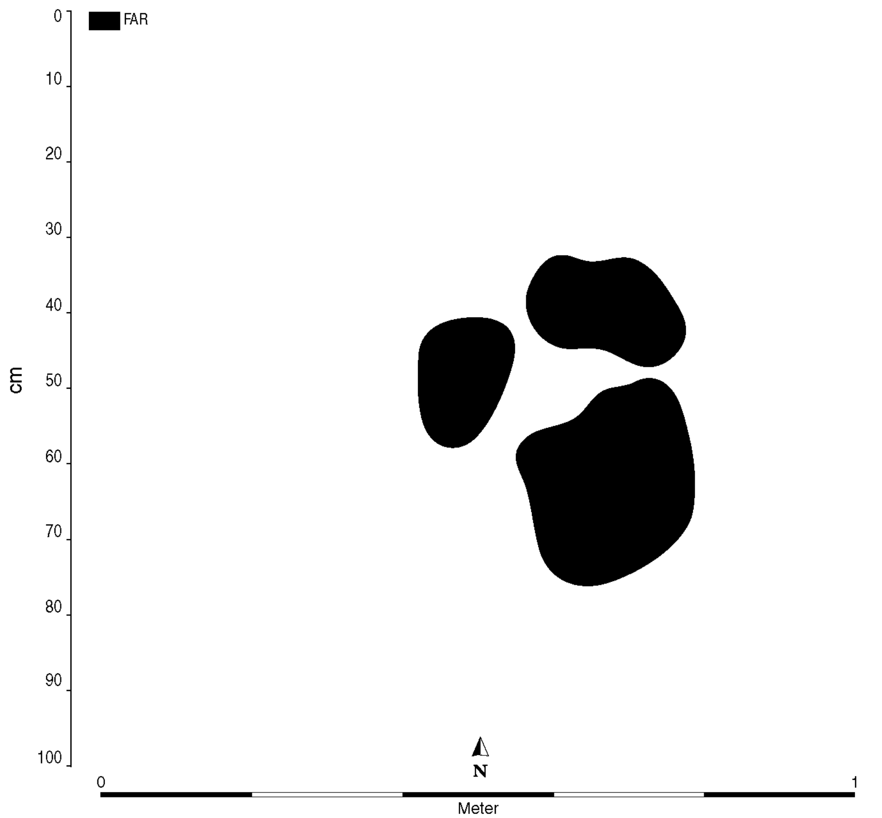


Figure 7.3. Plan map of Feature 2 at LAN-63.

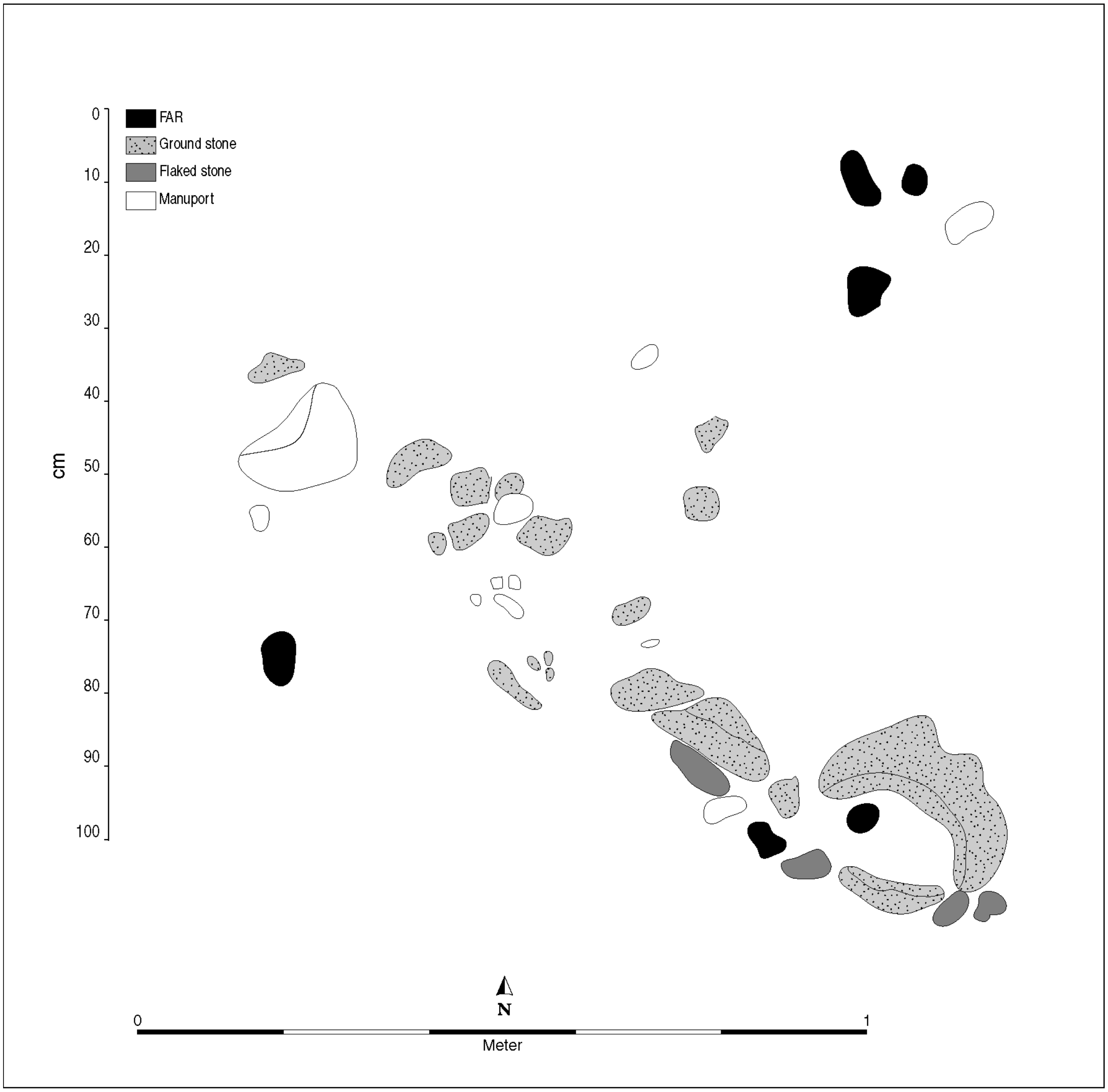


Figure 7.4. Plan map of Feature 4 at LAN-63.

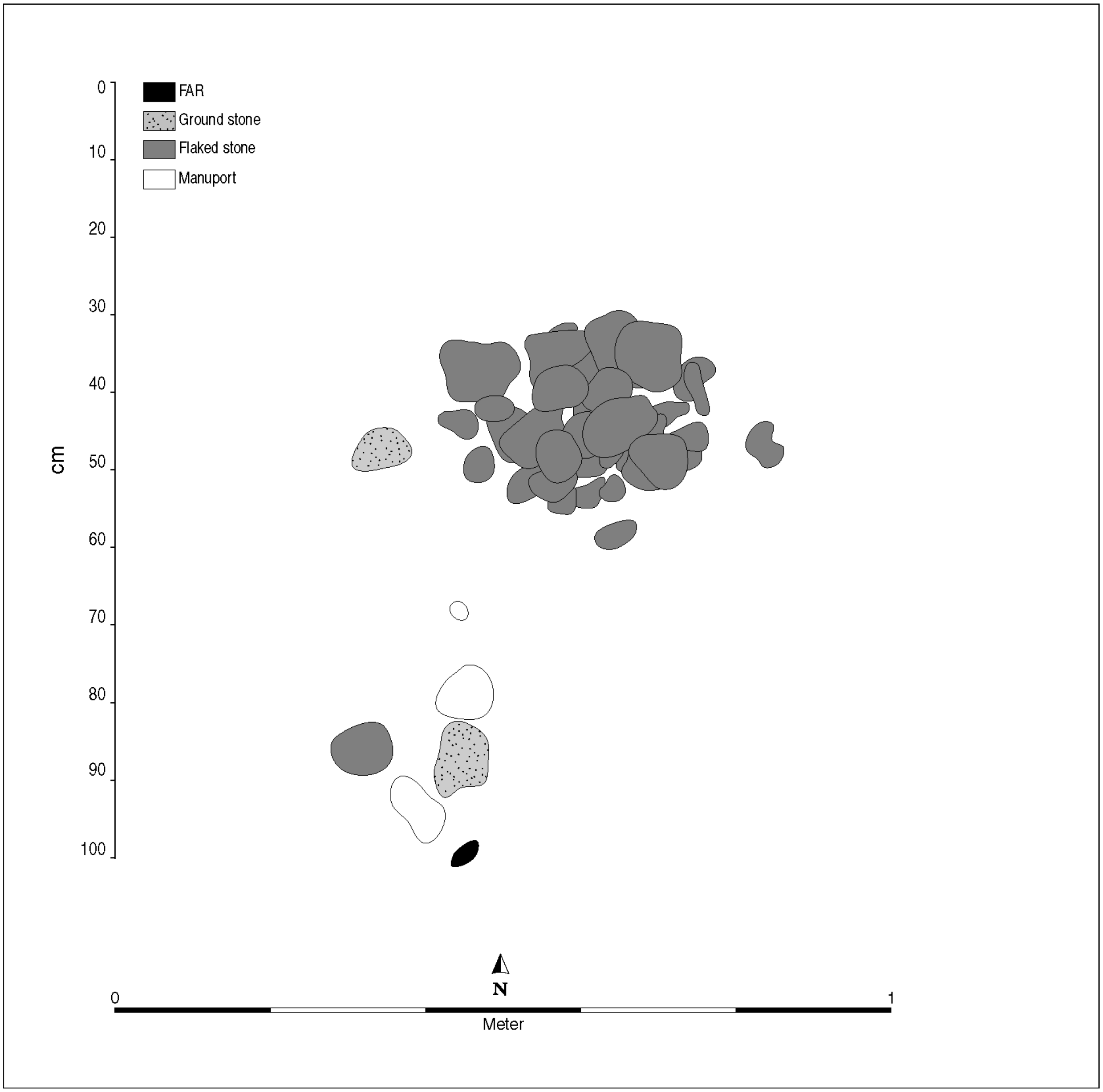


Figure 7.5. Plan map of Feature 5 at LAN-63.

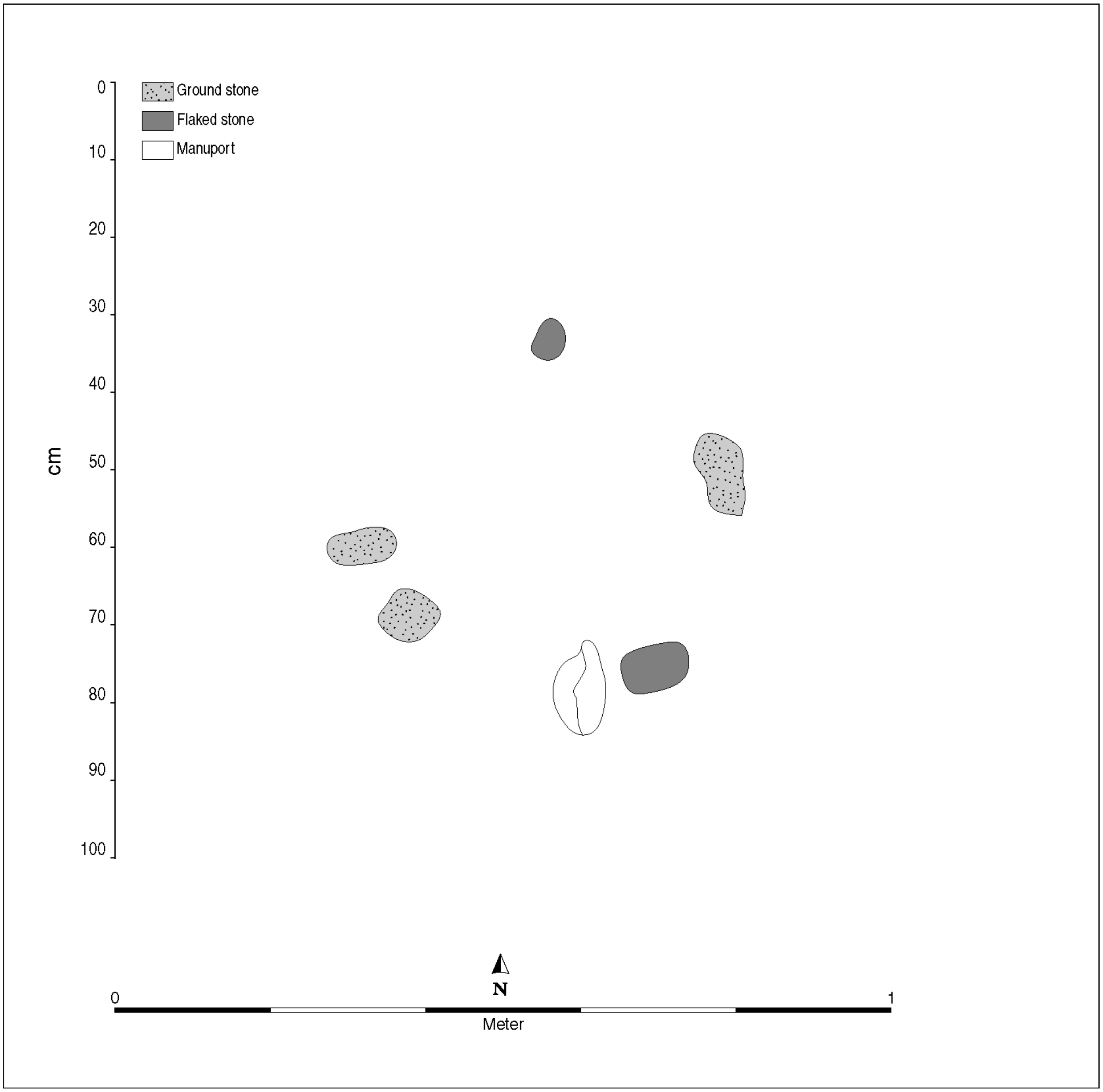


Figure 7.6. Plan map of Feature 6 at LAN-63.

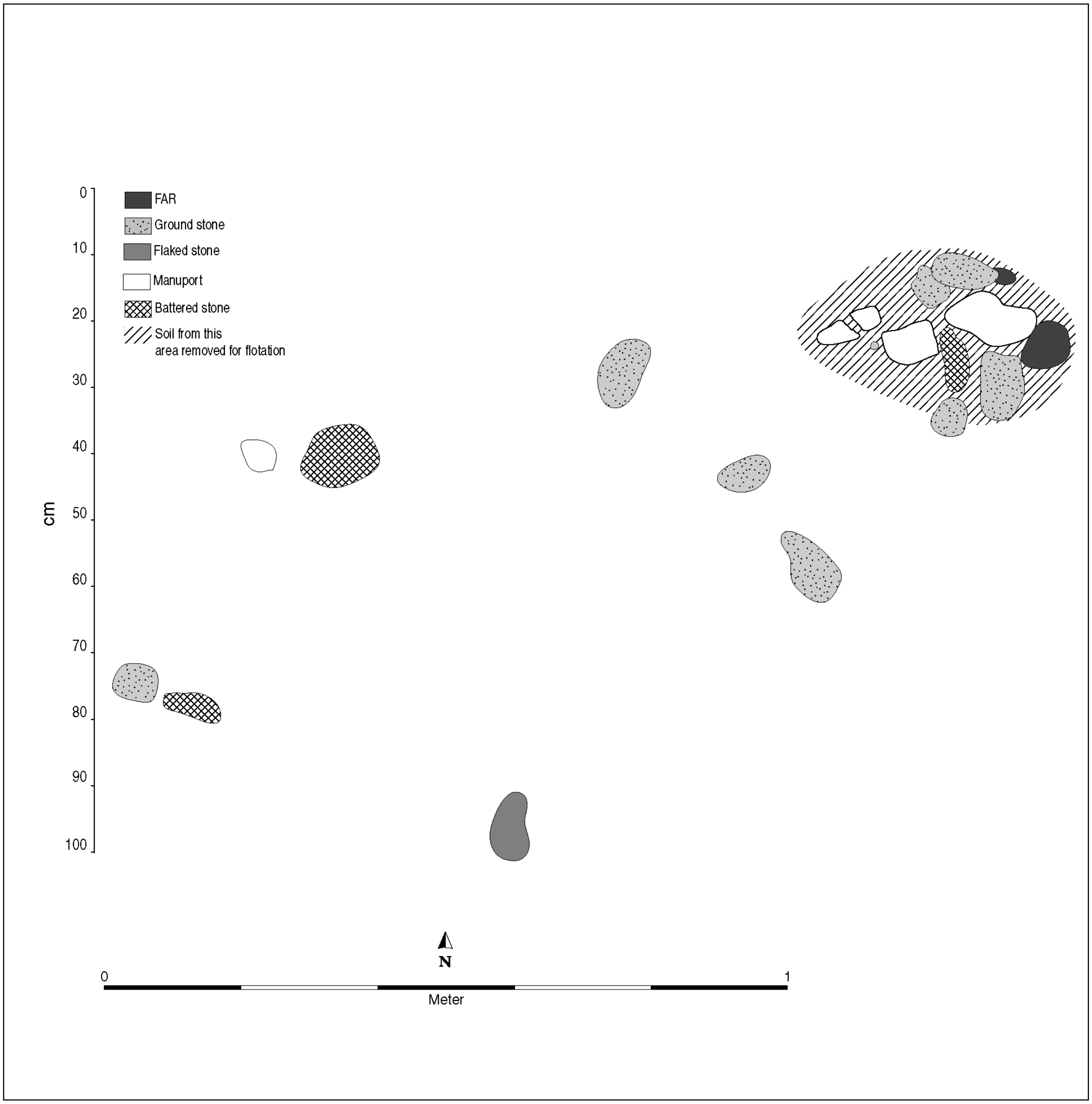


Figure 7.7. Plan map of Feature 7 at LAN-63.

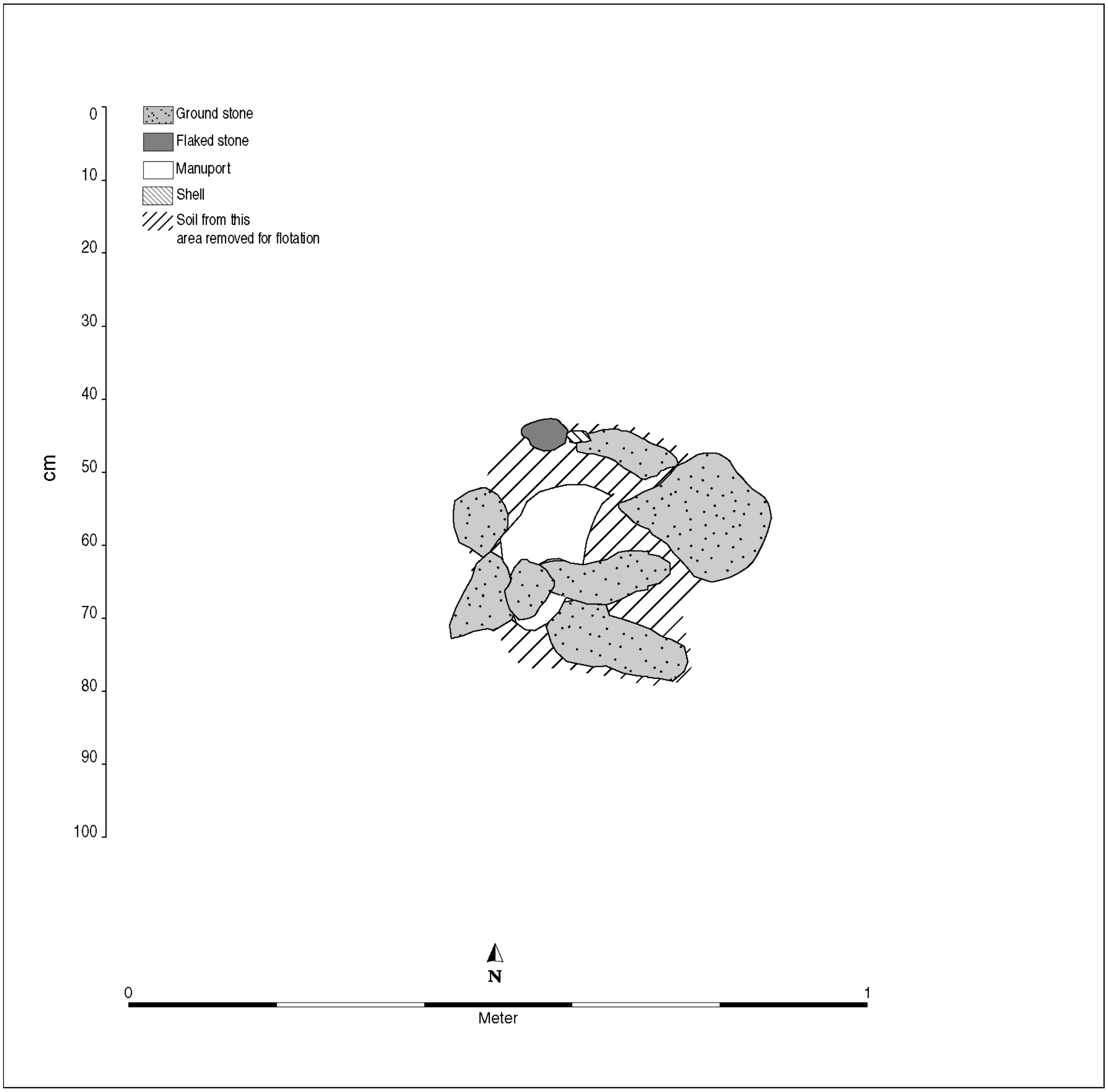


Figure 7.8. Plan map of Feature 8 at LAN-63.

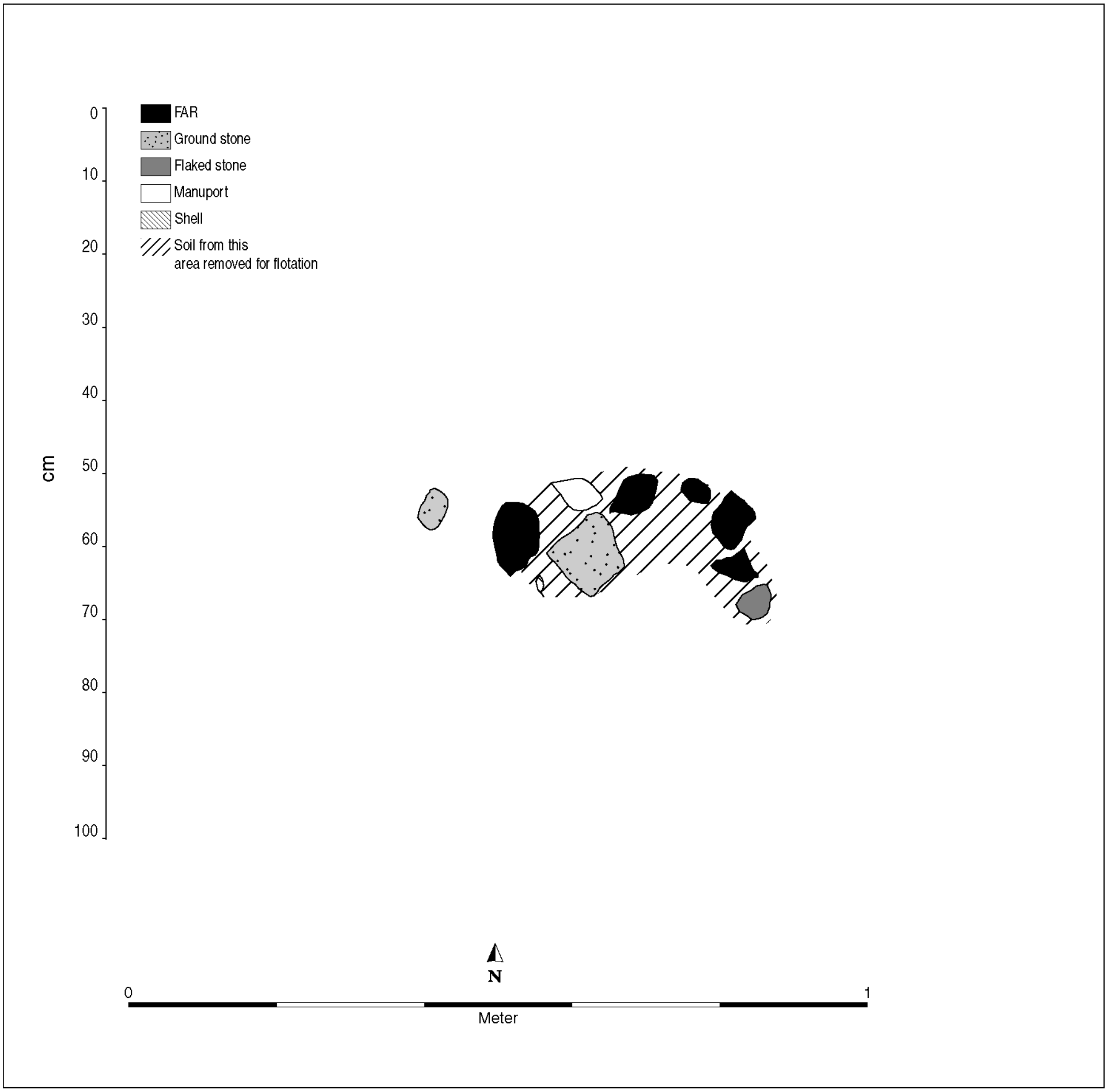


Figure 7.9. Plan map of Feature 9 at LAN-63.

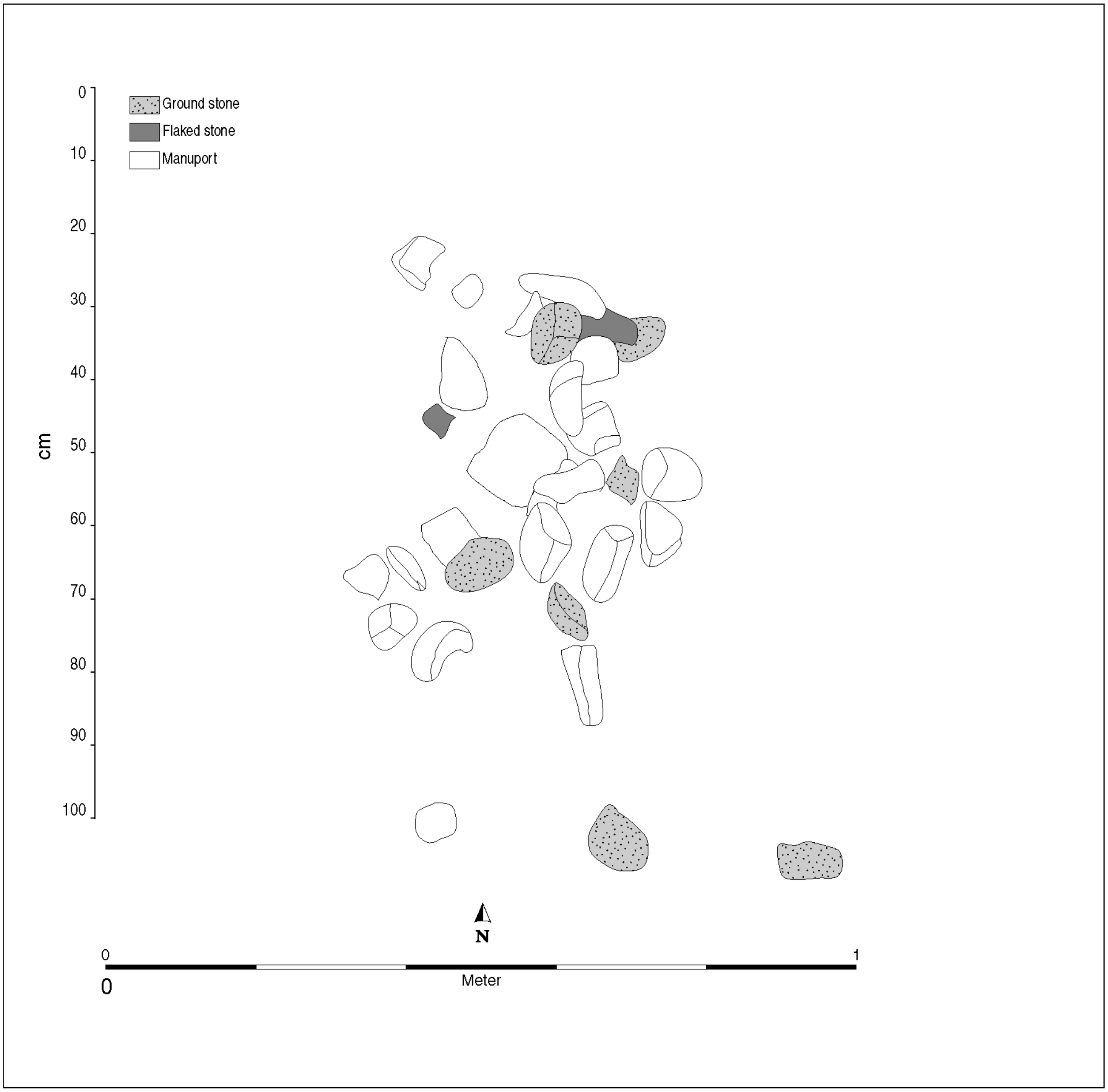


Figure 7.10. Plan map of Feature 10 at LAN-63.

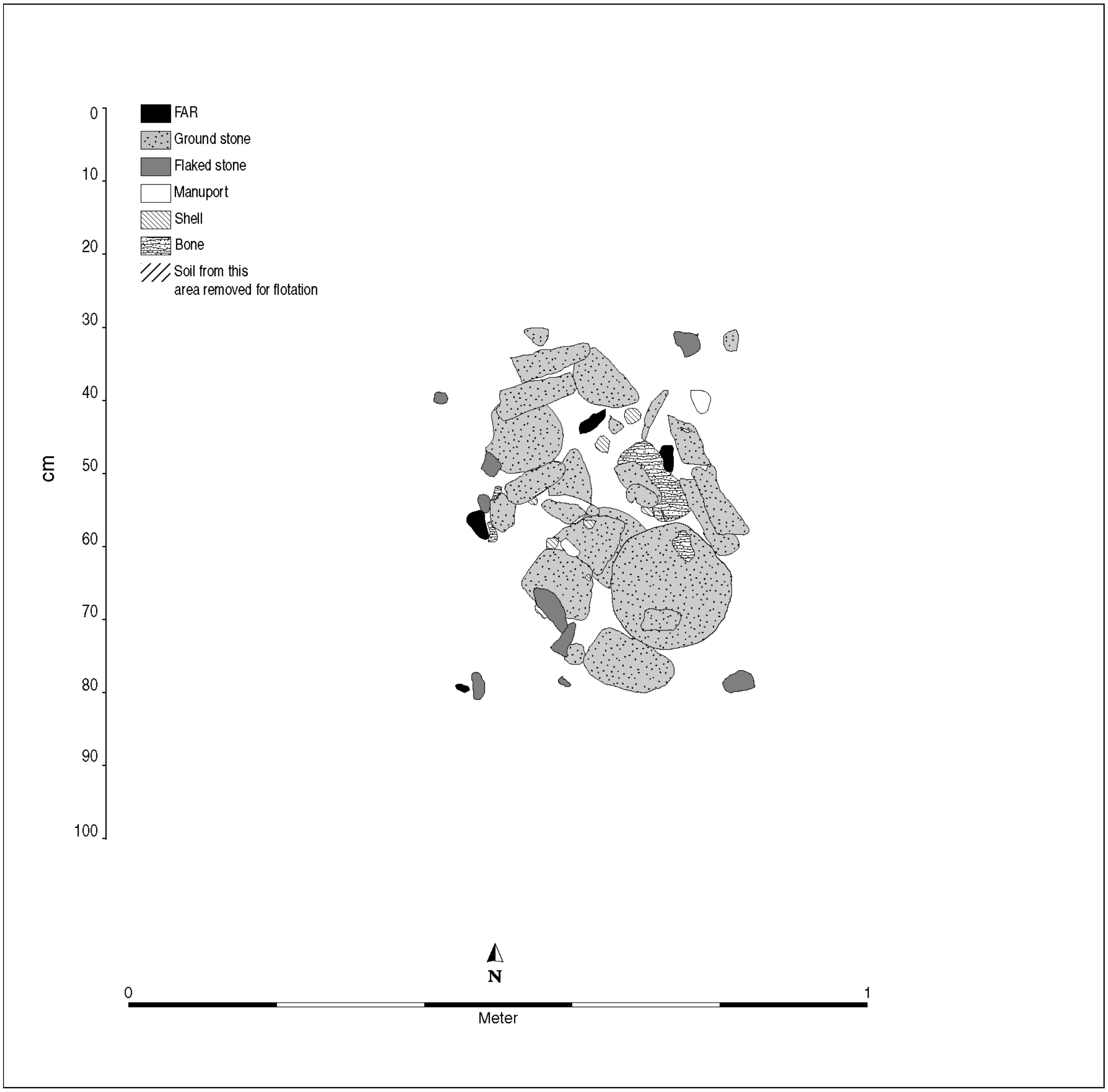


Figure 7.11. Plan map of Feature 11 at LAN-63.

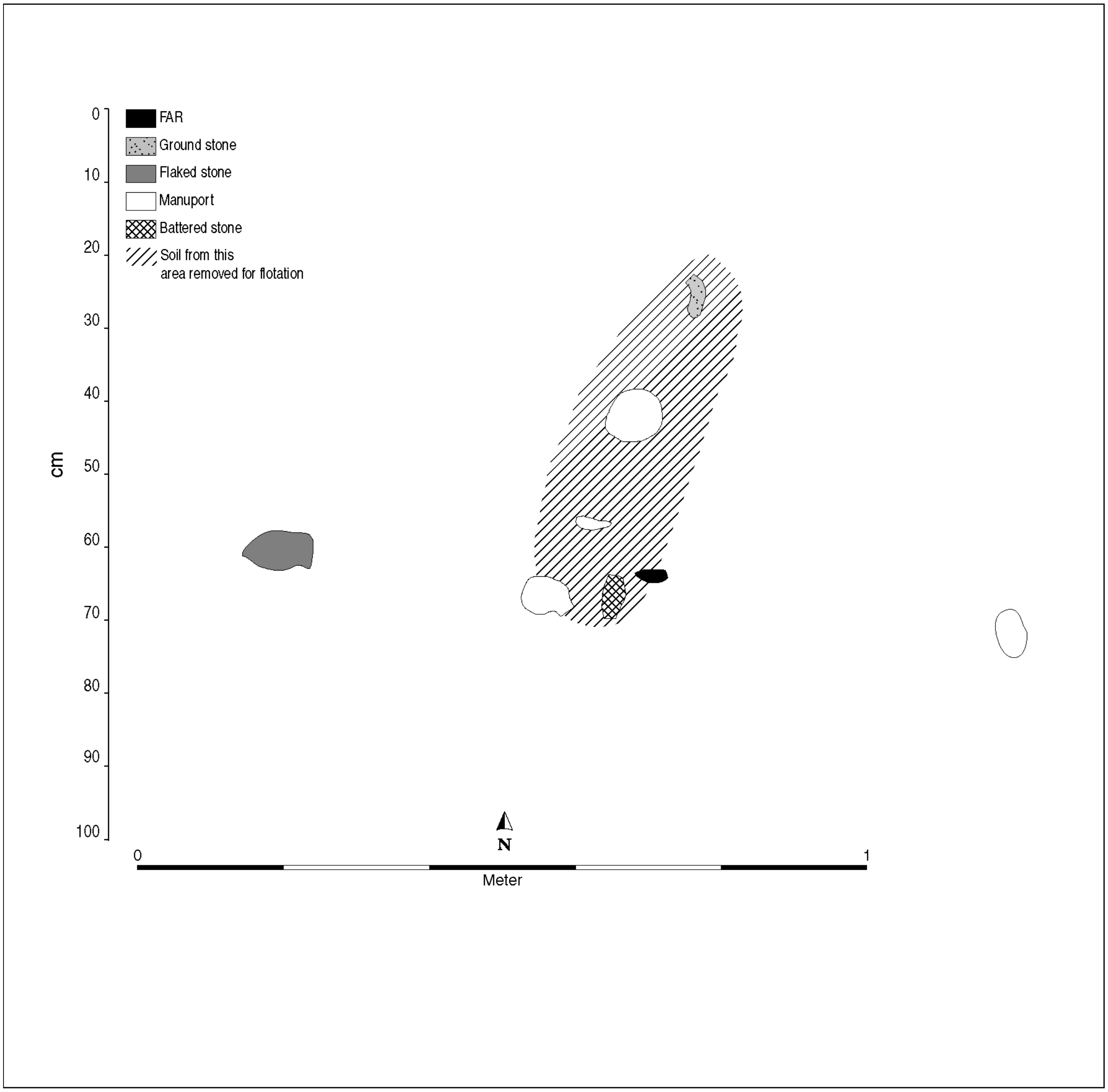


Figure 7.12. Plan map of Feature 12 at LAN-63.

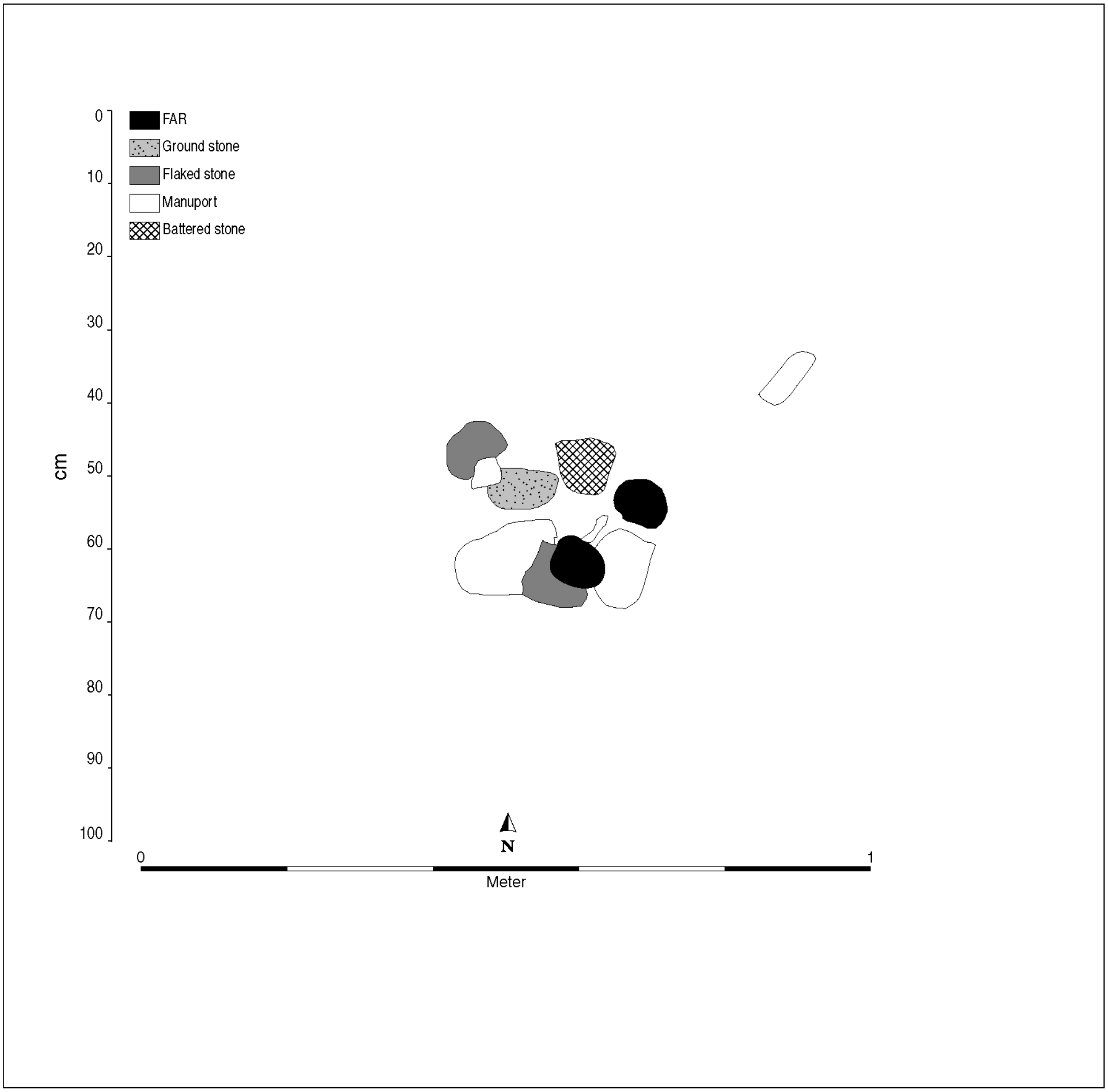


Figure 7.13. Plan map of Feature 13 at LAN-63.

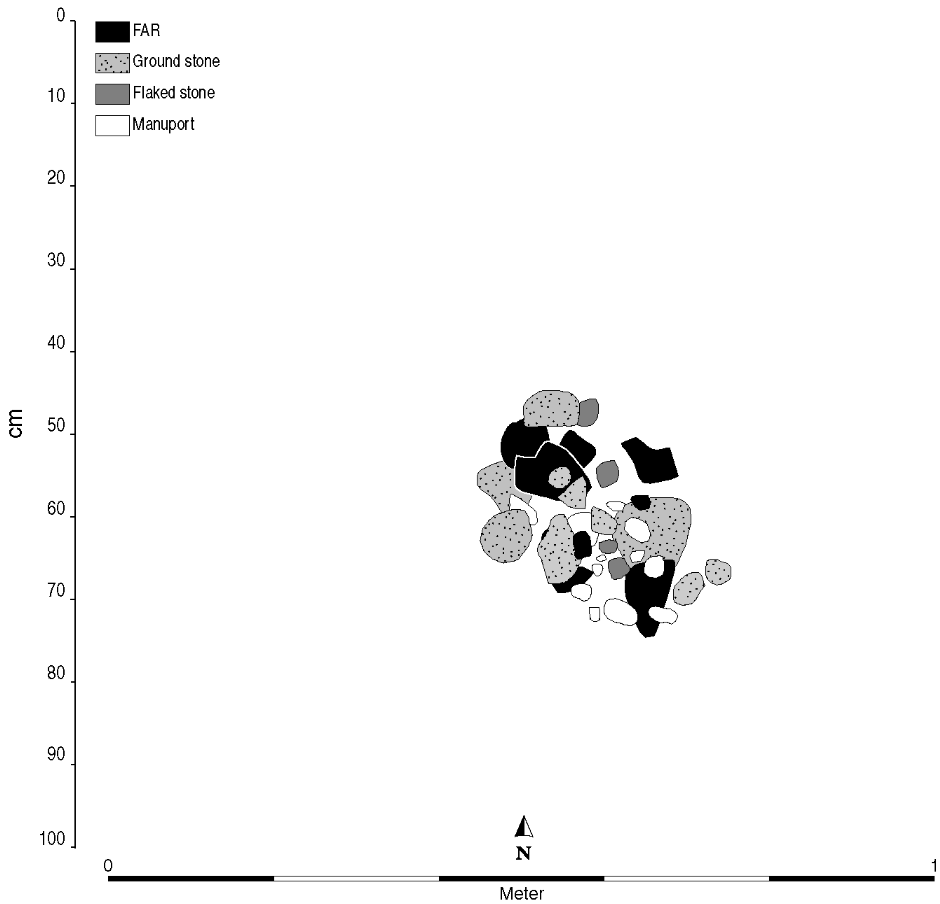


Figure 7.14. Plan map of Feature 14 at LAN-63.

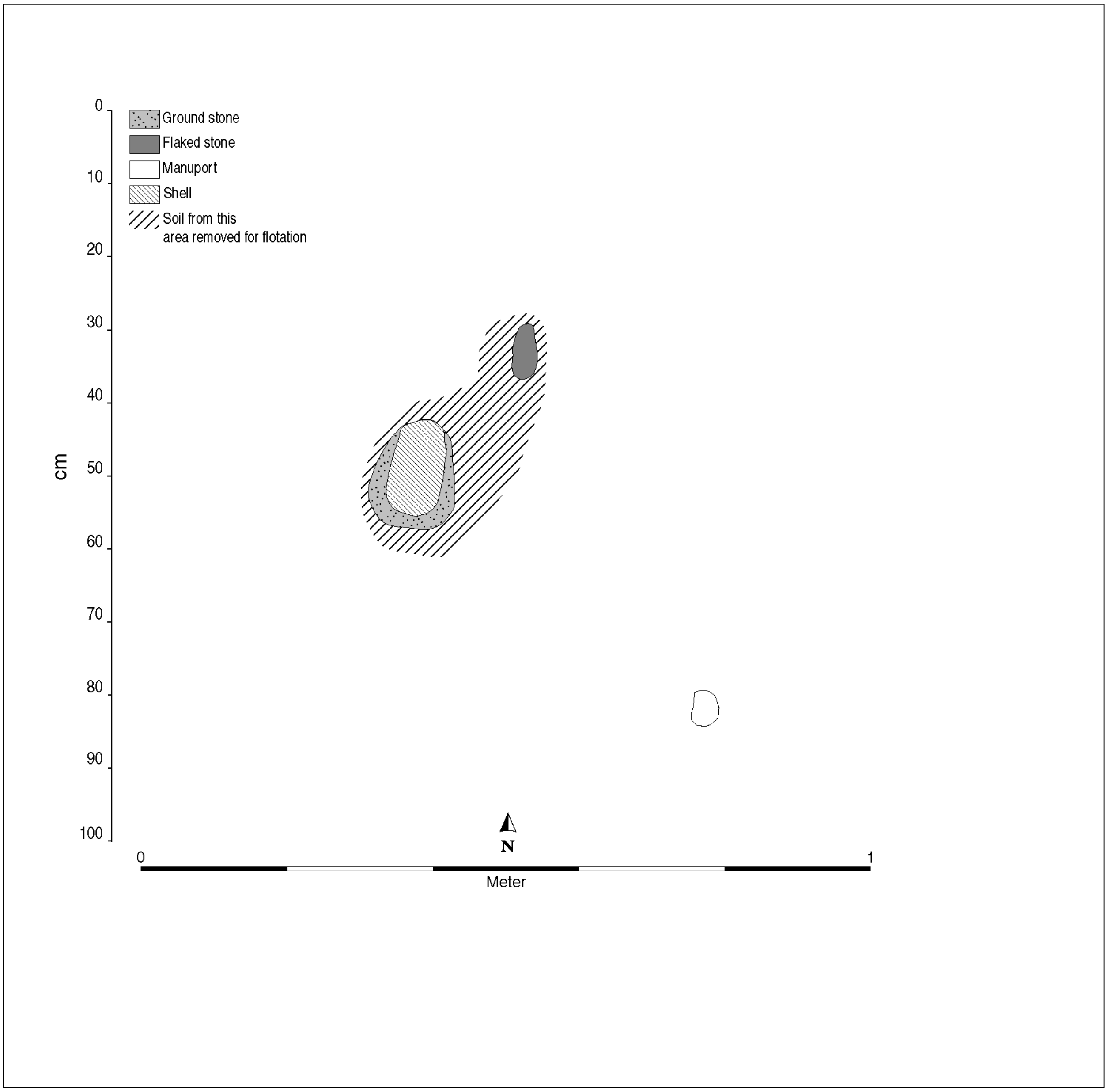


Figure 7.15. Plan map of Feature 15 at LAN-63.

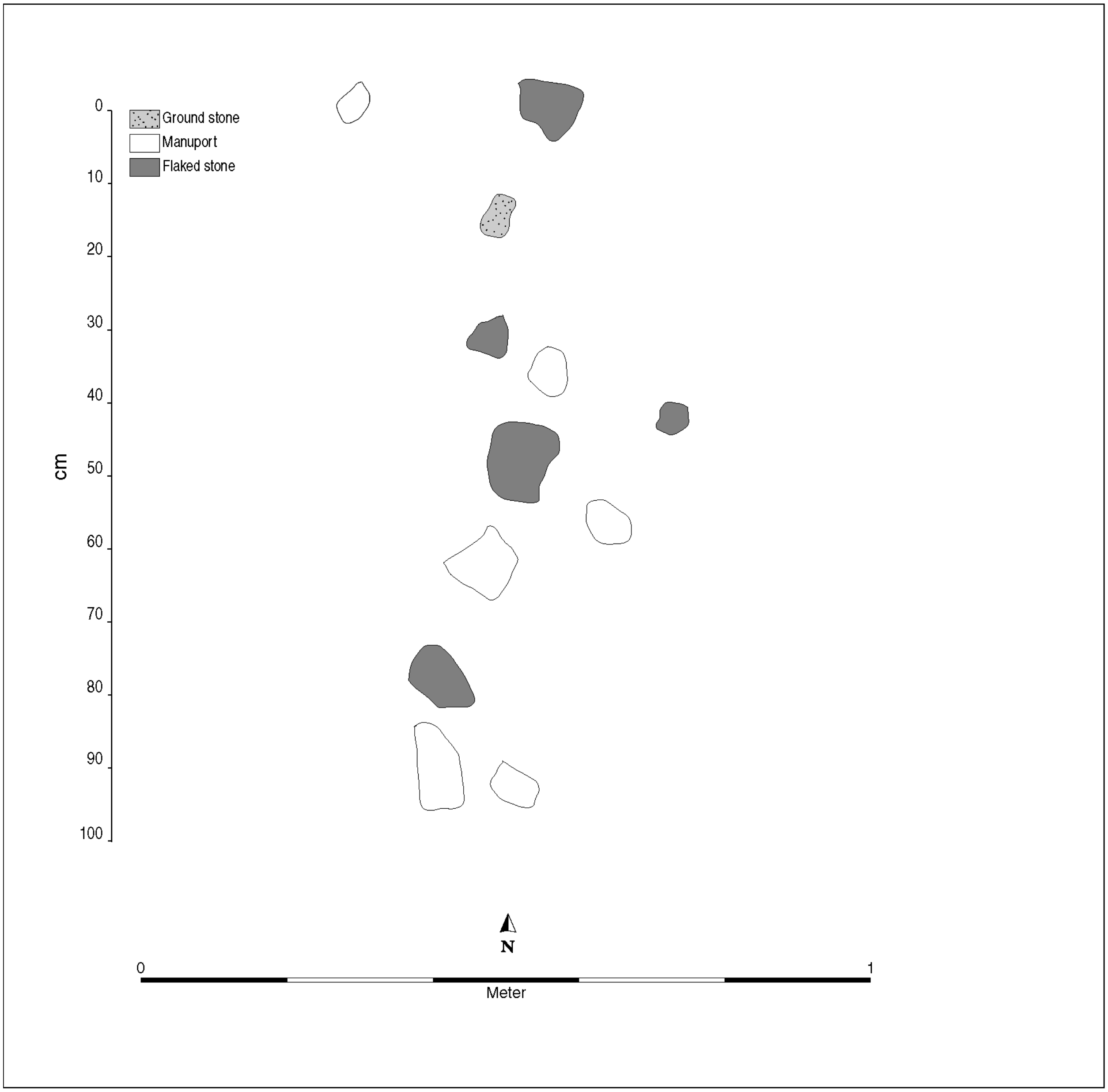


Figure 7.16. Plan map of Feature 16 at LAN-63.

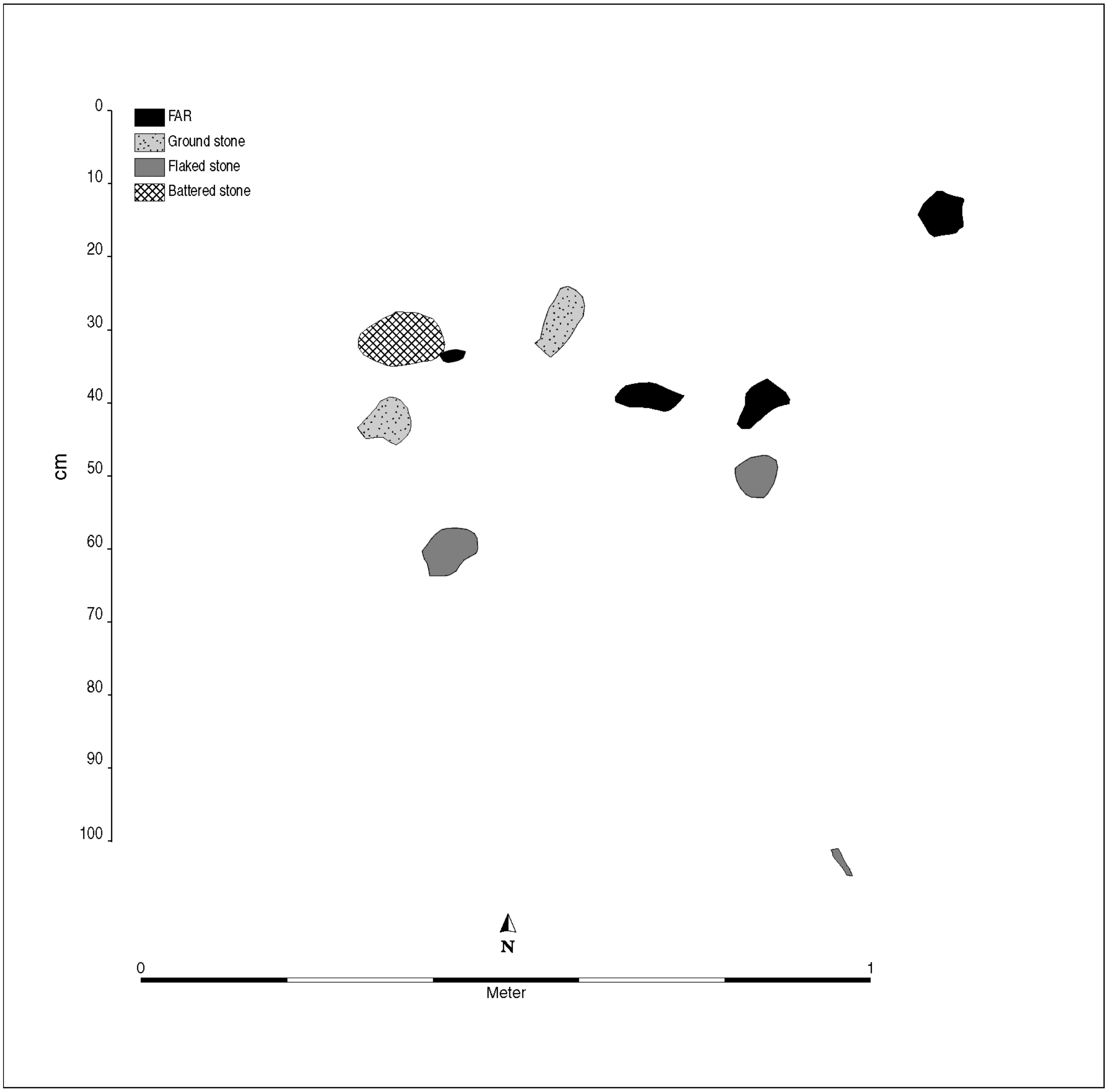


Figure 7.17. Plan map of Feature 17 at LAN-63.

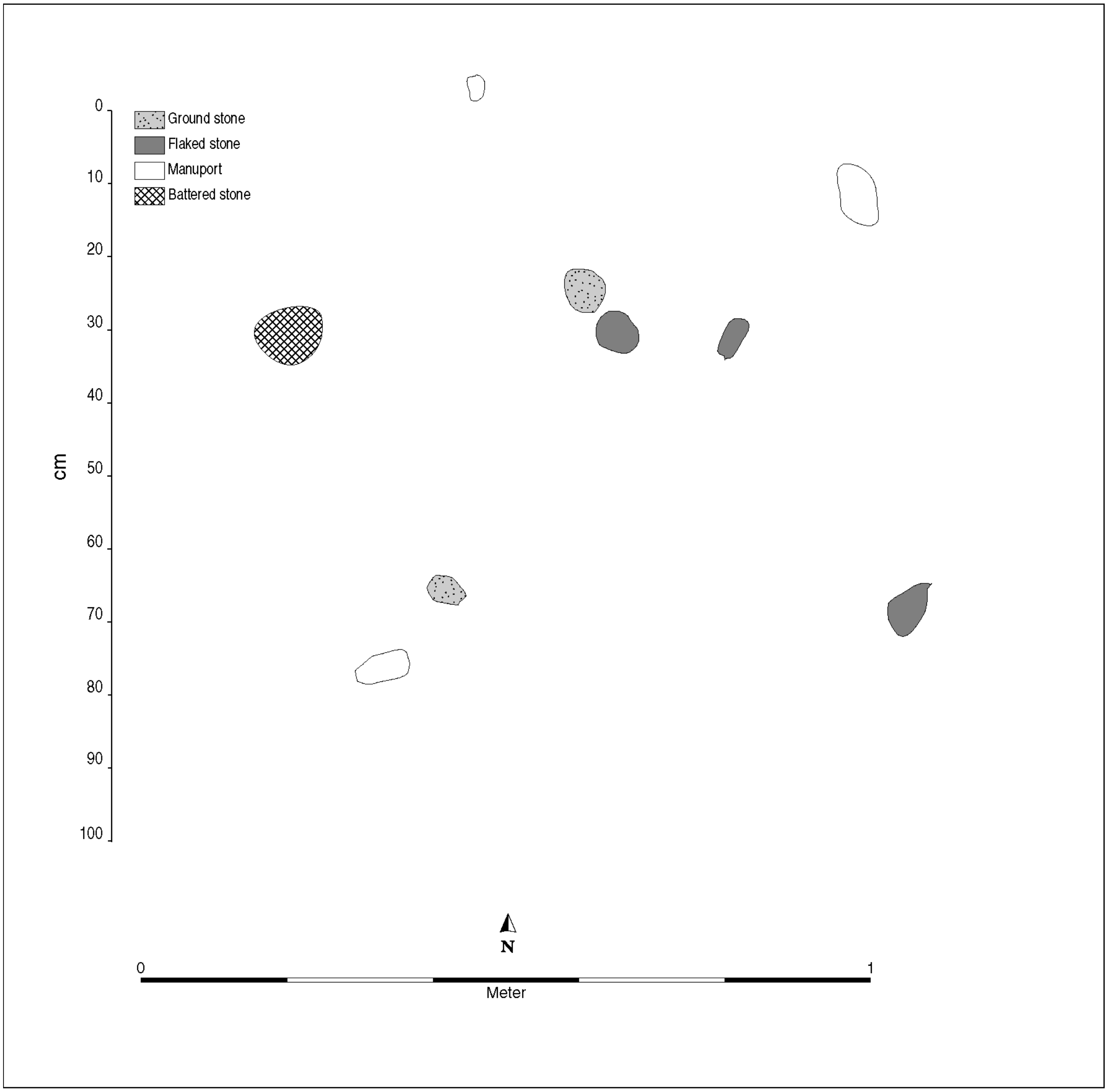


Figure 7.18. Plan map of Feature 18 at LAN-63.

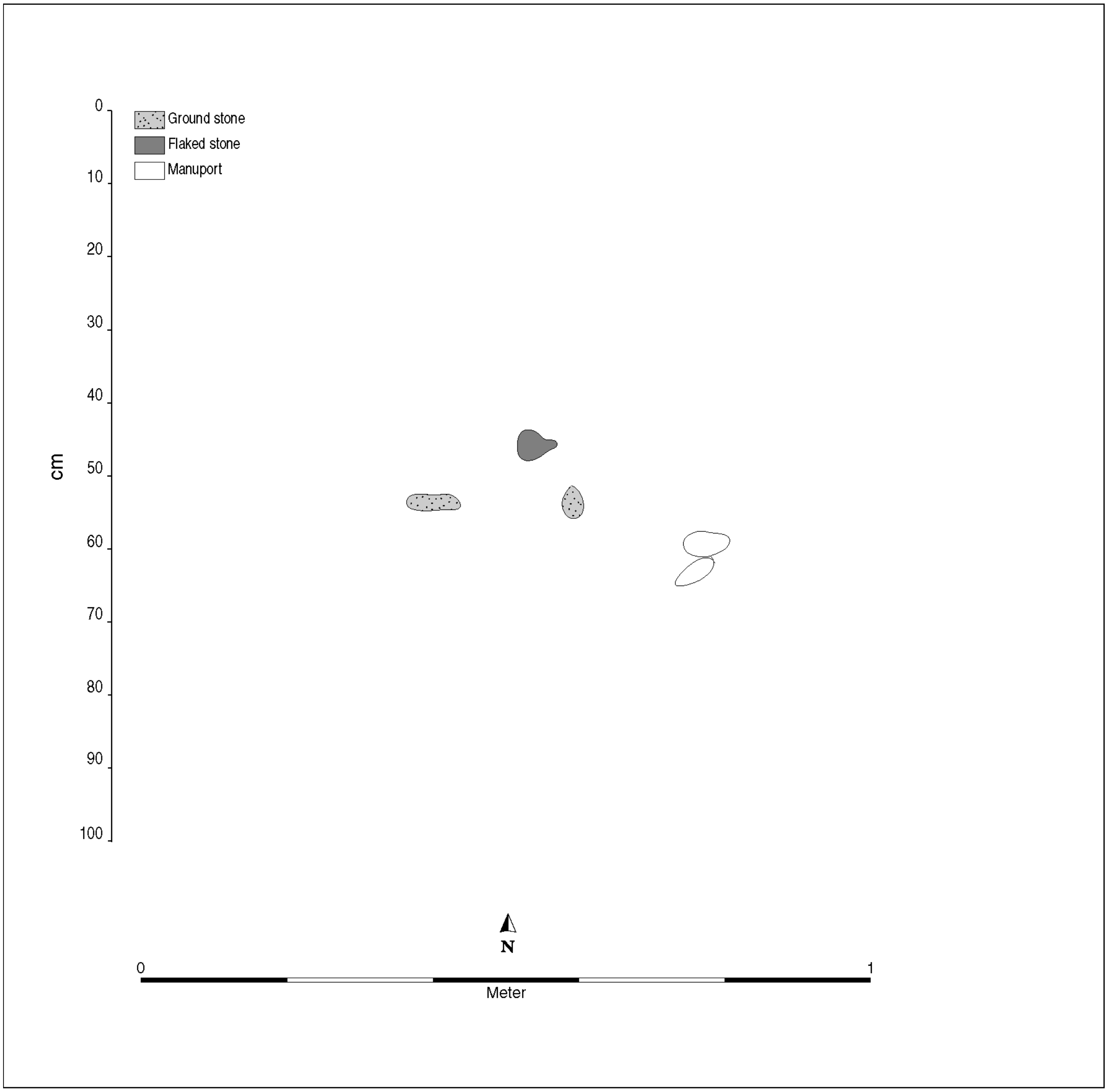


Figure 7.19. Plan map of Feature 19 at LAN-63.

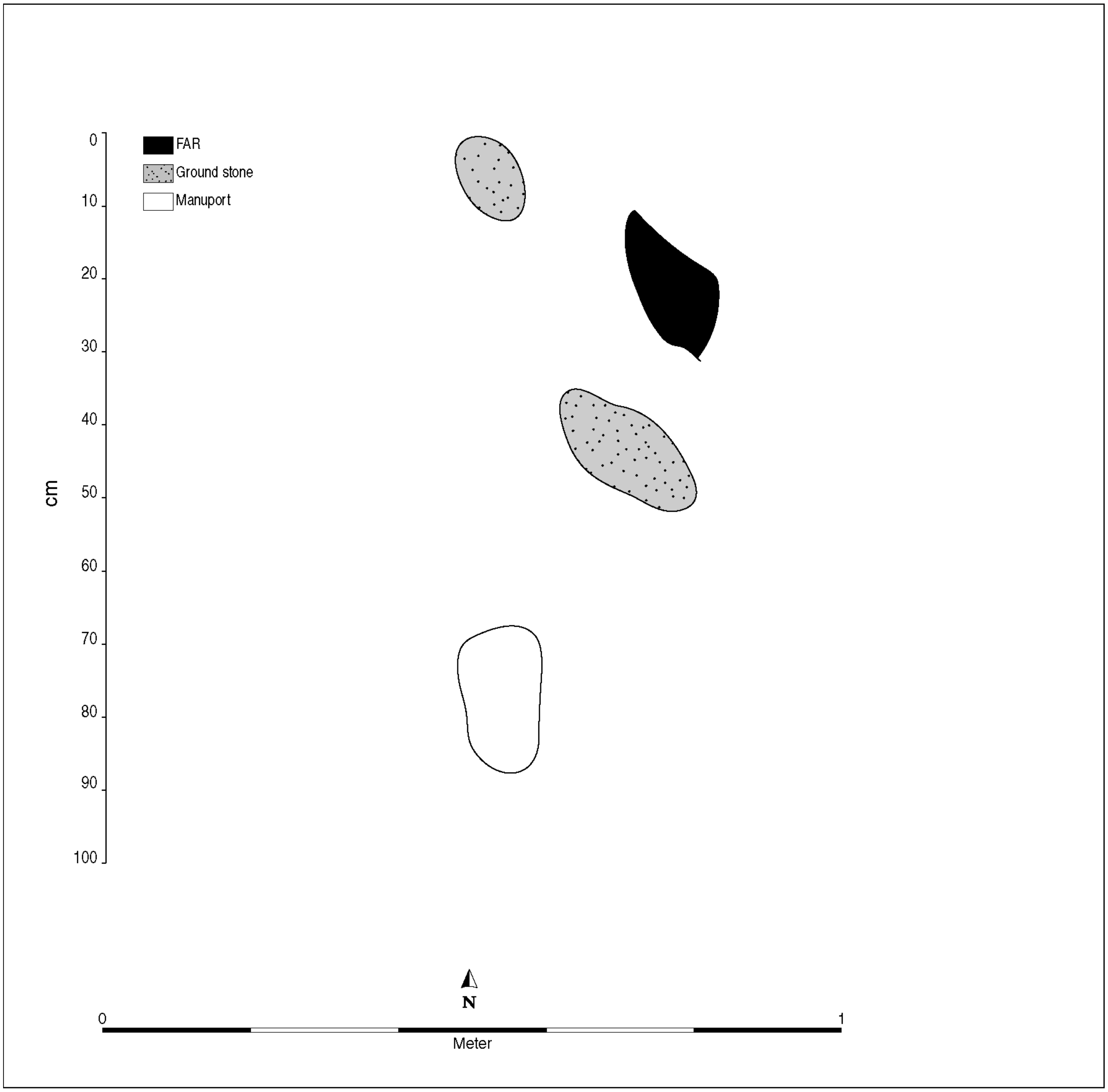


Figure 7.20. Plan map of Feature 20 at LAN-63.

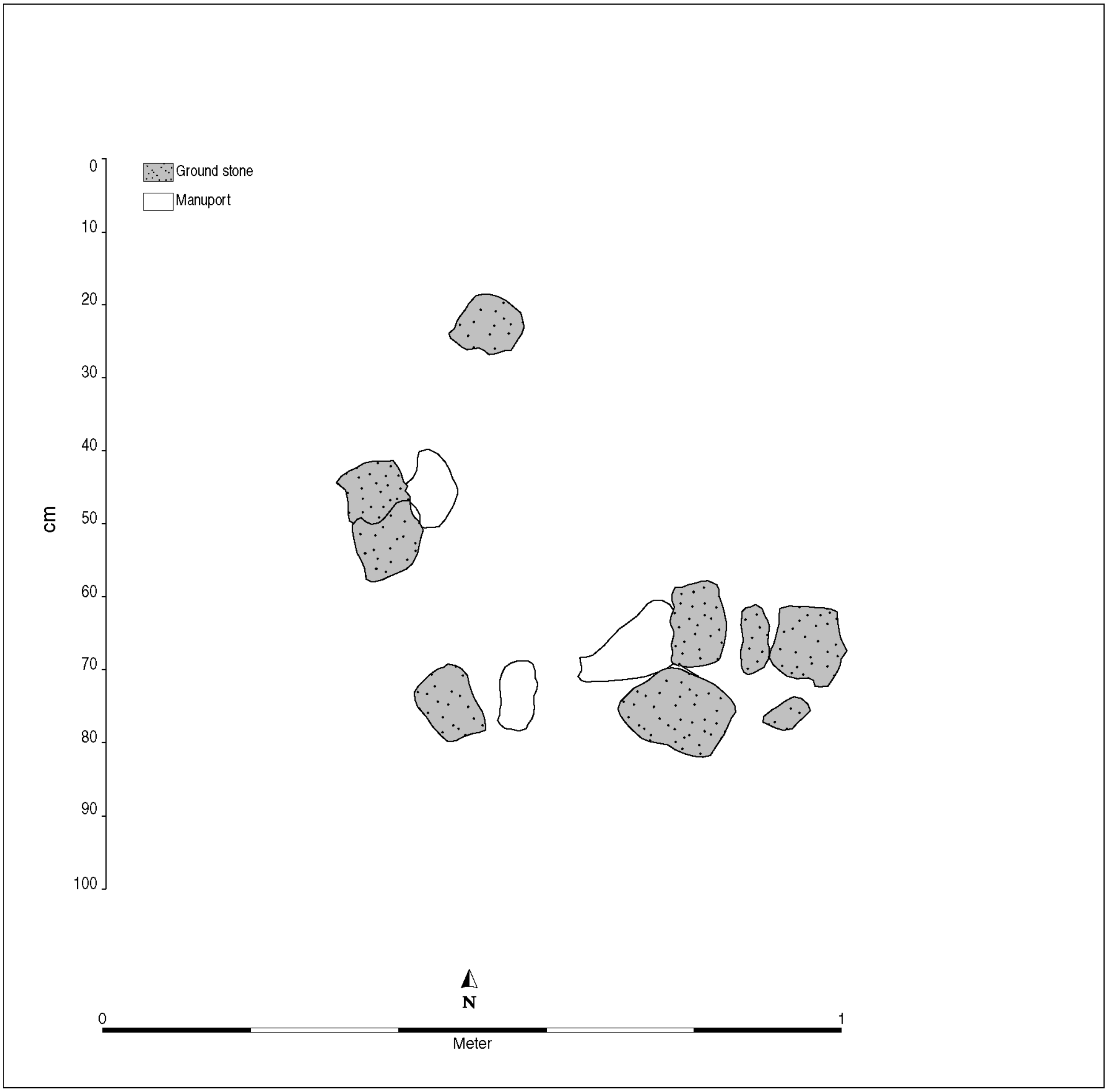


Figure 7.21. Plan map of Feature 21 at LAN-63.

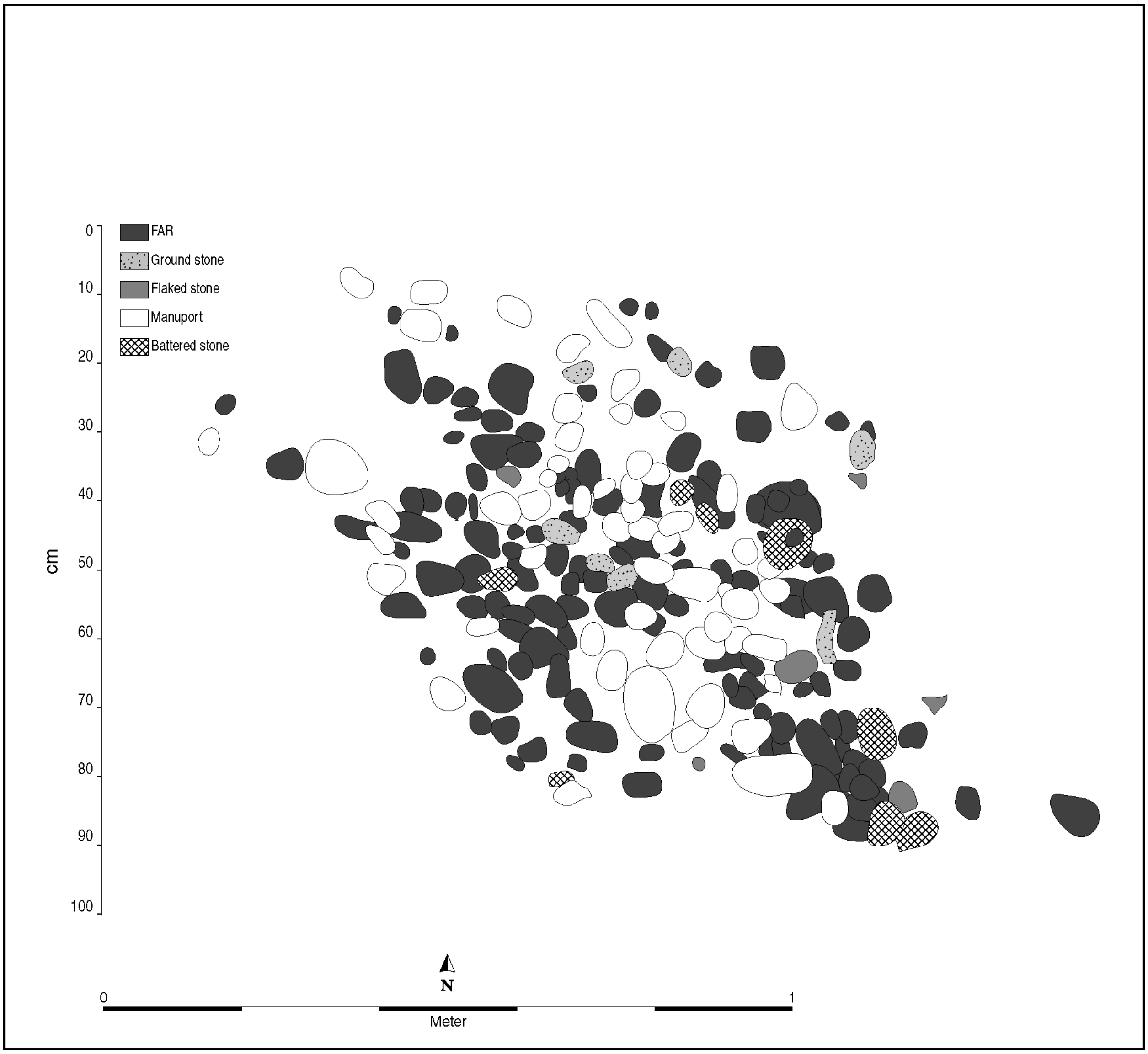


Figure 7.22. Plan map of Feature 318 at LAN-63.

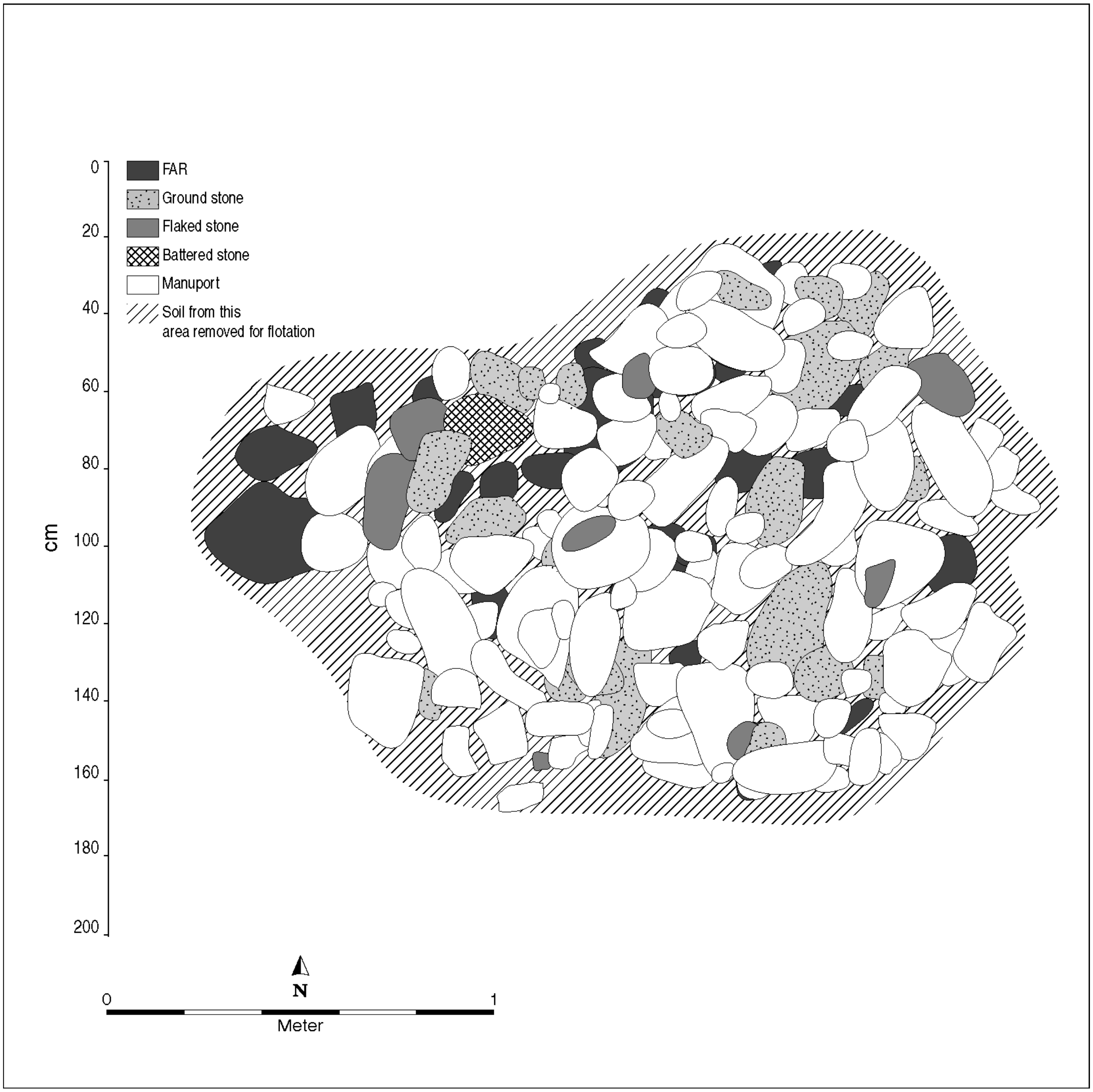


Figure 7.23. Plan map of Feature 337 at LAN-63.

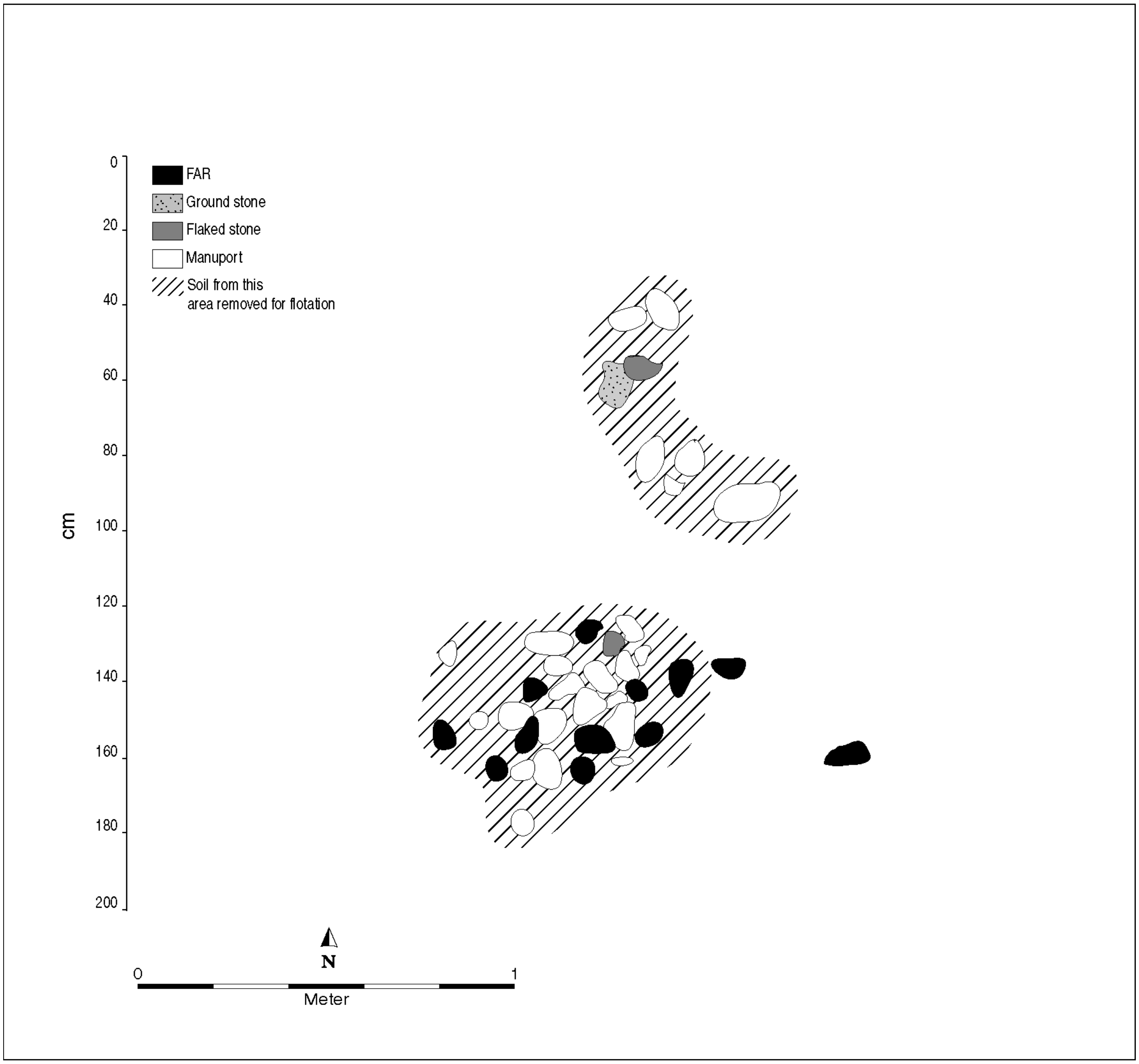


Figure 7.24. Plan map of Feature 340 at LAN-63.

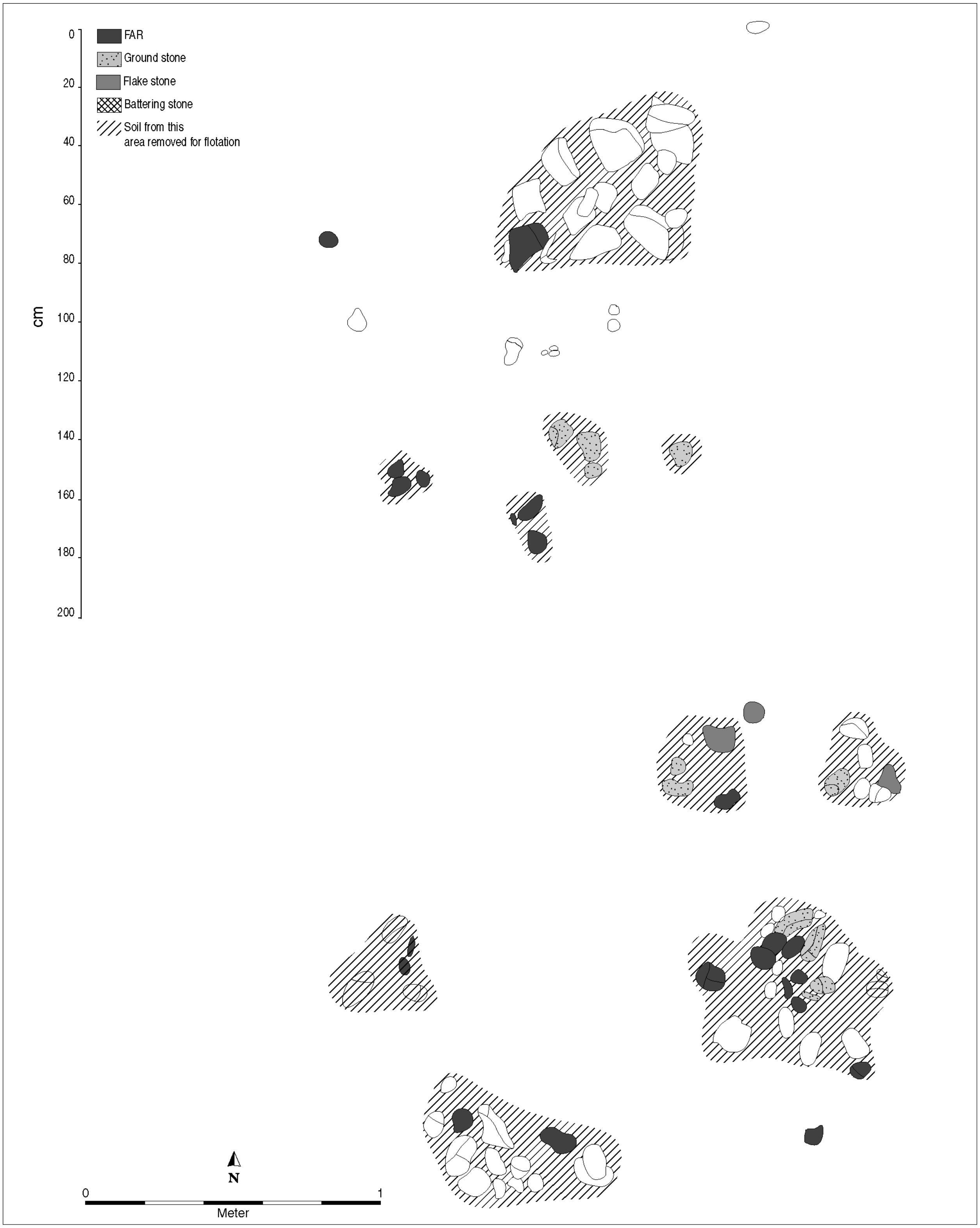


Figure 7.25. Plan map of Feature 409 at LAN-63.

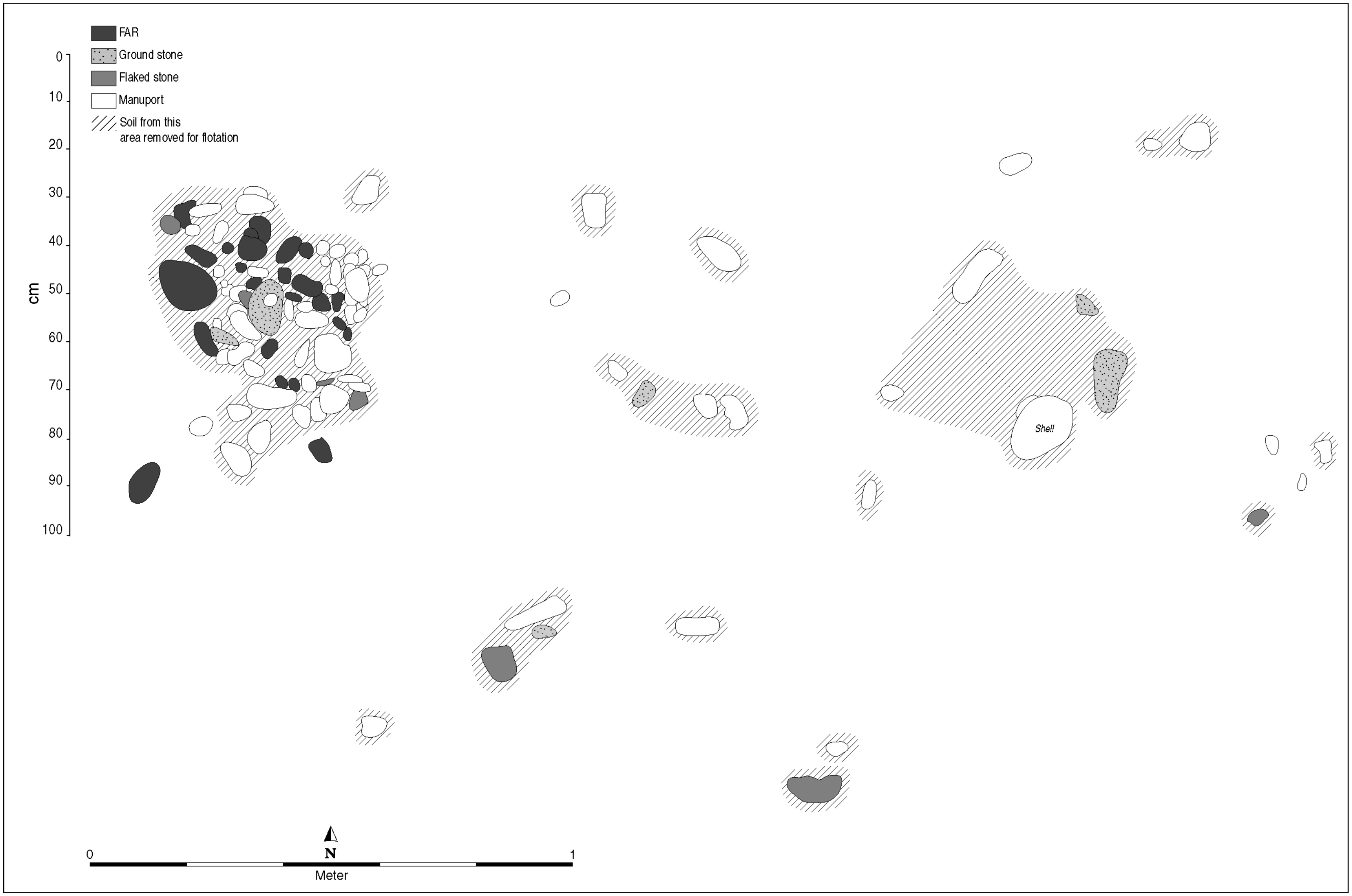


Figure 7.26. Plan map of Feature 444 at LAN-63.

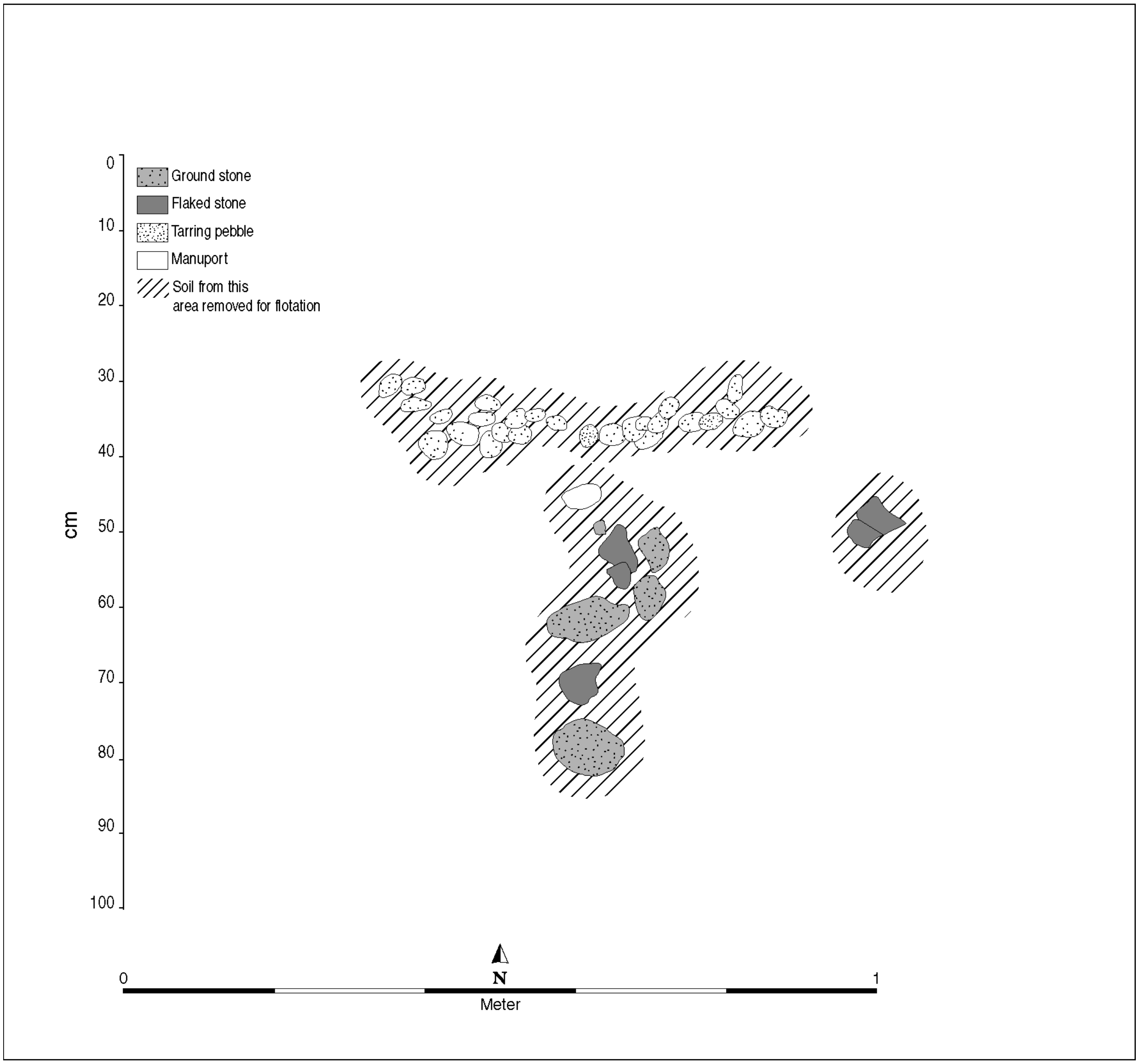


Figure 7.27. Plan map of Feature 446 at LAN-63.

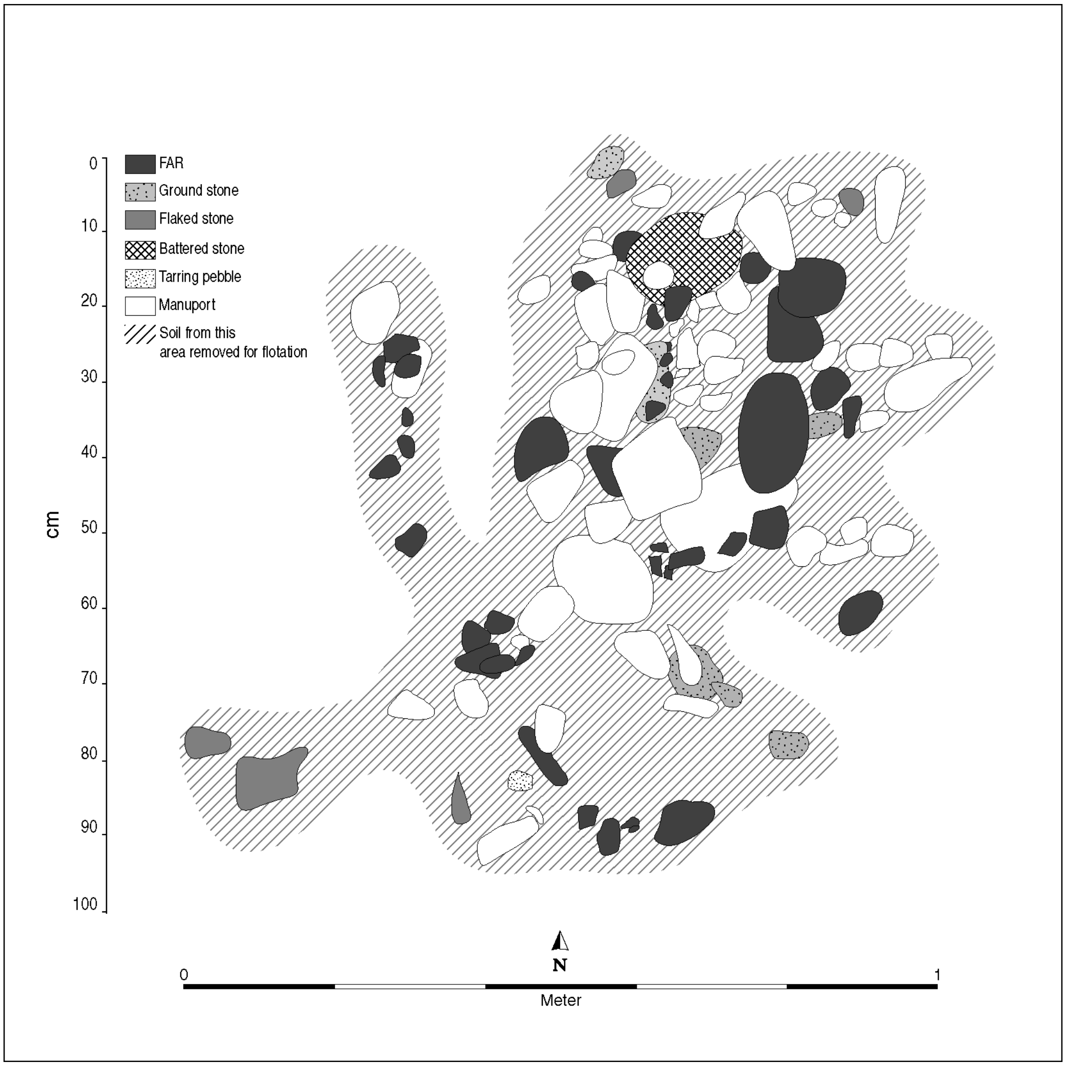


Figure 7.28. Plan map of Feature 462 at LAN-63.

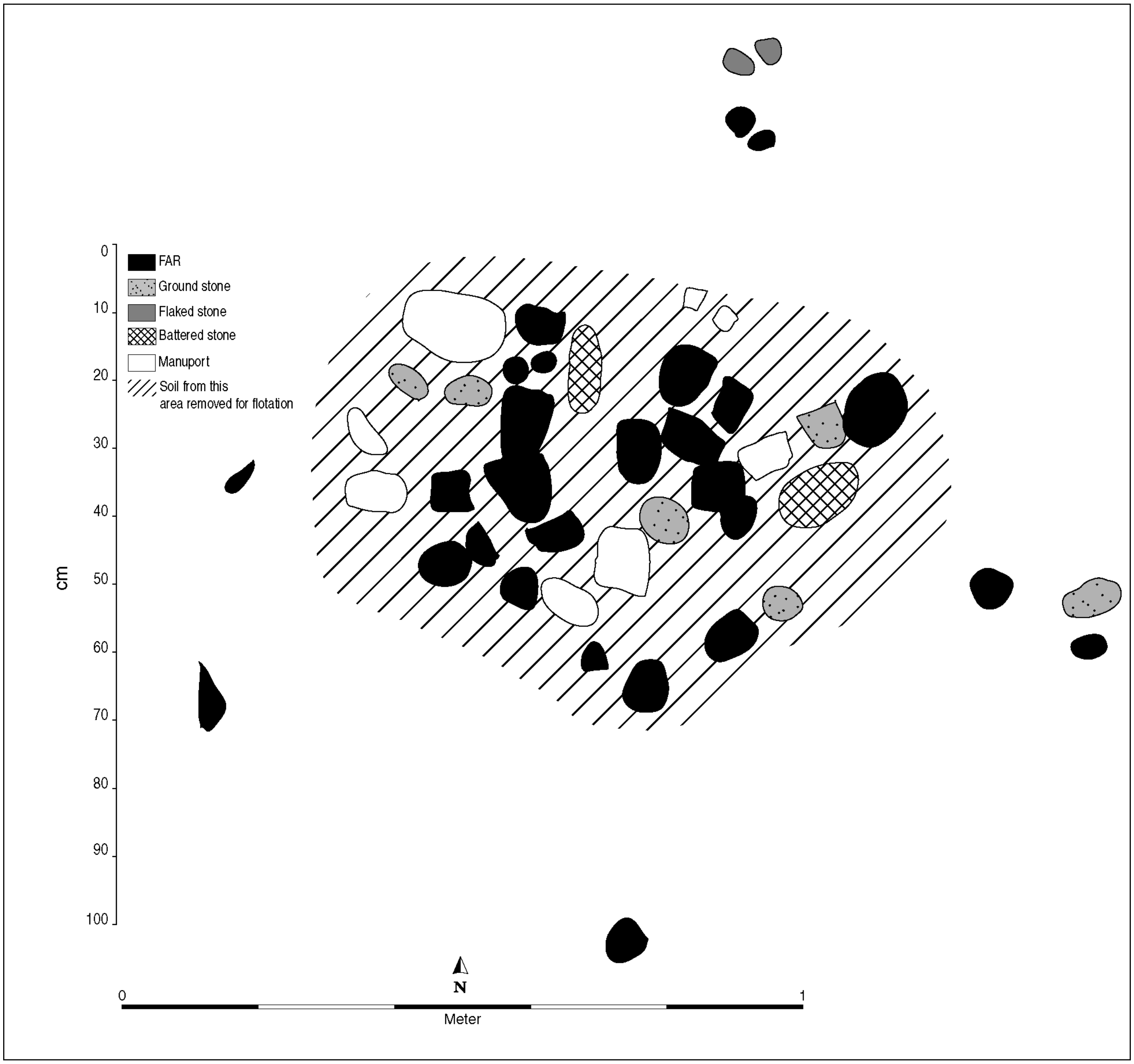


Figure 7.29. Plan map of Feature 468 at LAN-63.

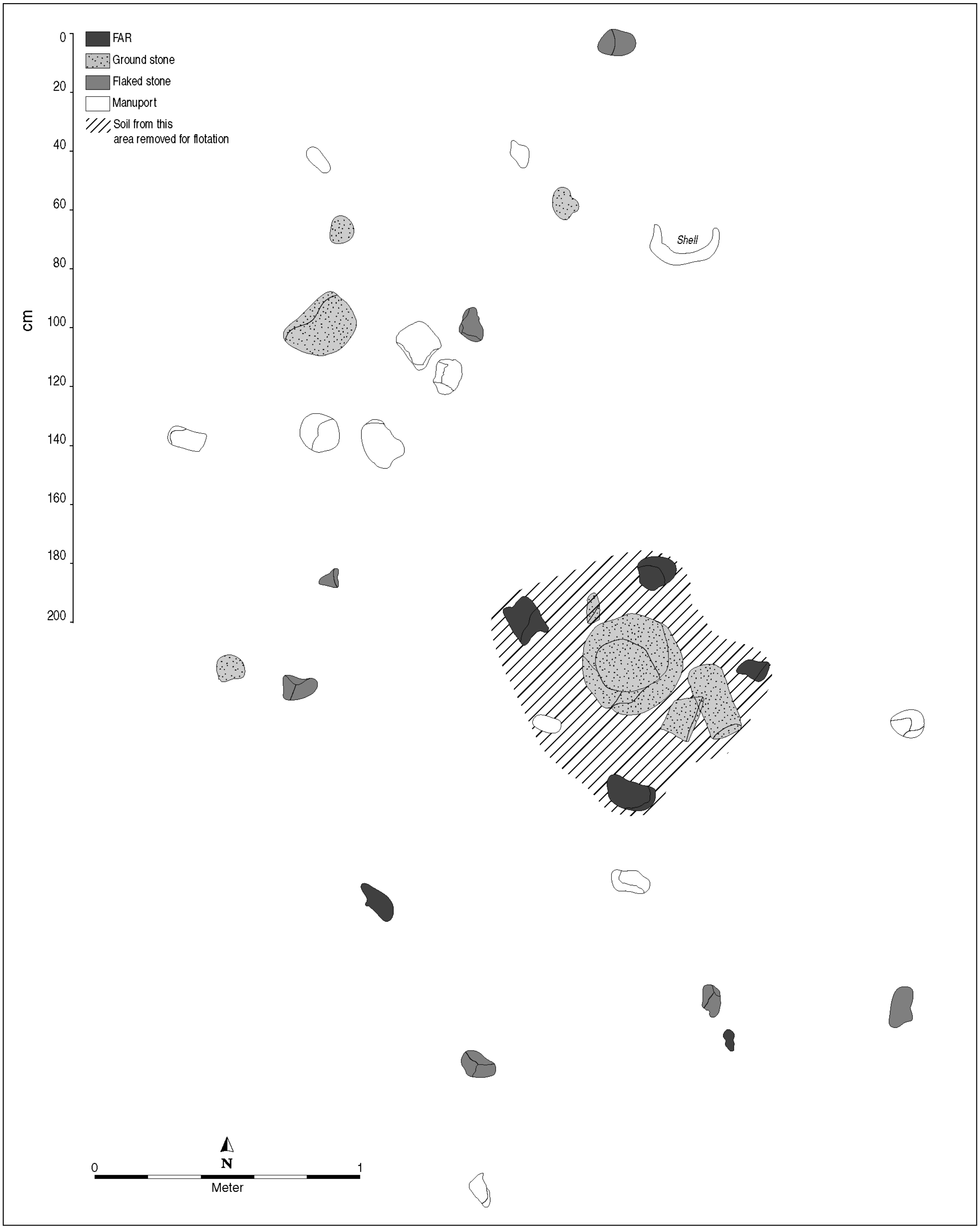


Figure 7.30. Plan map of Feature 509 at LAN-63.

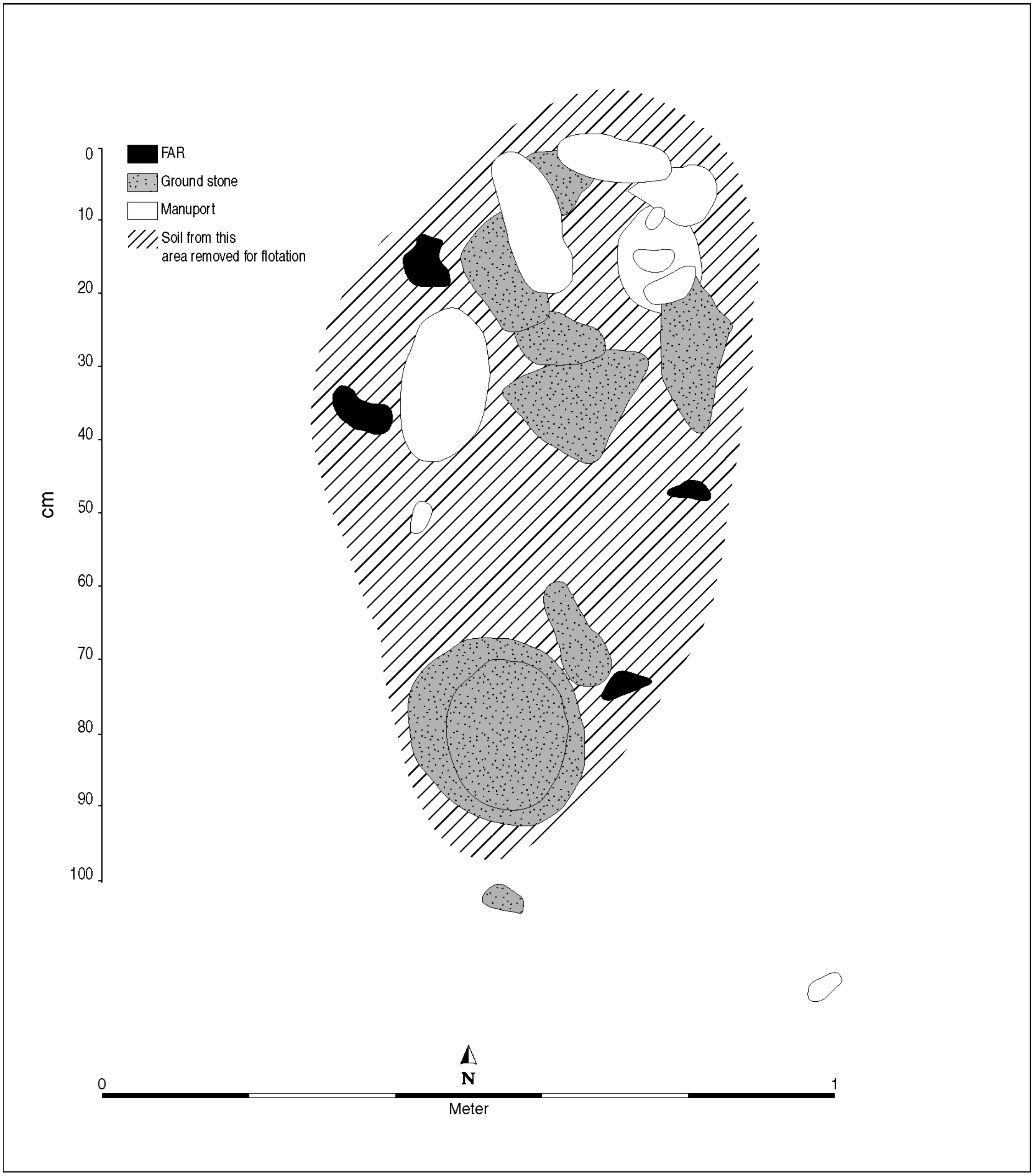


Figure 7.31. Plan map of Feature 521 at LAN-63.

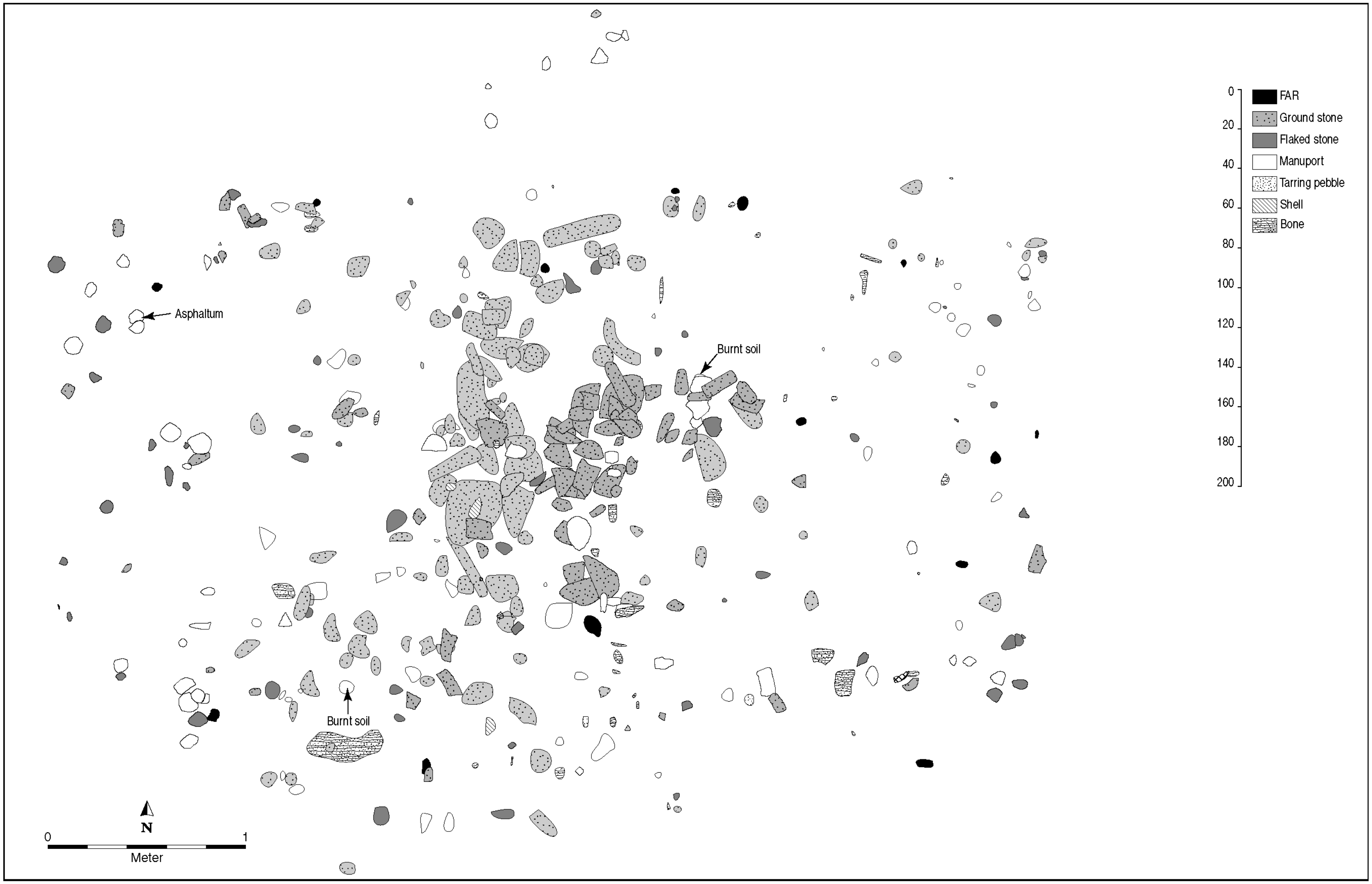


Figure 7.32. Plan map of Feature 587 at LAN-63.

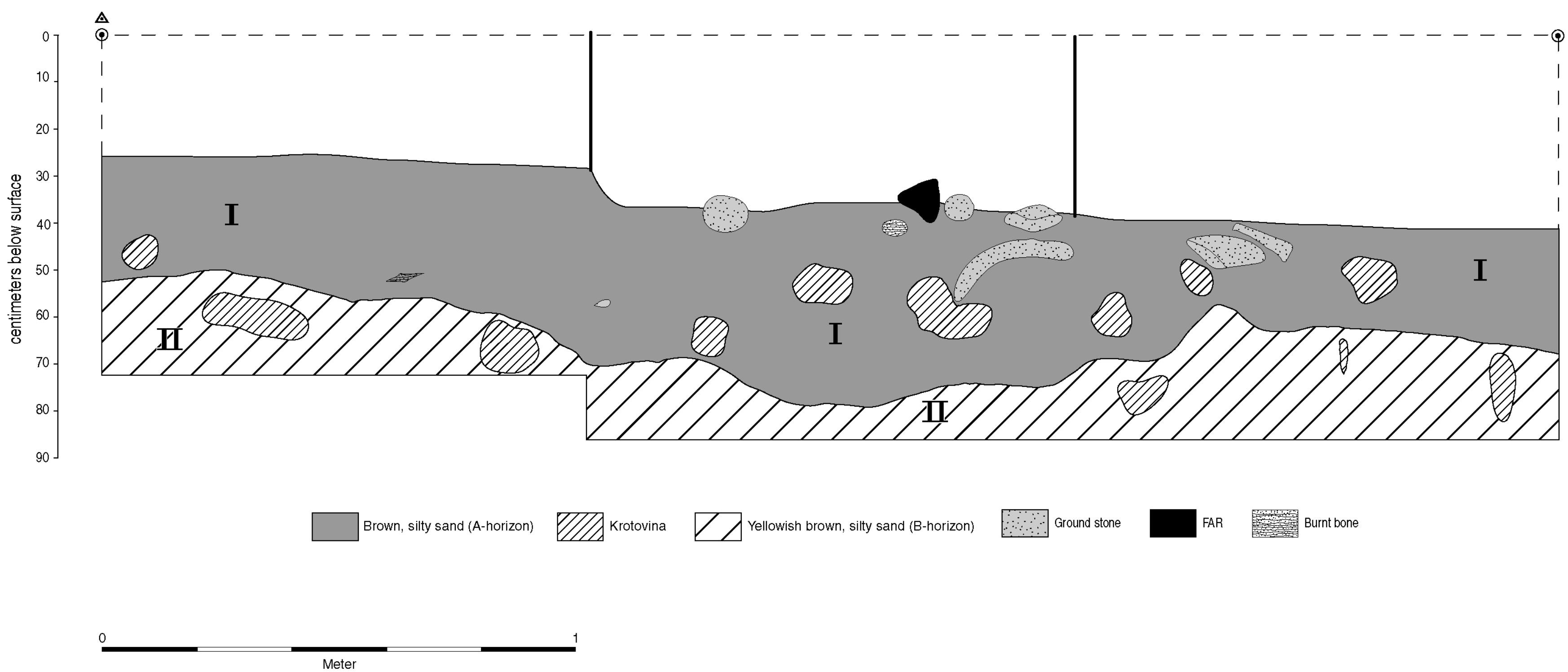


Figure 7.33. Profile of southern excavation wall, Feature 587 at LAN-63.

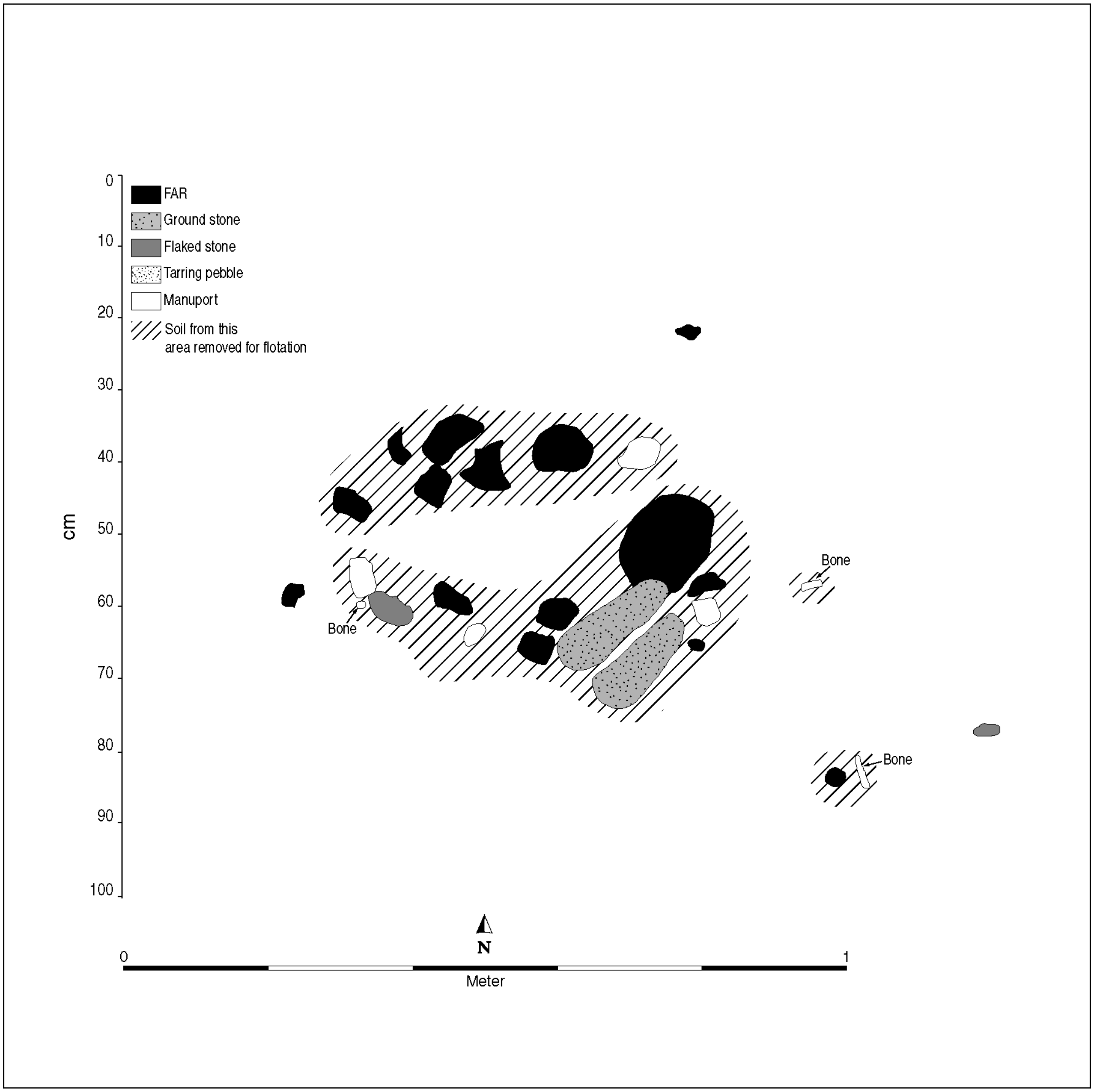


Figure 7.34. Plan map of Feature 594 at LAN-63.

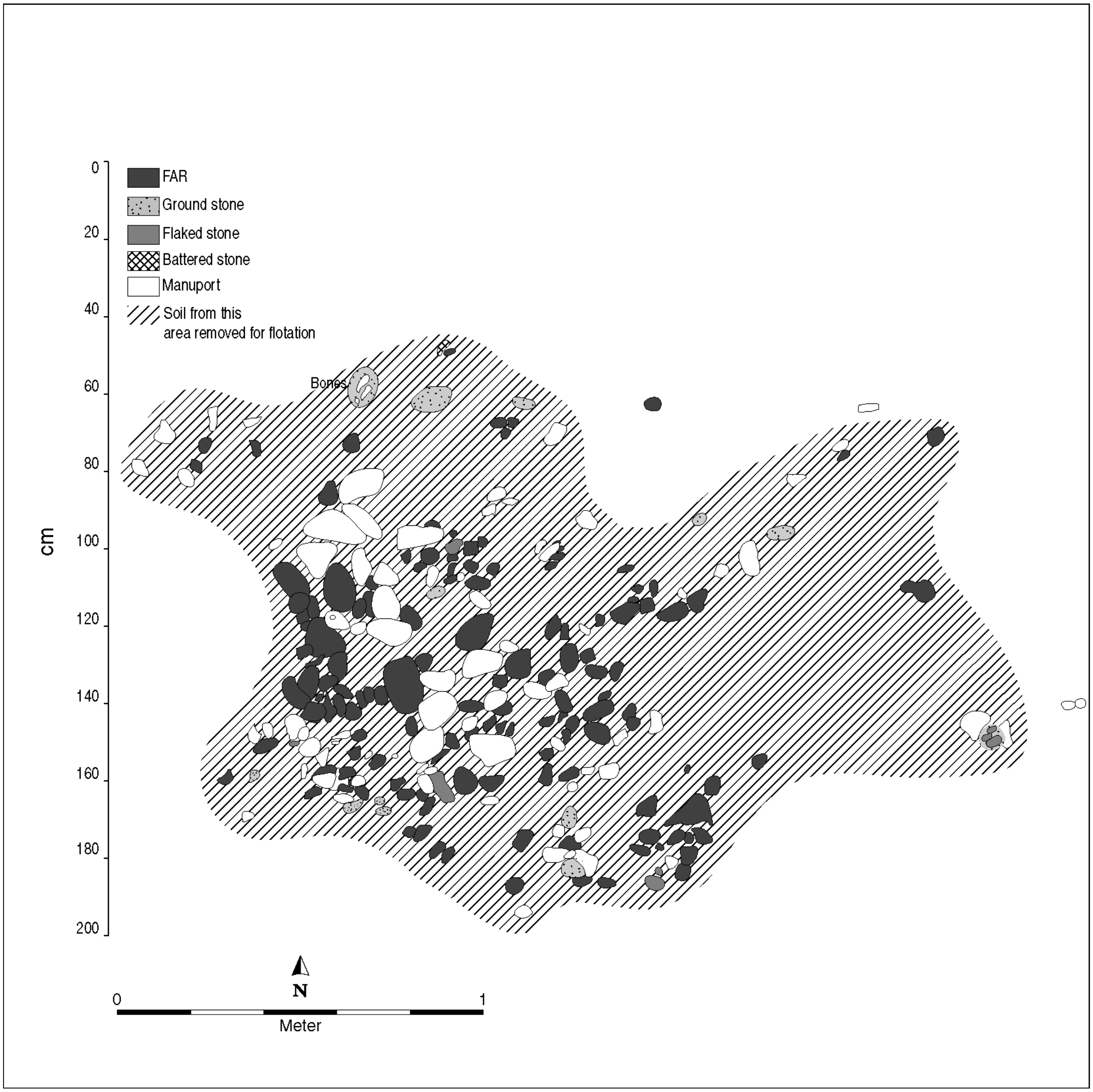


Figure 7.35. Plan map of Feature 601 at LAN-63.

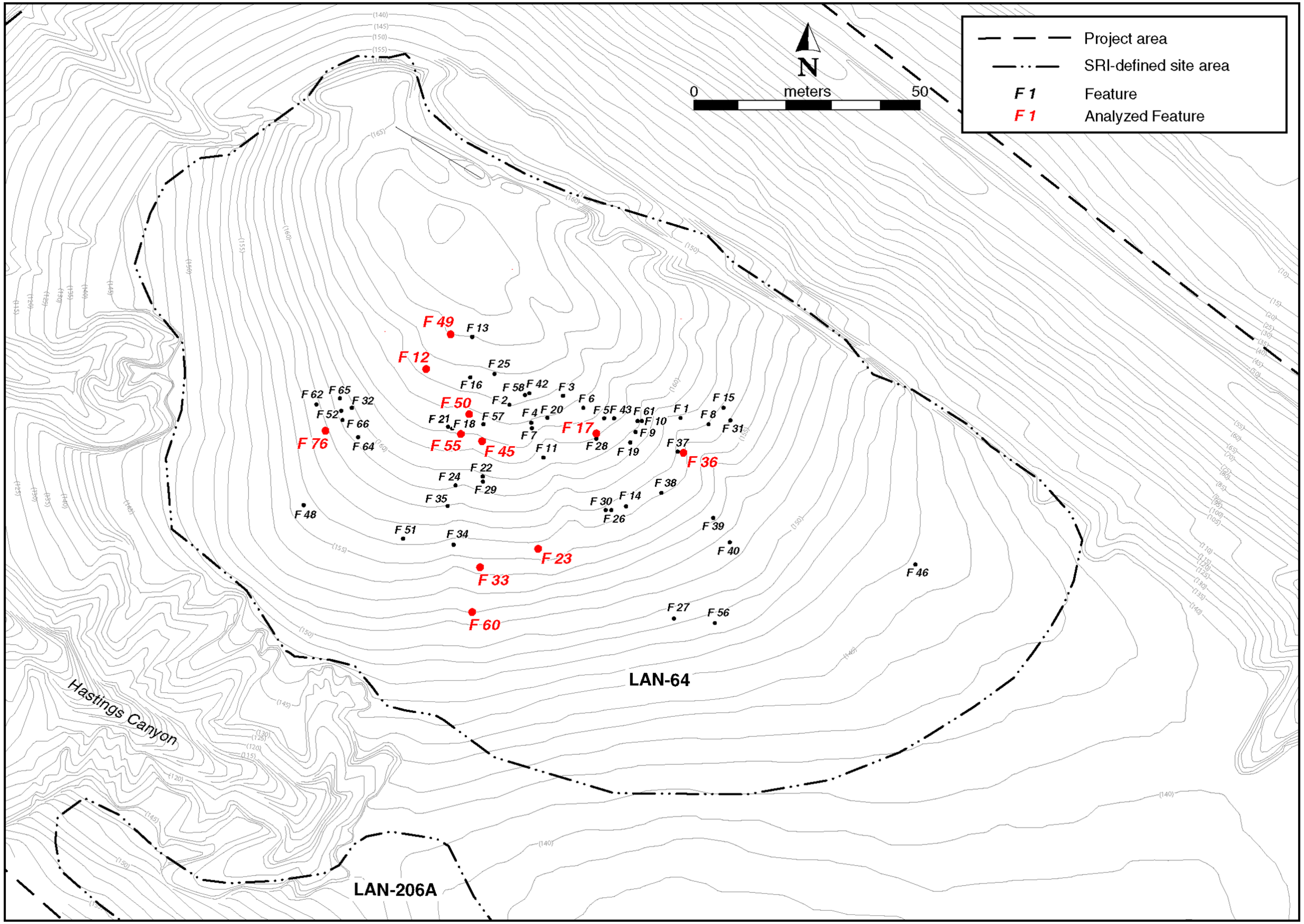


Figure 7.36. Location of analyzed features at LAN-64.

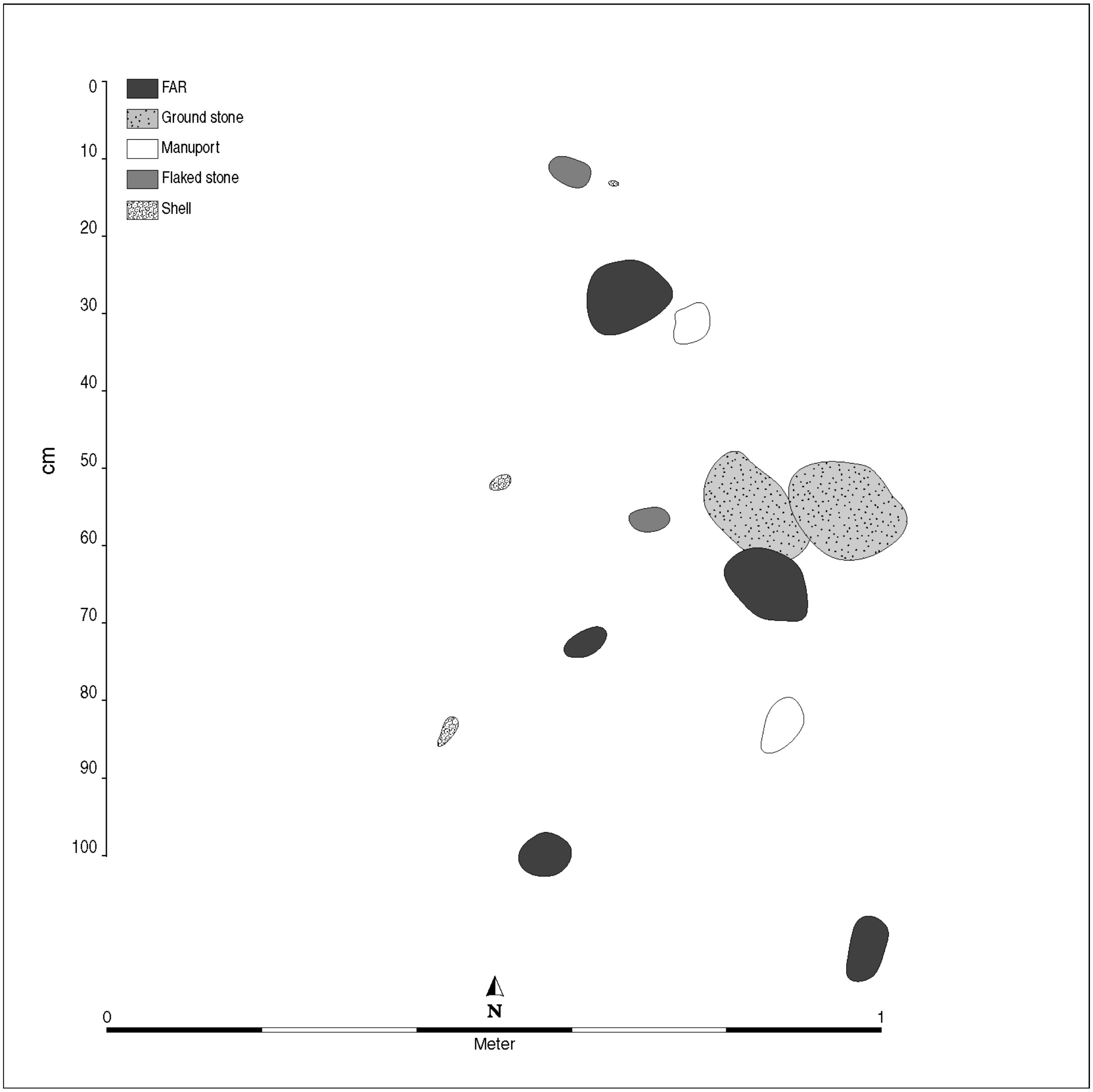


Figure 7.37. Plan map of Feature 12 at LAN-64.

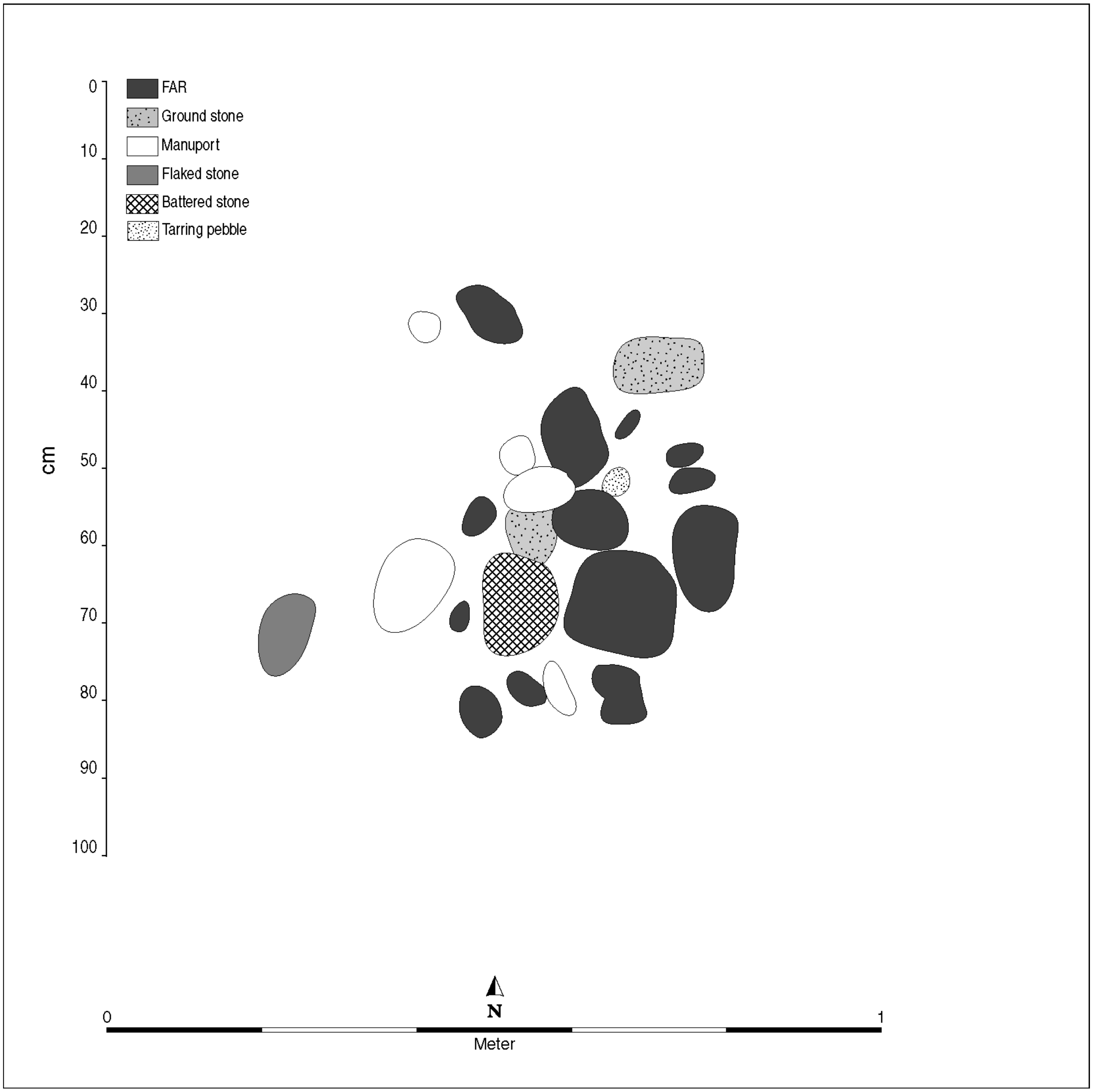


Figure 7.38. Plan map of Feature 17 at LAN-64.

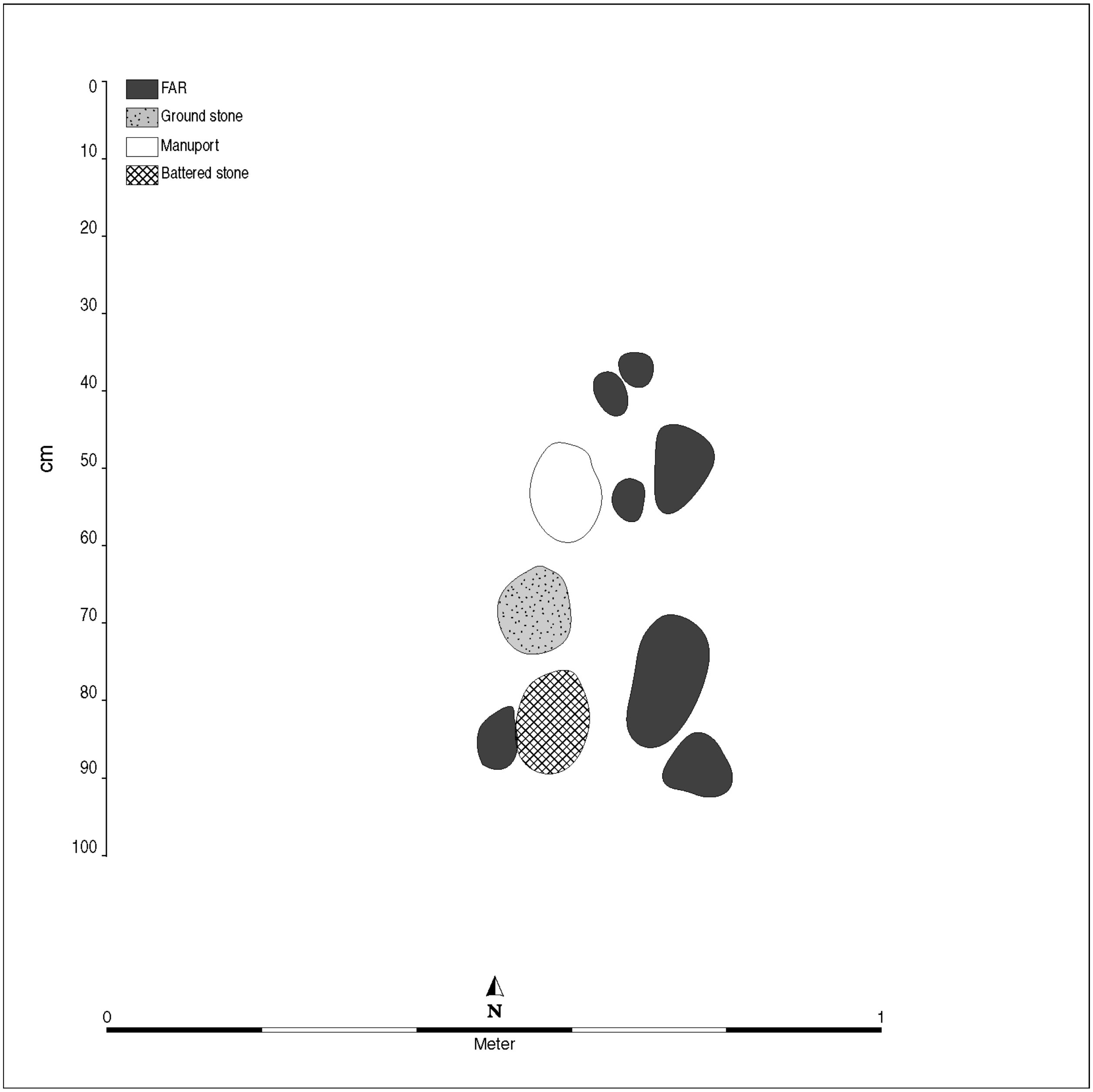


Figure 7.39. Plan map of Feature 23 at LAN-64.

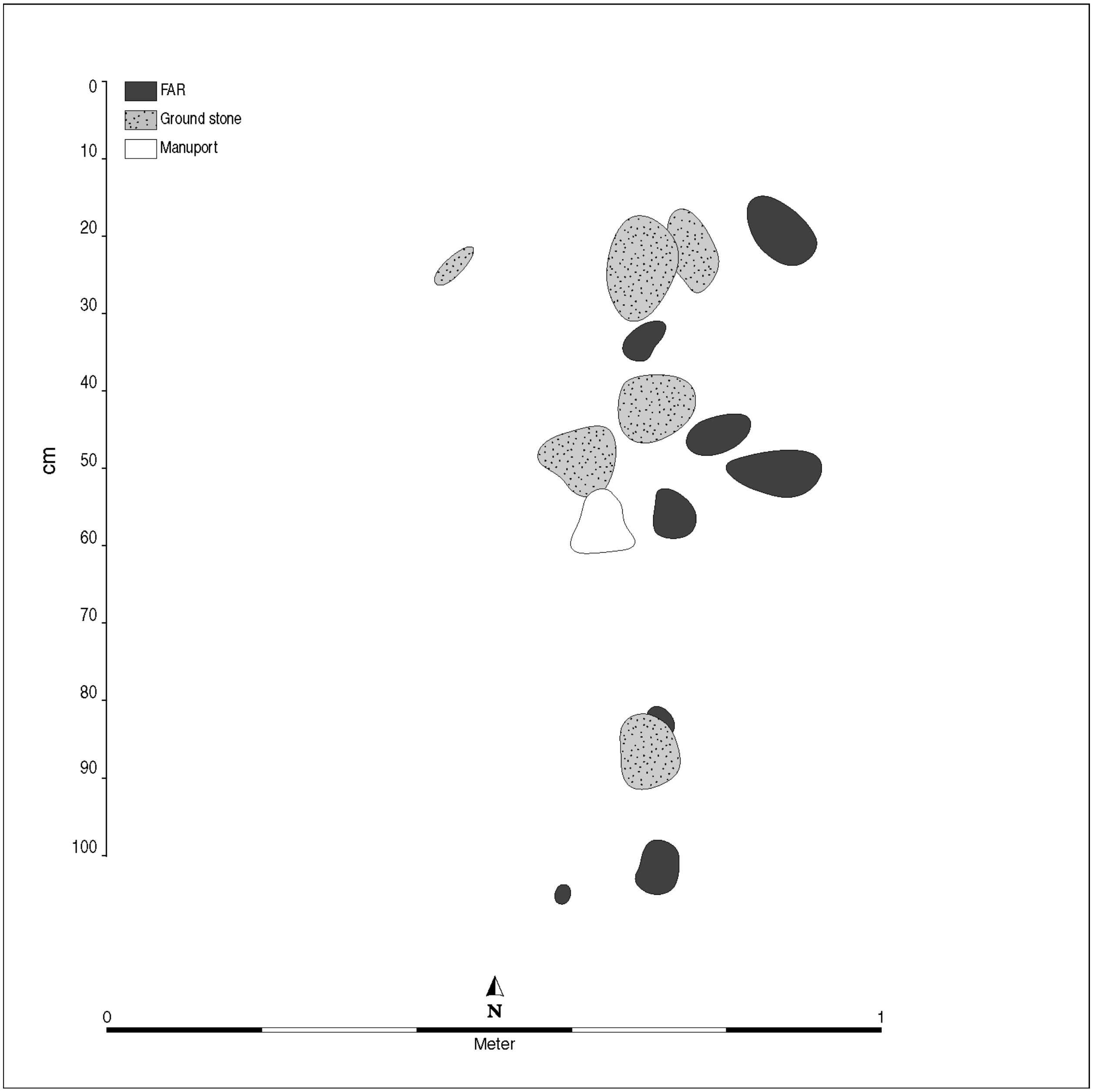


Figure 7.40. Plan map of Feature 33 at LAN-64.

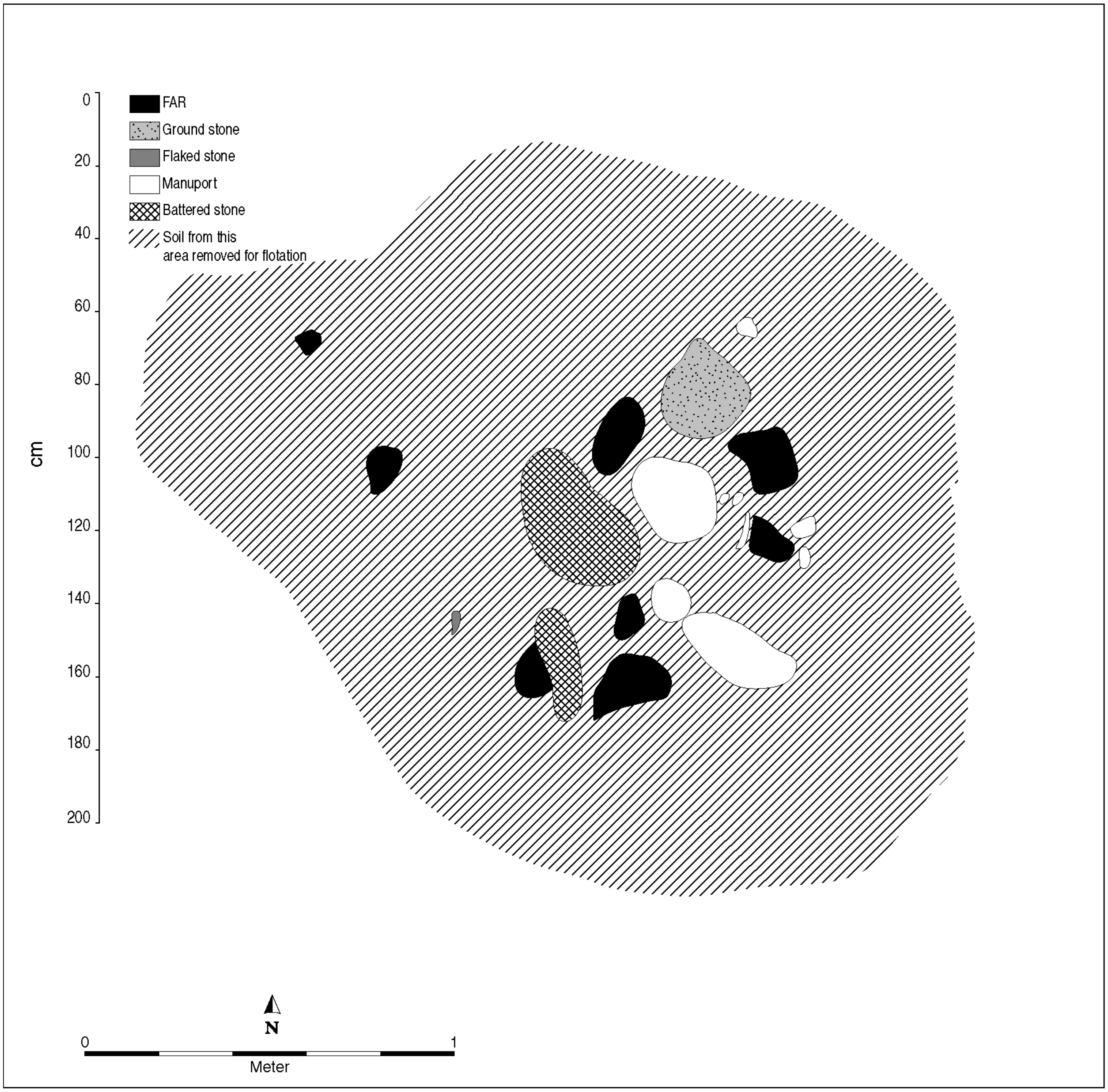


Figure 7.41. Plan map of Feature 36 at LAN-64.

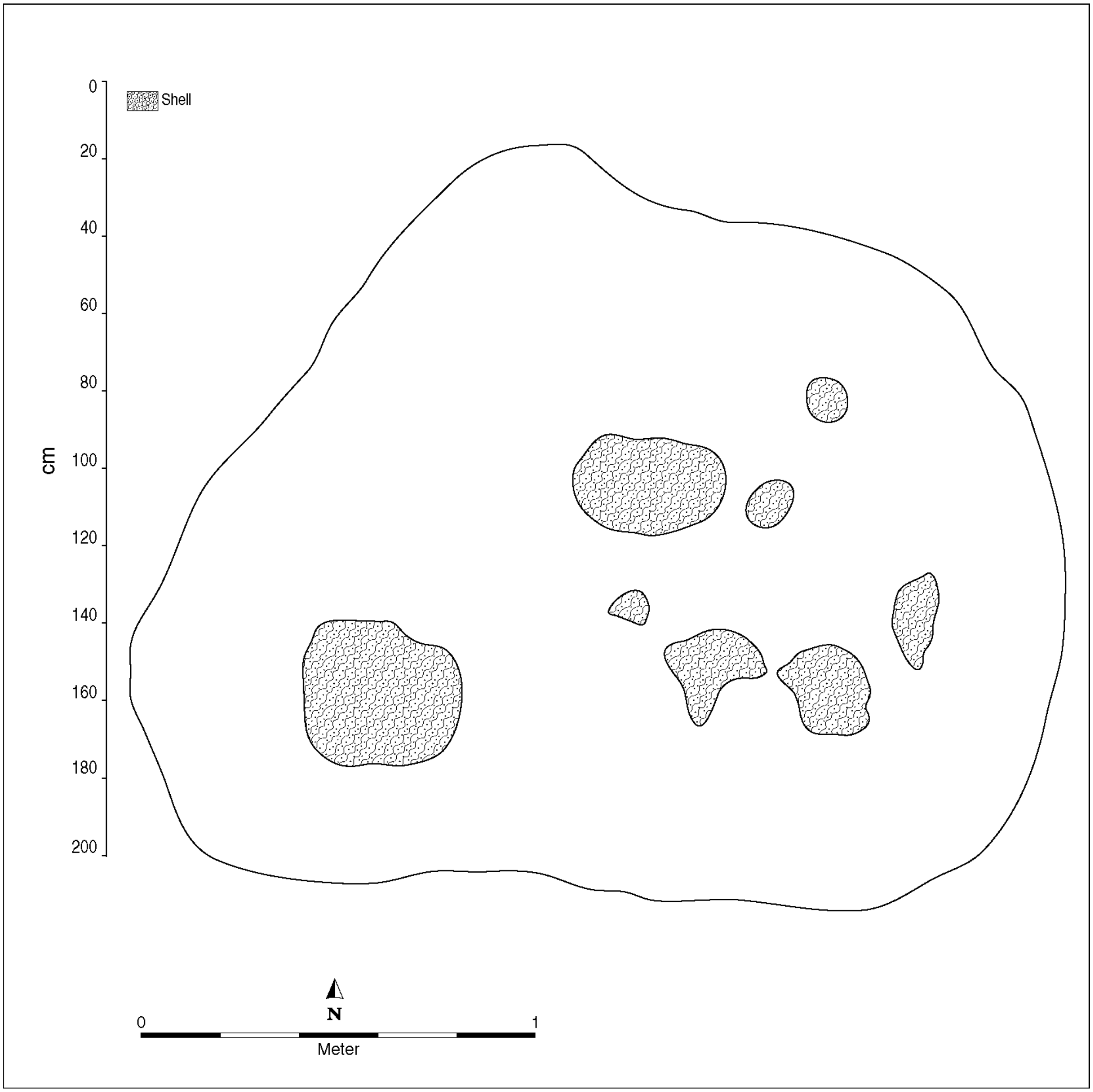


Figure 7.42. Plan map of Feature 45 at LAN-64.

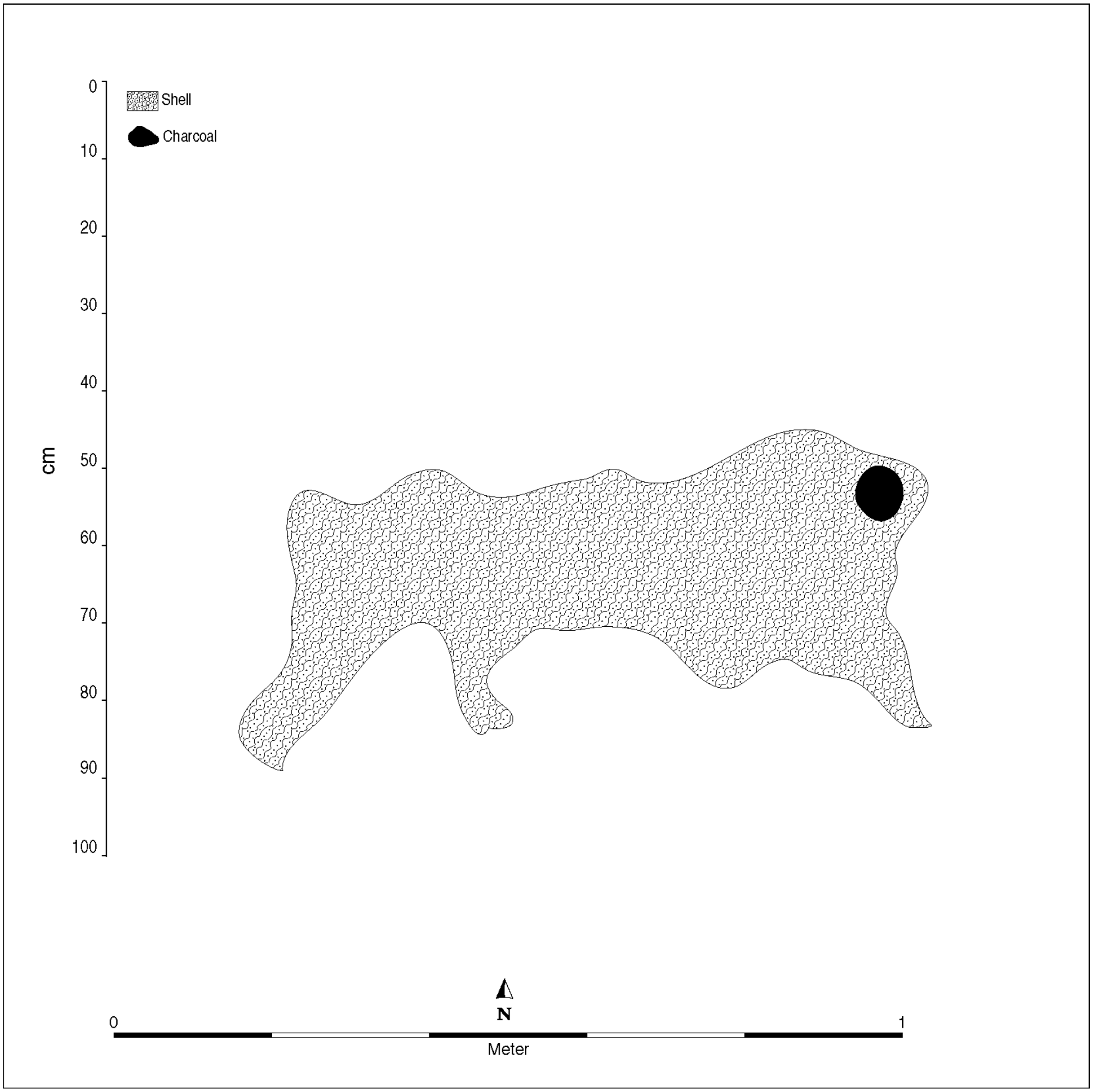


Figure 7.43. Plan map of Feature 49 at LAN-64.

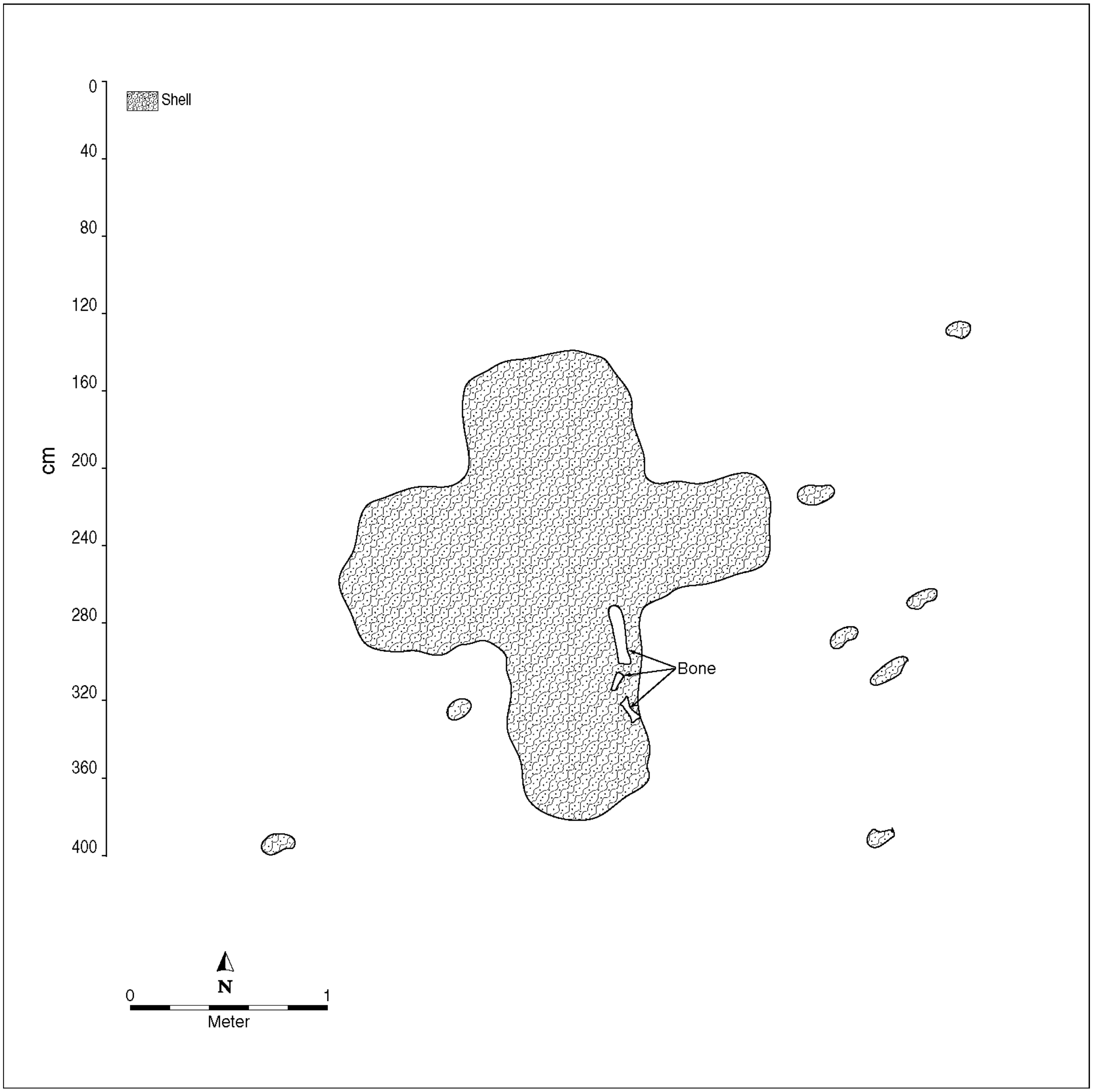


Figure 7.44. Plan map of Feature 50 at LAN-64.

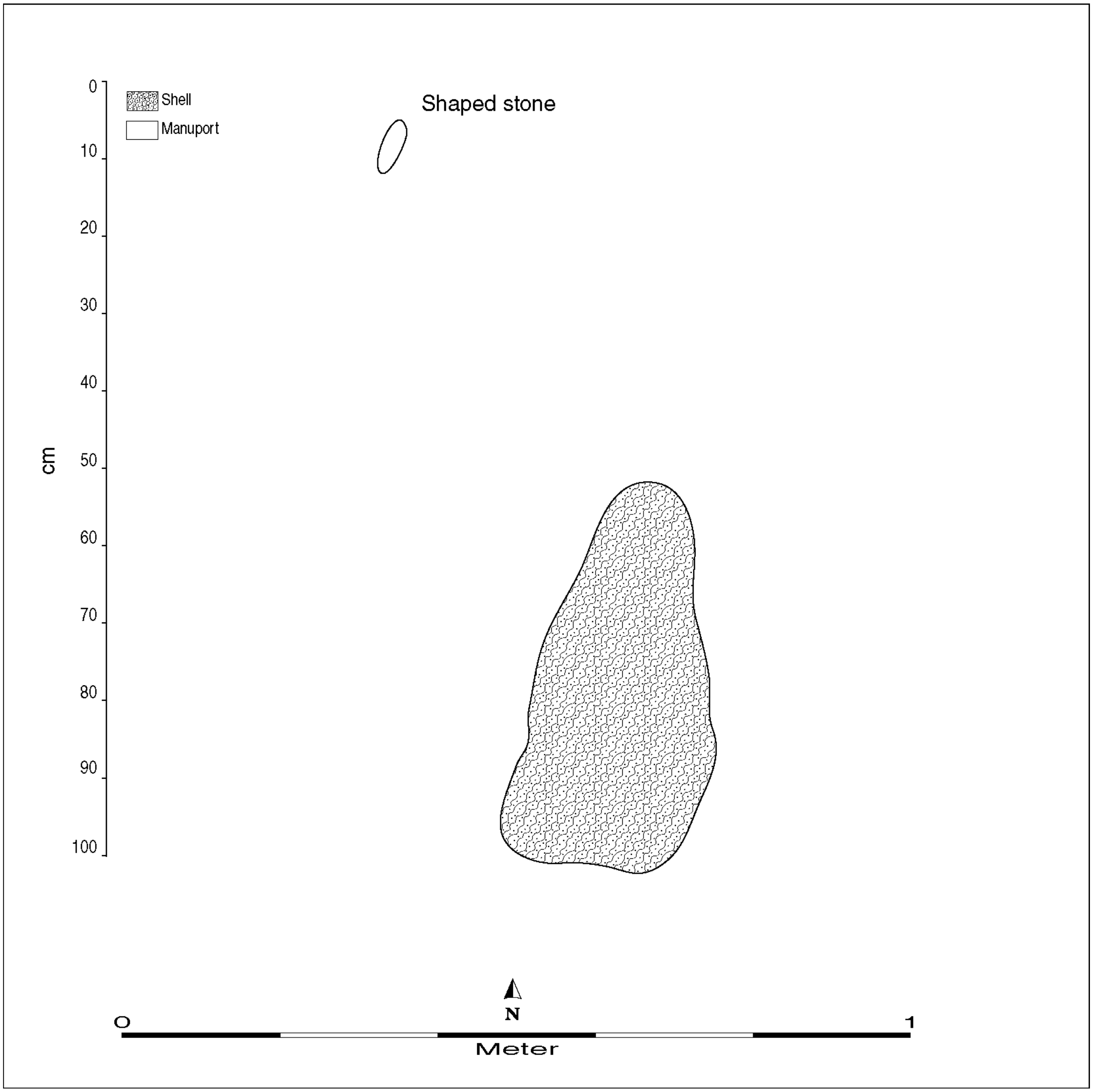


Figure 7.45. Plan map of Feature 55 at LAN-64.

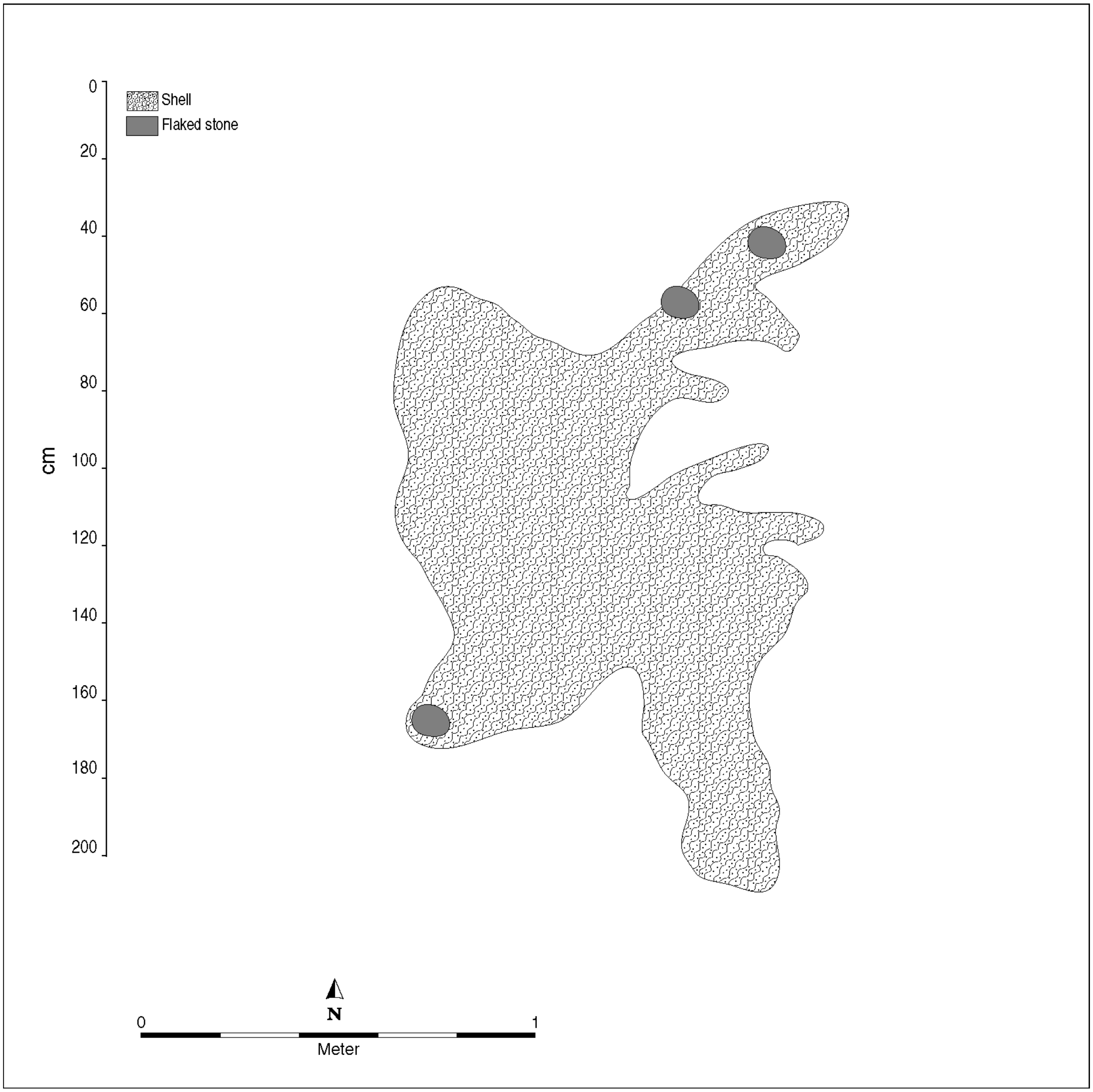


Figure 7.46. Plan map of Feature 60 at LAN-64.

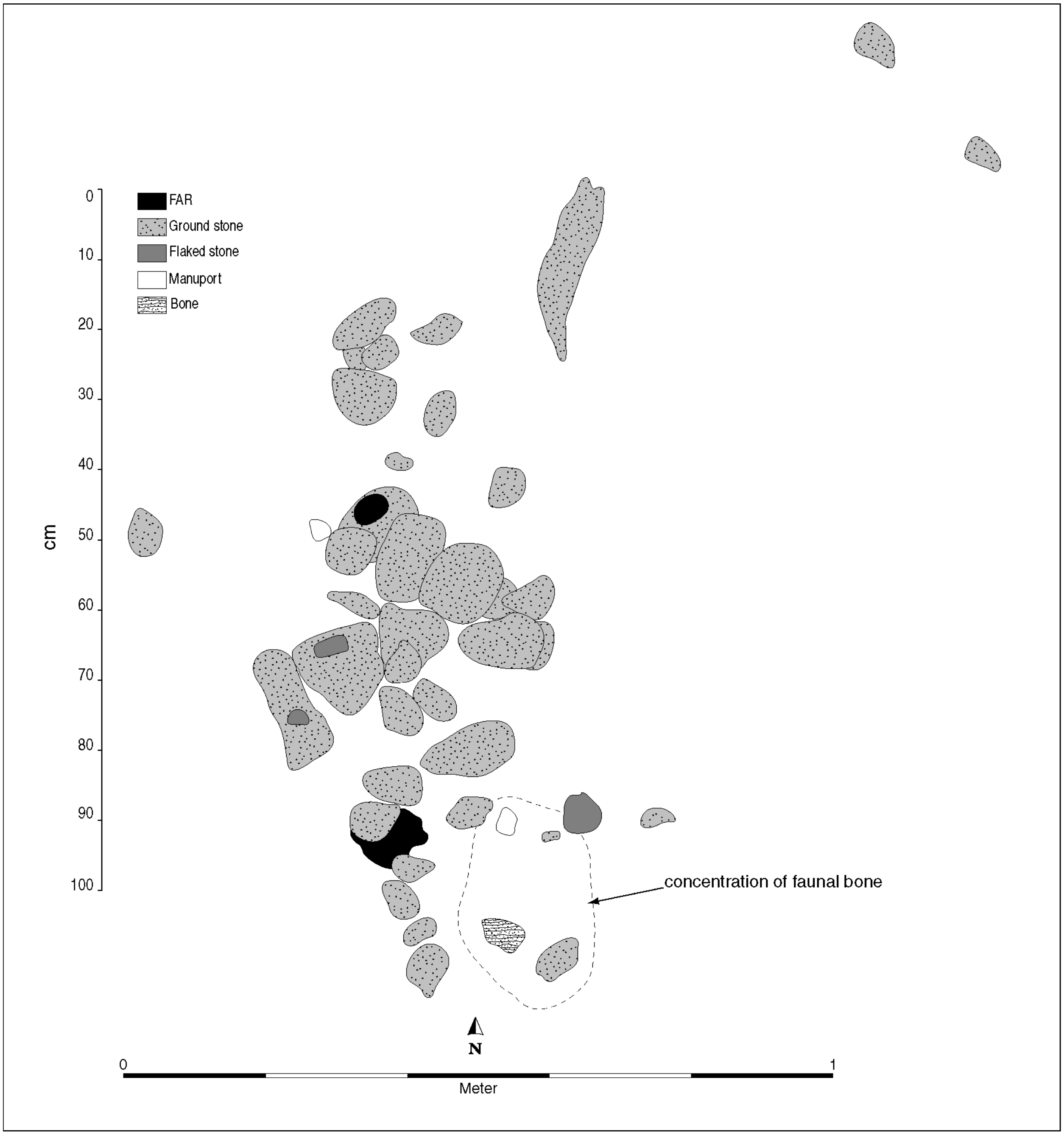


Figure 7.47. Plan map of Feature 76 at LAN-64.

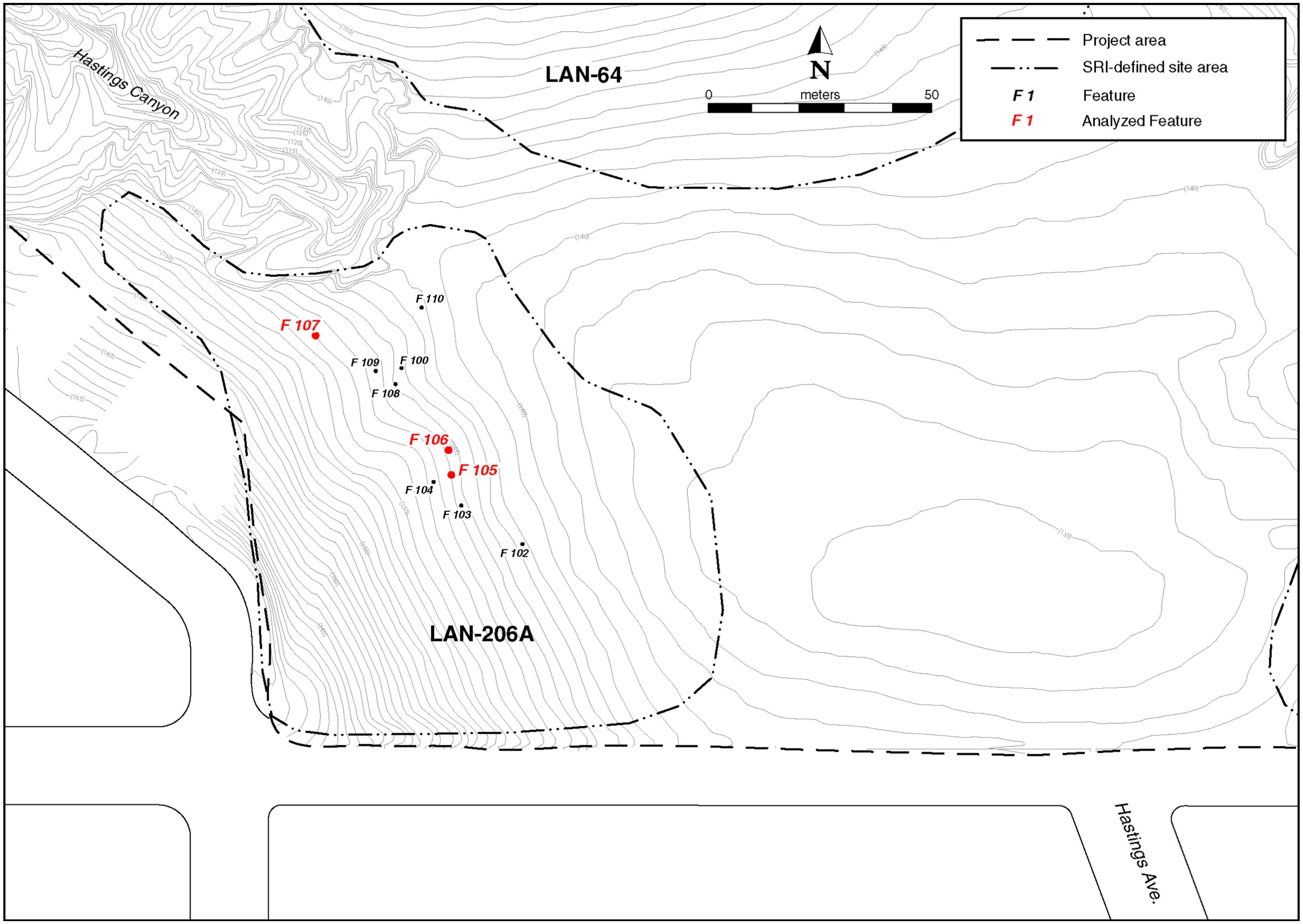


Figure 7.48. Location of analyzed features at LAN-206A.

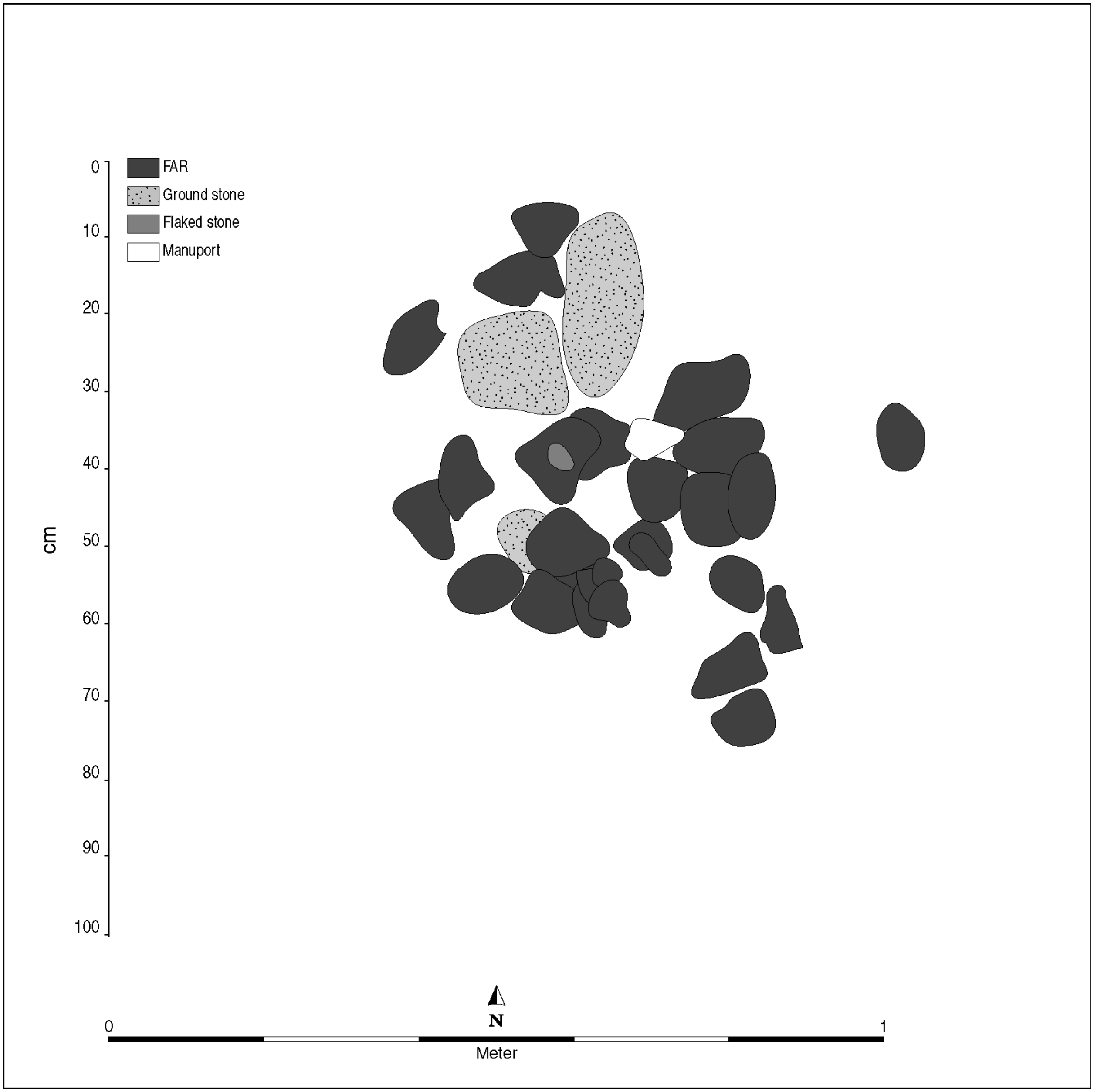


Figure 7.49. Plan map of Feature 105 at LAN-206A.

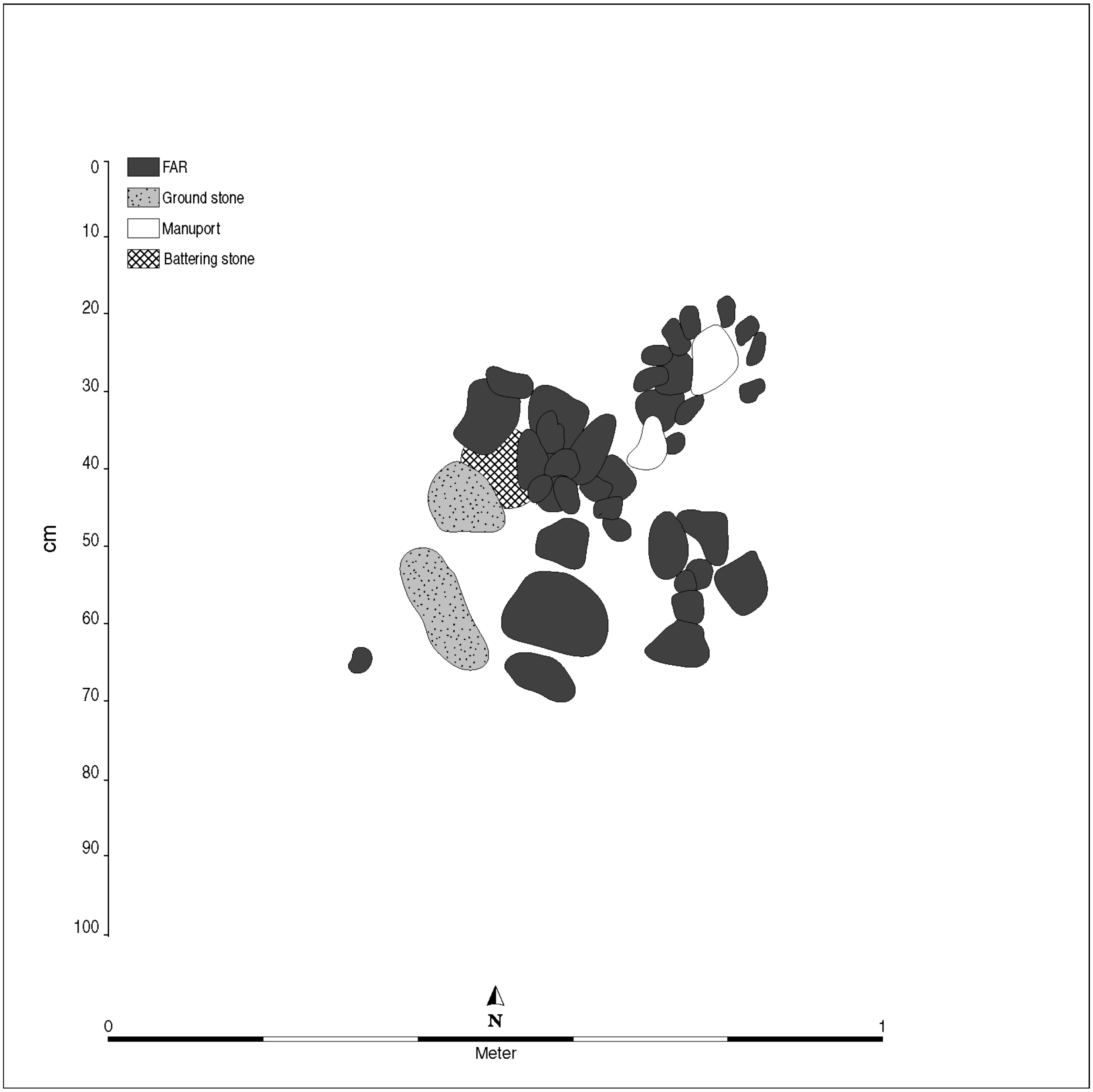


Figure 7.50. Plan map of Feature 106 at LAN-206A.

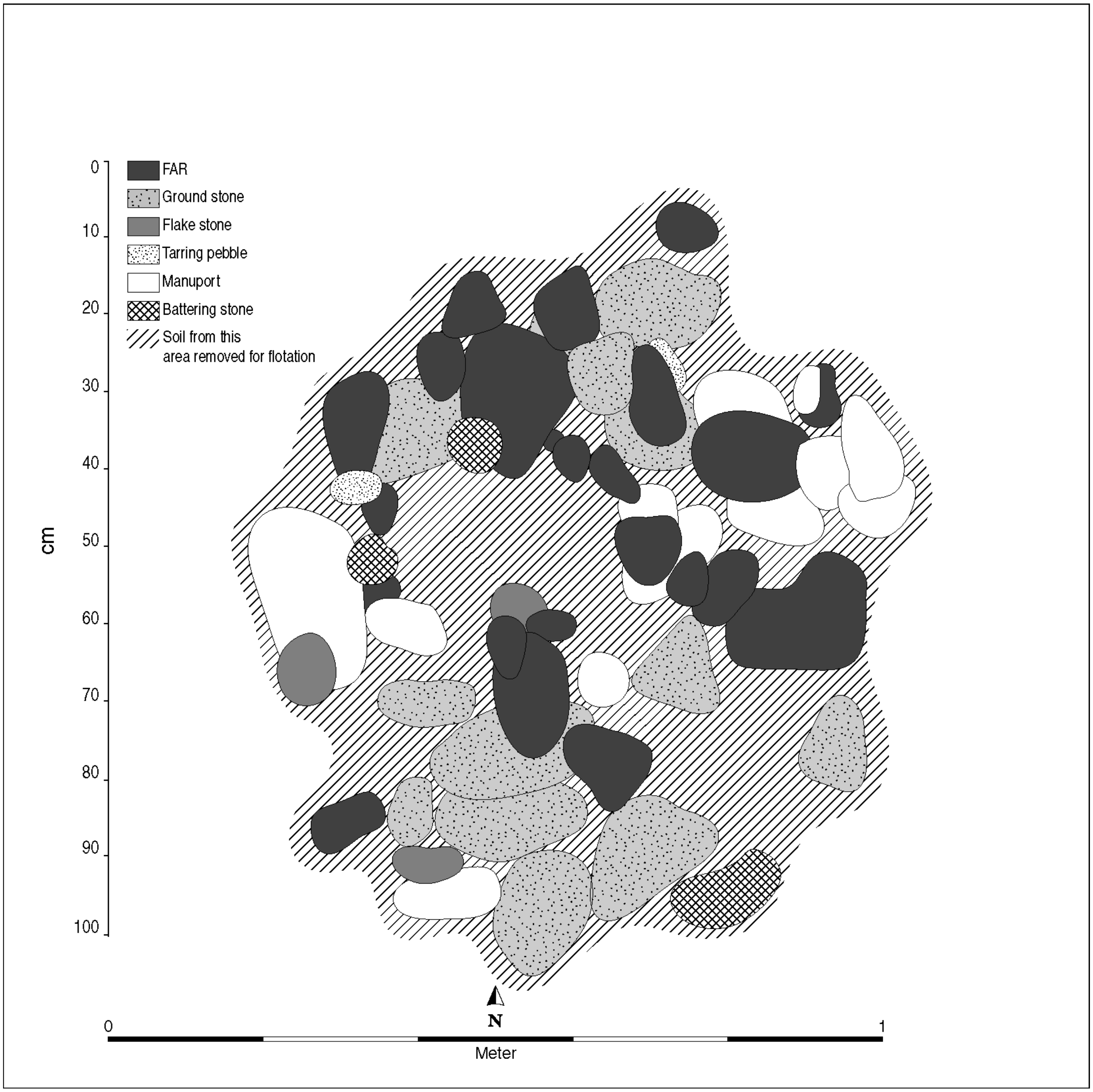


Figure 7.51. Plan map of Feature 107 at LAN-206A.

Table 7.1. LAN-63 Analyzed-Feature Summary

Feature No.	Length (m)	Width (m)	Depth (m)	Feature Type
1	0.4	0.4	0.2	thermal feature; processing activities
2	0.2	0.27	0.07	thermal feature; processing activities
3				thermal feature; processing activities
4	1.25	0.4	0.28	thermal feature; processing activities
5	0.55	0.7	0.25	flaked stone cache; processing with asphaltum
6	0.55	0.6	0.1	processing feature
7	1.5	0.8	0.2	thermal feature; processing activities
8	0.2	0.2	0.1	processing-activities feature
9	0.2	0.15	0.15	thermal feature; processing activities
10	1.1	0.6	0.2	processing-activities feature
11	1.0	0.8	0.3	ritual cache
12	0.55	0.22	0.2	lithic-tool-manufacture feature
13	0.35	0.32	0.1	thermal feature associated with lithic-tool manufacture and processing
14	0.3	0.25	0.12	thermal feature; processing activities
15	0.3	0.15	0.05	ritual cache
16	1.0	0.4	0.07	processing-activities feature
17	0.6	0.4	0.15	thermal feature; processing activities
18	1.0	1.0	0.05	artifact cache
19	0.5	0.25	0.05	processing-activities feature
20	0.8	0.9	0.1	artifact cache
21	0.8	0.7	0.1	processing-activities feature
318	2.5	1.5	0.25	thermal feature; processing activities
337	1.1	0.7	0.35	thermal feature; processing activities
340	1.5	1.2	0.2	thermal feature; processing activities
409	4.6	2.4	0.3	thermal feature; processing activities
444	0.6	0.5	0.2	thermal feature; processing activities
446	0.8	0.6	0.1	thermal feature; processing with asphaltum
462	1.05	1.0	0.25	thermal feature; processing activities
468	0.85	0.7	0.1	thermal feature; processing activities
509	0.5	0.4	0.1	thermal feature; processing activities
521	1.2	0.5	0.17	thermal feature; processing activities
587	5.0	5.0	0.5	ritual cache
594	1.0	0.65	0.1	thermal feature; processing activities
601	3.0	2.6	0.3	thermal feature; processing activities

Table 7.2. LAN-64 Analyzed-Feature Summary

Feature No.	Length (m)	Width (m)	Depth (m)	Feature Type
12	1.15	1.0	0.25	thermal feature, processing activities
17	0.9	0.8	0.25	thermal feature; processing activities associated with asphaltum
23	0.3	0.16	0.1	thermal feature; processing activities
33	1.0	0.6	0.11	thermal feature; processing activities
36	0.7	0.6	0.1	thermal feature; processing activities
45	1.0	1.6	0.12	shell dump
49	0.8	0.4	0.15	shell dump
50	0.6	0.8	0.15	shell dump
55	1.5	1.2	0.1	shell dump
60	1.7	1.1	0.08	shell dump
76	1.0	0.9	0.15	thermal feature; processing activities associated with asphaltum

Table 7.3. LAN-206A Analyzed-Feature Summary

Feature No.	Length (m)	Width (m)	Depth (m)	Feature Type
105	0.75	0.75	0.13	thermal feature; processing activities
106	0.55	0.5	0.1	thermal feature; processing activities
107	1.0	0.9	0.15	thermal feature; processing activities associated with asphaltum

Chapter 8

Stone Artifacts

Kathleen L. Hull

Lithic items constituted the bulk of the artifacts at the West Bluffs sites, with more than 40,000 recovered. Given the large collection, a sample of items was subject to detailed analysis, with this study providing information relevant to several research issues regarding native life at the Ballona. First, technological analysis was aimed at discerning modes of lithic-material procurement and strategies for the manufacture of stone artifacts. Such data speak to the integration of lithic procurement and production within settlement and subsistence systems, potential participation in interregional exchange, and manufacturing preferences that might relate to cultural identity. Second, detailed analysis considered artifact function, focusing on aspects of artifact morphology and use surfaces. Analysis of such data for a site, as a whole, as well as for selected features or areas in a site, can reveal the types and range of activities undertaken, providing insight into site structure and function. In addition, such analysis can identify temporally diagnostic artifacts and address site chronology. Finally, detailed analysis considered additional artifact attributes that reveal artifact life history (see Skibo and Schiffer 2001). Hence, SRI's analysis could identify the context and needs behind individual decision-making, as well as site structure and formation processes (see Schiffer 1996).

As a precursor to detailed discussion of the results of these analyses, a brief summary of analytical methods and terminology is presented. This is followed by an overview of the "lithic landscape" of the Ballona and larger region, indicating the availability, distribution, and qualities of the lithic resources potentially used by the residents of the West Bluffs sites. The third section of this chapter provides a summary of previous studies of lithic artifacts from the three sites investigated. Detailed descriptive information for current site lithic collections is then provided, serving as the basis for subsequent interpretations of site activities and past lifeways. The interpretations are, in turn, presented in the final section, addressing lithic technology, procurement and exchange, and site and feature function.

Analytical Methods and Terminology

The stone artifact classification employed for the current study facilitated both description and interpretation, as various classes reflected different production technologies, material qualities and use preferences, and use histories. As outlined in Figure 8.1, the first order within the classification addressed production technology, distinguishing three general classes: lithic items shaped or produced (i.e., "reduced") by flaking; items generally shaped by grinding and/or battering; and so-called "expedient use" items, whose shape was largely unmodified for, or by, use as tools. Ground and battered items were considered together at this level, as many such tools reflected shaping by both methods. For example, pecking might have been used to define the general shape of the tool, but grinding was employed for final shaping or resulted from use. Unshaped objects reflected the expedient use of natural pebbles, cobbles, or tabular pieces such as for tarring pebbles or in thermal features, as well as damaged or weathered items insufficiently intact to identify whether they were intentionally flaked, ground, or battered. For example, highly deteriorated fire-altered rock was included in this category.

The second level in the classification further addressed technology and, to a certain extent, artifact function for flaked, ground, or battered stone items. At this level, flaked stone items were divided into debitage and tools, with the former representing unmodified debris resulting from flaked stone tool manufacture or use. Similarly, ground and/or battered stone implements were segregated into hafted and unhafted items at this level in the classification scheme, with the latter class encompassing items such as milling equipment, hammer stones, and pipes. Although shaped by grinding and, hence, encompassed in this class, stone beads and other lithic ornaments will be discussed separately, in Chapter 9. Hafted ground or battered stone implements might include grooved axes, mauls, or other implements modified to attach a handle. For the West Bluffs collection, however, no such artifacts were identified in the analysis sample.

At the third and lower orders of distinction for classification, more-specific shape and use details clarified artifact function and use history. Flaked stone tools were further subdivided into bifacial and nonbifacial implements, reflecting the degree of investment in planning, design, and production for specific, rather than general, functions. At this level, a distinction was also made between hafted and unhafted bifaces group, with a hafted biface modified on the proximal end for the purpose of attaching it to a handle or shaft. In the West Bluffs collection, all such items were projectile points. Likewise, flake tools were distinguished from core tools in the nonbifacial group, as these two categories of items often represented disparate functions based on characteristics of the working edge, material qualities, and/or weight of the artifact: a small flake scraper, for example, would have had a different function than a heavy chopping tool. For the purposes of this discussion, cores were included in the "core tool" category, although their function as tools, in most cases, was limited to serving as a source of tool blanks rather than for manufacturing, procurement, processing, or consumption in the traditional sense of such terms (see Thomas 1983). In the class of unhafted ground and/or battered stone objects, implements used for grinding were distinguished from those used for battering or pounding and objects serving as vessels. Likewise, "other" unhafted ground stone items may be identified, encompassing objects lacking obvious utilitarian function such as effigies.

Flaked Stone Analysis Methods

Debitage

As reviewed by Andrefsky (1998, 2001) and others (e.g., Odell 2004; Steffen et al. 1998; Shott 1994), various methods of debitage analysis have been employed by archaeologists to assess reduction strategies and describe particular technologies used to produce flaked stone tools. The simplest analytical approach is aggregate, or mass, analysis, based on a few general criteria such as flake size, weight, or shape (e.g., Patterson 1990; Stahle and Dunn 1982). The relative quantity of material within such categories was established and compared to debitage assemblages produced experimentally by known reduction methods. Such methods are unable to address more-detailed features of lithic reduction, however, and may only be sufficient to distinguish core from biface reduction, for example. In addition, aggregate debitage studies suffer when multiple technologies are present in a site (see Morrow 1997; Shott 1994).

As a result, typological approaches are often advocated instead of aggregate methods, although the level of detail recorded varies greatly between such studies. For example, some researchers have advocated discrimination of types based on only a few characteristics, such as the presence of cortex or flake completeness (e.g., Ahler 1989; Sullivan and Rozen 1985). Conversely, other analysts (e.g., Amick and Mauldin 1989; Prentiss and Romanski 1989) have maintained that this level of distinction is insufficient to identify technologically diagnostic traits. For these latter researchers, multiple traits of any given flake are used to ascribe each piece to a particular reduction technology and, even, a stage within a production sequence (e.g., Callahan 1979; Flenniken 1981). For example, flakes produced by percussion or pressure flaking are identified, although early- versus late-stage biface production may be discerned. In addition, specific features that provide evidence of a particular flaked stone tool manufacturing technique such as bipolar reduction or projectile-point notching are observed (e.g., Kuijt et al. 1995; Titmus 1985).

The attributes contributing to such detailed typological classifications include platform characteristics, prominence of the bulb of force, ventral surface topography, dorsal flake scar morphology, termination (i.e., distal end), and flake curvature. Such traits are usually assessed as qualitative rather than quantitative characteristics (cf. Andrefsky 1986; Dibble and Pelcin 1995; Wilmsen 1970), as metric analysis is time consuming and has often been found to be no more objective or informative than qualitative assessment (see Skinner 1986:483). Although critics have contended that definitions for any technological typology are too subjective, results may be difficult to replicate, or procedures are too time consuming (e.g., Ahler 1989; Sullivan and Rozen 1985), technological approaches have proven very valuable for prior studies in California and the Great Basin (e.g., Gilreath and Hildebrandt 1997; Skinner 1990) given the types of research questions addressed (see Steffen et al. 1998). Therefore, a technological debitage typology was used for the current analysis, with the relative frequency or presence of particular flake types providing a picture of flaked stone procurement and technology.

Following segregation by geologic material (see below), debitage was initially sorted into six size classes: specimens measuring between 0.0625 and 0.125 inches, 0.125 and 0.25 inches, 0.25 and 0.5 inches, 0.5 and 1 inches, 1 and 2 inches, and greater than 2 inches in minimum dimension. No attempt was made to distinguish between complete and fragmentary specimens within these groups in this initial sorting, but these data offered a general picture of the distribution of flakes by width (i.e., often the minimum dimension) rather than length, which is more often affected by breakage. When used in conjunction with other traits (see below), such data can provide a general sense of the size and nature of the parent piece (e.g., pebble or cobble, core or biface) and, hence, the quantity of toolstone available and the potential for production of particular tools (i.e., large projectile points cannot be produced from small pebble cores). Although weight can serve as a similar indicator of material quantity, this variable was not recorded, as the variety of lithic materials and small sample sizes rendered such data less informative.

Following size sorting, debitage was further segregated into one of three groups based on the amount of cortex on the dorsal surface: completely cortical (100 percent cortex), partially cortical (99–1 percent), and noncortical (0 percent). Replicative studies (e.g., Callahan 1979; Flenniken 1981; Tomka 1989) have demonstrated that flakes from earlier core reduction generally have more dorsal cortex, and that later-stage core reduction or tool production results in less dorsal cortex. Therefore, the relative quantity of flakes in these three categories of dorsal cortex coverage can serve as a convenient proxy for distance from the source, if lithic reduction proceeds from initial procurement and reduction of material at the geologic source area through subsequent reduction and transport of cores back to a habitation or use site. For example, if completely cortical or, to a lesser extent, partially cortical, flakes were present at habitation sites, lithic material was likely procured from outcrops or deposits relatively close to such sites rather than at a great distance.

As noted above, the combined characteristics of the platform, bulb of force, ventral face, dorsal flake scar morphology, longitudinal curvature, and termination type serve to identify the production techniques used and objectives of reduction (e.g., core or biface). During this step in the analysis, angular specimens that did not exhibit clear platforms or unambiguous detachment (i.e., ventral) surfaces were relegated to "shatter" (see Odell 2004:122; cf. Mauldin and Amick 1989:83; Morrow 1997:59), and broken pieces lacking a sufficient combination of traits to distinguish the specific reduction technology were segregated as "flake fragments." All of the remaining intact or broken debitage was identified as either core- or biface-reduction flakes based on attribute combinations. Core-reduction flakes, for example, were recognized by the presence of two or more of the following traits: wide, thick platforms with less acute platform angles; pronounced bulbs of force and compression rings indicative of percussion flaking; the presence of dorsal or platform cortex; simple dorsal flake-scar morphology (i.e., fewer, often unidirectional, flake scars); a thick profile relative to width; and lack of longitudinal curvature. Core-reduction flakes are also more likely to have hinge or snap terminations. The number of facets on the platform might have varied for core-reduction flakes depending on the degree of platform preparation and the degree of reduction. Debitage from biface reduction, on the other hand, generally has more-complex platforms (i.e., multiple facets) with more-acute platform angles; complex dorsal flake-scar morphology (i.e., more, often multidirectional, flake scars); a thinner profile relative to width than core-reduction flakes; feather terminations; and distinct longitudinal curvature resulting from the thinning of the lenticular cross section of the biface.

The expression of each trait for individual flakes will vary with completeness and the stage in the biface reduction sequence (discussed below), so identification of biface-reduction debitage was based on the preponderance of the evidence rather than the exhibition of all these archetypal traits. For example, dorsal-scar morphology tends to become more complex, then somewhat less complex, throughout the reduction continuum. Platform complexity and longitudinal curvature follow a similar trend when the entire sequence from percussion reduction through pressure shaping is considered. Such subtleties contribute to further distinction between early percussion, late percussion, early pressure, and late pressure biface-reduction flakes, drawing especially on the characteristics of platform preparation, the prominence of the bulb of force and compression rings, the width to length ratio, and dorsal-scar morphology. Specifically, pressure flakes tend to have small platforms that might have been prepared by scrubbing or grinding to prevent slippage of the flaking implement, a more diffuse bulb of force and less distinct conchoidal ripples, parallel rather than diverging flake margins, and few unidirectional dorsal scars, often with a single longitudinal arris.

Finally, specific flake types indicative of particular reduction trajectories or parent-material qualities were noted. For example:

- *Alternate* flakes (Crabtree 1982:14; Goldberg et al. 1990:389) are generally associated with the reduction of tabular stone or flake blanks with steep edges. Alternate flakes were detached along the obtuse edge of the core or blank by alternating the face serving as the platform as flaking proceeds along the margin, thereby reducing the steep, thick margin to a sinuous edge. Alternate flakes were identified by retention of a portion of the obtuse angle on the distal portion of the dorsal surface. These flakes also tended to be broad relative to length and had simple platforms that reflect use of the previous flake removal scar as the platform for the next alternate flake.
- *Popout* (i.e., interior collapsed platform) flakes had bulbs of force on both faces that were produced by percussion reduction. These flakes were formed between the bulb and removal scar of a parent flake and were detached simultaneously with—and from the same platform as—the larger flake as it was removed from the core (Dames and Moore 1994:Appendix 6-1; Goldberg et al. 1990:393).
- *Bipolar* flakes had sheared bulbs of force, distinct compression rings, crushed proximal and distal ends, opposing conchoidal ripples and dorsal flake scars, and, in some cases, a wedge shape (Crabtree 1982:16; Kuijt et al. 1995). Such flakes are associated with the reduction of small parent pieces such as pebbles or bifaces, from which removal of flakes of sufficient size for tool blanks would have been impossible by other percussion techniques.
- *Bulb-removal* flakes represent initial reduction of a flake blank through the percussion or pressure thinning of the bulb. These flakes were identified by a dorsal surface lacking negative flake scars and, instead, completely composed of the convex, bulbar ventral surface of the parent flake.

In addition, several other specific flake types related to biface, as opposed to core, reduction. For example:

- *Edge-preparation* flakes were removed from a biface edge to adjust the margin up or down relative to a particular face, facilitating subsequent flaking to thin or shape the tool. Therefore, these small flakes had wide platforms and tended to be wide in comparison to both length and thickness; the percussive force did not follow the flake's dorsal ridge. (Skinner 1986:487).
- *Margin-removal* flakes retained a large section of the biface margin on the platform. Such flakes were a consequence of detachment of the flake at greater distance from the biface margin than is generally desired in biface reduction, resulting in a "bite" from the tool margin that may lead to discard of the biface or significant subsequent modification to restore a regular edge. Therefore, margin-removal flakes usually indicate manufacturing errors.
- Similarly, *overshot* (i.e., *outrepassé*) flakes resulted from biface thinning, but in this case, retained a portion of the biface edge on the distal rather than proximal end (Callahan 1979:85; Crabtree 1982:46). Such flakes are also generally thought to represent manufacturing errors, although recent analysis of Clovis points, for example, has suggested that such outcomes might have been desired in the production of extremely thin, large bifacial tools (e.g., Stanford and Bradley 2002). In either case, the presence of overshot flakes indicates on-site tool manufacturing, as opposed to maintenance, activities.
- *Notching* flakes exhibited thin, narrow, concave platforms; feather terminations; a concave dorsal face often defined by a single dorsal scar that resulted in a crescent-shaped cross section for the piece; and a roughly circular plan view, except for the rounded indentation of the platform (Titmus 1985:251; see also Ainsworth 1987). These pieces indicate that notching—and, therefore, final finishing—of projectile points was carried out on-site.

As noted above, by considering material, flake size, cortical coverage, and flake type, typological debitage analysis can address a variety of research issues. For example, such data can reveal how different materials were procured and their relative distance from the source, the size of the parent pieces, and material-specific preferences for production of particular tools. These data also indicate the degree of investment in tool manufacture, which may reflect material availability or the types of activities conducted on-site.

Flaked Stone Tools

Bifacial artifacts were worked on both faces from more than one margin, with pieces exhibiting relatively great width to thickness (i.e., more than 2:1) and length to width (i.e., more than 1:1) ratios. Depending on whether such items were finished tools or pieces lost or discarded at earlier stages in the manufacturing process, bifacial artifacts ranged from formal implements with symmetrical outlines and cross sections to initially worked, irregular flake blanks or nodules. For this analysis, the primary attributes observed on bifacial artifacts included length, width, thickness, shape, the location and nature of breaks or residues, and characteristics of flaking that provide for determination of the stage in the reduction sequence and of artifact function. Description of flaking followed Crabtree (1982:51), who identified patterns ranging from "nonpatterned" and collateral flaking—often associated with early stages of reduction or less formal tools—to regular diagonal (i.e., oblique) or double diagonal (i.e., chevron) parallel flaking particularly characteristic of symmetrical finished tools. The location and nature of breaks on bifacial tools can identify use versus manufacturing damage (e.g., Whittaker 1987, 1994). Facial and edge burination, for example, results from impact damage to a projectile (Titmus and Woods 1986), but overshot and perverse fractures are usually due to manufacturing errors. Bending and radial breaks can result from either use, manufacturing, or postdepositional damage such as trampling, and a crenulated fracture reflects postdepositional heat damage. Finally, evidence of postdepositional damage, reworking, and reuse were also recorded. Postdepositional damage was identified by traits such as random surface etching from trampling and potlid fractures from heat, although such features are often limited to particular materials. Reworking and reuse are indicated by traits such as a low width to thickness ratio for the tool (i.e., less than 2:1), steeper edge angles (see Keeley 1980:19), and asymmetry of the blade or shoulders. Many of these traits reflect the fact that tool margins are moved closer to the midline of the tool face as damaged areas on the more fragile edges are reworked. In some cases, differential patination or weathering of flake scars can serve to identify reworking.

Several types of artifacts were encompassed by the biface category:

- *Projectile points* exhibit modified proximal ends that permitted hafting of the point to a wooden shaft. In the absence of damage or reworking, projectile points tend to be pointed at the distal end and symmetrical in outline and cross section. For the current analysis, projectile points were further classified into temporally significant morphological types on the basis of attributes such as basal width, stem shape, neck width, shoulder angles, and basal indentation (see Thomas 1981).
- *Drills* have long, narrow, pointed working bits, with the width of the bit approximately equal to its thickness. Such morphology facilitated punching or twisting the tool to create a perforation in hard or soft materials, and striations or other wear on the bit may reflect the specific motion of use. The shape of drill bases may vary, however, and this trait has been used to define specific drill types in California and elsewhere (e.g., Arnold 1992; Moratto 1972).
- *Bifaces* lack the distinctive characteristics of base or blade that would permit identification as either a projectile point or drill, and also often lack a pointed distal end. Therefore, this category encompassed both finished tools of more generalized function, unfinished pieces, and bifaces that might have served as cores particularly amenable to transport by residentially mobile people (see Kelly 1988).

Recognizing various stages in the manufacture of even unfinished bifaces can speak to raw material procurement, manufacturing decisions, production sequencing in a settlement system, and the desired outcomes of the producers (e.g., Andrefsky 1998; Callahan 1979; Muto 1971; Whittaker 1987, 1994). Therefore, for the current study, four of the five reduction stages outlined by Callahan (1979; see also Gilreath and Hildebrandt 1997:34–35; Skinner 1986; Whittaker 1994) were used to recognize the place of each biface in the reduction sequence and permit comparison with previous studies in southern California (e.g., Arnold 1992). Callahan's (1979) earliest stage (Stage 1) was omitted, as this type encompasses blanks not yet modified and, hence, is inconsistent with the definition of bifaces used for this study because such specimens represent potential, rather than actual, bifaces. Regardless of the stage sequence employed, however, lithic analysts generally concede that reduction was likely a continuous rather than the partitioned process of tool production that stages might imply, and such stages might not have been recognized in the mind of the maker.

- *Stage 2* bifaces represent initial edging through percussion flaking, with continuous or discontinuous removal of flakes from both faces and multiple edges of the piece, creating a rough preliminary shape and sinuous margin. The flake scars are typically confined to the edge rather than extending far across the face, and Andrefsky (1998:181; see also Callahan 1979:Table 5) noted that such pieces have width to thickness ratios between 2:1 and 4:1, and edge angles varying from 50 to 80 degrees. At the quarry sites of the Coso volcanic field, Gilreath and Hildebrandt (1997:35) noted that specimens comparable to Callahan's Stage 2 bifaces were worked along approximately 60 percent of the margin, "suggesting affiliation with a biface reduction trajectory, rather than a flake-production core trajectory."

- *Stage 3* bifaces also reflect percussion reduction, but at this stage, the piece begins to be thinned by removal of flakes that extend to the midline of the face or beyond. During this process, both the plan shape and margin profile become more regular and symmetrical, and the decreasing thickness is apparent in a width to thickness ratio of approximately 3:1–4:1 and an edge angle of 40–50 degrees (Andrefsky 1998:181; see also Callahan 1979:Table 5).
- *Stage 4* bifaces, often referred to as "preforms" (see Gilreath and Hildebrandt 1997:35; Andrefsky 1998:181; cf. Whittaker 1994;156), represent a shift from thinning to shaping, and display initial pressure flaking that facilitates such refinement. The margin becomes straighter in profile, and the piece may become even thinner, as indicated by a width to thickness ratio of 4:1–6:1 and an edge angle of 25–45 degrees (Andrefsky 1998:181; see also Callahan 1979:Table 5).
- Finally, *Stage 5* bifaces exhibit significant, contiguous pressure flaking, straight margins, thin cross sections, and bilateral symmetry characteristic of finished tools. Width to thickness ratios and edge angles are in the same range as Stage 4 bifaces, but edge details such as serration may also be present.

These characteristics of stages pertain especially to the reduction of cores or large flake blanks. For smaller flake blanks, pressure flaking may be evident prior to Stage 4.

Nonbifacial flaked stone tools represent a less substantial investment in planning, design, and execution than bifacial implements, in part because such items need not be symmetrical for service as projectiles or for hafting. As noted above, this category included both flake and core tools, as well as cores. Although some of these implements might have been bifacially worked, they lacked the lenticular cross section and bifacial modification around the majority of the margin that are characteristic of the bifacial group. On nonbifacial tools, one or more margins provided the working edge, in contrast to bifacial implements, which generally served a function in their totality. Attributes recorded for nonbifacial tools include blank type (flake or core) and size; type, location, and extent of flaking; working-edge angles; location of residues; postdepositional alteration; and use damage such as spalling, pitting, microflaking, rounding, and polish that can identify artifact function (see Keeley 1980). For the lithic analysis sample from the West Bluffs sites, the nonbifacial flake tools identified include burins, edge-modified pieces, and scrapers, whereas core tools included choppers and cores.

- *Burins* have a beveled, chisel-like working edge formed by a single parallel flake removal along the longitudinal edge of a flake (Crabtree 1982:27). These tools were used for engraving of wood, bone, or similar materials.
- *Choppers* are relatively thick, fist-sized, core tools, with unifacial or bifacial working along a single edge that displays a moderate edge angle (e.g., 50–80 degrees) and, in many cases, spalling, edge dulling, or edge or facial faceting from impact. The end opposite the working edge on a chopper may be unworked or otherwise rounded to facilitate handling and minimize discomfort to the user. Likewise, to withstand significant impact during use and permit grasping in one hand, choppers tend to be roughly equal in length and width. The thickness may be nearly equal that of the width.
- *Scrapers* were distinguished from edge-modified pieces by the extent of the flaking along the edge, the invasiveness of the flaking across the face, and edge angle. Specifically, scrapers tend to exhibit more continuous and substantial (i.e., not simply marginal) modification, as well as steep edge angles (approximately 70–90 degrees) that would have prevented both inadvertent cutting of the material being worked, and failure or significant edge attrition when scraping hard materials (see Andrefsky 1998:193; Keeley 1980).

- *Edge-modified pieces* were a catch-all category of tools exhibiting at least three contiguous flake scars along one edge, that were presumed (as a result of continuity and morphology) to reflect purposeful modification or use rather than postdepositional damage. Sometimes termed "utilized flakes," a more generic moniker was favored for this type, as both the origin of the modification (i.e., use versus intentional retouch) and the potential function of the implement was sometimes unclear. In addition, the "piece" might have been either angular shatter or a flake (see above).
- *Cores* were unique in the nonbifacial category, as they represented sources of raw material rather than implements used for a task. The number of flake detachments could range from just one to several, as indicated by negative flake scars. In some cases, cores may be very formalized, permitting controlled production of flakes of a specific size and shape (e.g., blades). In other cases, cores may be less structured, with reduction taking advantage of the particular shape and size characteristics of the parent material to produce less standardized flake blanks. Therefore, several types of cores were identified for the current analysis, focusing on the direction of flake removals as an indicator of the type or formality of the reduction process. Core types recognized included unidirectional, bidirectional, multidirectional, and bipolar. As noted above, the latter is usually associated with flake production through percussion of small parent pieces, such as pebbles, that are difficult to reduce by other methods. Unidirectional cores, on the other hand, are generally associated with more formalized flake production working from a single, often prepared, platform.

As this review highlights, classification and analysis of specific characteristics of bifacial and nonbifacial flaked stone tools can provide insight into the degree of investment in stone tool manufacture, the types of activities conducted on-site, and the potential curation and reuse of tools. All of these factors address site function and the integration of flaked stone reduction into settlement and subsistence activities. In addition, these data may provide insights into material availability and lithic production that complement and expand on interpretations made possible through debitage analysis.

Ground and/or Battered Stone Tools

Unlike flaked stone tools and debris, implements shaped by grinding and/or battering have often presented a challenge to lithic analysts, as a comprehensive synthesis and formal guidance for describing and interpreting such tools has only recently been published (Adams 2002). Likewise, this class can be ambiguous, since many of these objects were also used for grinding and pounding rather than simply being shaped by such techniques. Adams (2002) was clear, however, about the need to distinguish attributes related to design and manufacture from those reflecting function, kinetics, and wear. Detailed analysis and recognition of types focused on attributes pertaining to the latter three characteristics.

Adams also made important observations about how ground or battered stone implements entered the archaeological record (e.g., through discard). Detailed consideration of such specimens with respect to site formation processes is clearly warranted given the potential for recycling of ground or battered stone tools or tool fragments for uses significantly different from their original function. At West Bluffs, for example, many fragmentary items were reused in thermal features such as hearths. Such reuse was common because the material characteristics that favored use for ground or battered stone tools also contributed to utility in this very different context. In contrast, such utility was not usual for flaked stone tools, as material selection was based on fracture mechanics that undermine application to significantly different tasks. Macroscopic observation of damage apparently unrelated to the primary use of ground or battered stone tools was a critical aspect of the current analysis, and included comparing the dulling of fractured surfaces and rounding of adjacent edges to discern such potential postdepositional damage as trampling and subsequent reuse.

All additional traits recorded for ground or battered stone tools for the current analysis were also based on macroscopic examination, although Adams (2002) incorporated microscopic observations into her analysis scheme. Likewise, a conservative approach was invoked for recognition and classification of tools in this class, in general, as many pieces initially identified as ground stone in the field were relatively small fragments. Given the generally small artifact size, it was often impossible to determine during analysis if such pieces were highly shaped and polished tools or naturally waterworn cobble fragments. This was especially true given that such cobbles were very common, as indicated by analysis of the complete lithic collection. In such ambiguous cases, fragmentary specimens were relegated to "manuports" in the expedient-use class rather than being considered as ground stone tools (see also Elston 2004). By ascribing ambiguous pieces to a class lacking an implied function, ground stone representation was not inflated, and concomitant errors in functional assessment of sites or features were avoided. Likewise, the relative rarity of highly worked ground stone implements suggested that this analytical practice was unlikely to result in significant underrepresentation of potential ground stone tools in interpretation, and the fragmentary nature of all such objects undermined quantitative analysis, in general. As noted above, remaining implements were ascribed to one of four functional groups: grinding, battering/pounding, vessels, and other.

Grinding tools reflect the use of friction between two stones through reciprocal (i.e., back-and-forth) or circular motion to process animal, vegetal, or mineral materials. The attributes recorded—and contributing to the recognition of an artifact's function—for grinding tools include the material, size (i.e., length, width, thickness), shape, cross section, number and morphology of use surfaces, extent of grinding (i.e., wear level) (Adams 2002), evidence for deliberate breakage (i.e., "killing"), and the nature, location, and orientation of use wear such as striations or polish (see Adams 2002). The latter wear may result from either adhesive wear associated with handling or grip of the tool, or from contact between the stone implements during tool use. Although the majority of the attributes observed and recorded relate to function, the extent of grinding is often a reflection of both manufacture and use. For the current analysis, this trait permitted assignment of each specimen to one of four "stages." *Stage 1* implements were ground only on the highest points of the natural surface topography, reflecting initial preparation or use of the tool. *Stage 2* implements exhibited grinding on nearly 50 percent of the surface, but nearly 75 percent of the surface was ground for *Stage 3* tools. Therefore, both Stage 2 and Stage 3 tools reflected the extension of grinding into low (or previously low) natural surface topography as manufacture or use progressed. *Stage 4* tools reflected resharpening through pecking or other roughening of the surface, presumably after the tool had achieved maximum life of the existing use surface. *Stage 5* implements were thoroughly ground and smooth over the entire use surface. Such surfaces were completely or nearly exhausted.

Specific artifacts used for grinding were identified by the combination of such attributes.

- Following Adams (2002:13), *manos* were "handstones" used to grind materials on an underlying "netherstone." No restriction in the material processed or motion of use is implied by the use of this term for the current analysis, although Southwestern archaeologists sometimes make a distinction between manos and handstones based on the material processed (i.e., manos process corn; see Adams 2002:13) and some California researchers (e.g., Mikkelsen 1985) make such a distinction based on motion (i.e., reciprocal motion for manos, rather than circular). Manipulated by gripping in one or both hands, manos might have had single or multiple working surfaces that varied from flat to convex in cross section. In addition, these pieces might have been shaped by pecking to a particular size or form to facilitate handling, whereas others simply might have been naturally shaped cobbles.

- *Metates* served as the netherstones to manos in the West Bluffs analysis, although again, no processing restrictions or directionality of motion is implied by the use of this term in lieu of "milling stone" (cf. Mikkelsen 1985). Metates and their use surfaces vary in size and shape. The latter may range from flat to deeply concave (i.e., basins), and implements may exhibit one or two use surfaces. For both manos and metates, wear, if visible, is in the form of abrasion (i.e., striations), polish, or sheen, consistent with the rubbing together of implements in the process of grinding vegetal materials, animal products, or minerals such as pigment. In some cases, the fragmentary nature of the piece prohibited distinction as either a mano or metate, although the presence of a flat working surface suggested that one of these grinding implements was represented. Such fragments were simply categorized as "unidentifiable ground stone."

- *Shaft straighteners* reflected friction of a wooden shaft within a groove on the face and/or edge of the stone implement. Such tools might have had one or several such grooves, perhaps reflecting serial use as one groove ceased to provide the desired shape with increasing depth and another groove was initiated. The location (e.g., only on one face) and nature (e.g, irregular depth) of grooves was such that they did not appear to be features related to potential hafting. Other features of wear that were consistent with hafted tools (e.g., impact damage) are also absent.

Battered tools may reflect pounding or hammering. Similar to grinding implements, attributes observed included material, size (i.e., length, width, thickness), shape, cross section, number and morphology of use surfaces, type and location of residues, and the nature, location, and orientation of use wear, such as spalling from impact, striations, or polish. Several categories of implements were encompassed here, including hammer stones, anvils, pestles, and mortars.

- *Hammer stones* are generally unshaped pebbles or cobbles that are pitted or spalled from impact and, therefore, were considered battered stone tools rather than expedient-use artifacts. Such implements might have been used to crack or crush material on an anvil or to remove flakes from cores or tools. The size and shape of the use surface, which may be located on the face or edge of the hammer stone, may indicate the artifact function and control of motion exerted during use. For example, a narrow band of micropitting along one edge implies more-focused use for biface reduction, for example, than a broad area of rough pitting on a face likely related to plant processing.
- In contrast, *pestles* are shaped implements, usually cylindrical to conical in shape, with wear from pounding restricted to one or both ends. Such tools may be round to oval in cross section, and the proximal end may be shaped for decoration or to enhance grip.
- *Anvils* are netherstones used in pounding that varied in size and shape, but have one or more distinct areas of pitting on one or more faces as a result of impact while materials were cracked or crushed. Similar to hammer stones, anvils often indicate the expedient use of natural stones with flat surfaces rather than purposeful shaping.
- *Mortars* serve as netherstones for pestles and, similar to their counterparts, were shaped to facilitate use. These tools had slightly to deeply concave working surfaces, reflecting a range from hopper mortars to more substantial, bowl-shaped implements. In the latter case, the distinction between a function as a mortar or bowl may be difficult to establish unless unambiguous use wear is present in the base of the vessel, or characteristics of wall thickness (i.e., thin) or material (e.g., steatite) argue against their use as netherstones. This functional ascription is further complicated when only a fragment of the tool is present, and so, in the current analysis, ambiguous fragments were simply categorized as "unidentifiable ground stone."

Stone vessels were identified on the basis of size, shape, and material, as well as the absence of use wear associated with grinding or pounding. Attributes observed included material; length, width, and thickness; shape; depth and diameter of the aperture; and the location and nature of residues and post-depositional alteration. More-detailed metric or descriptive characteristics, such as those considered in ceramic vessel analysis (e.g., Shepard 1980; Sinopoli 1991), were not employed, given the reductive rather than additive technology of stone vessel manufacture. This technology results in less variety in vessel forms, detail, and decoration, as, for example, the size and shape of the parent material can significantly influence vessel form. *Pipes* were included in this category, as they served as vessels to hold and smoke tobacco. For the current analysis, all remaining stone vessels were categorized as *bowls*, despite the fact that this group encompassed substantial variety in size, shape, and depth.

Finally, ground or battered stone artifacts not included in these three functional groups were classified as "other" ground or battered stone objects. This group included *cogged stones, discoids,* and *effigies.* Although the last category could include highly variable and idiosyncratic items of geometric, anthropomorphic, or zoomorphic shapes, the first two categories were more formal, and types have even been defined for cogged stones (Eberhart 1961). Both cogged stones and discoids were highly shaped pieces that were round in plan view and roughly rectangular in cross section. A central perforation was also sometimes present. Cogged stones were distinguished from discoids by the presence of parallel longitudinal grooves of more or less consistent width and depth around the perimeter of the artifact. Following Eberhart (1961), types of cogged stones include "fish-vertebra" and "land-and-groove" types, which may or may not have a central perforation; "intermediate perforated"; and "intermediate imperforate." These four types are distinguished primarily by the length and depth of the grooves. The number of grooves, however, can vary within and among types. As noted above, other ornamental objects shaped by grinding—such as beads and pendants, which were in the "other" category—will be discussed in Chapter 9.

Unshaped Stone Artifacts

As noted above, this class of objects encompassed cultural items whose shape was unmodified for, or by, use as tools. Residues, postdepositional alteration, or context of recovery indicated their cultural significance, although their use as tools in a traditional sense is often undeterminable due to the absence of use surfaces. For the West Bluffs collection, this class included manuports, tarring pebbles, and fire-altered rock. *Manuports* are unmodified pebbles, cobbles, or tabular pieces transported to the site from elsewhere. As noted in Chapter 4, the West Bluffs sites were located in dune deposits that lack natural stones. Therefore, any rocks found in the deposit were culturally transported, and those not identifiable as flaked, ground, or battered stone objects were deemed manuports. The potential use history of such objects was unclear, although many show fire damage (i.e., fractures, discoloration) that suggest their latest use was in thermal features. *Tarring pebbles* are intact or broken stones that are entirely covered by traces of asphaltum. Ethnographic data (e.g., Kroeber 1925:561) stated that these were used to coat the interior surfaces of baskets with asphaltum to seal the vessels for liquid storage (e.g., canteens). *Fire-altered rock* are pieces so extensively thermally damaged that whether the pieces were manuports or ground or battered stones cannot be discerned.

The Lithic Landscape

As the above review suggests, the techniques for manufacture and the array of stone tools potentially produced by the inhabitants of the West Bluffs sites were diverse. Individual tools might have served as projectile points, cutting or scraping implements, hammers, choppers, milling tools, or vessels. Others might have functioned in more than one capacity concurrently or in sequence over the lifetime of the tool. Given the diverse functions to which stone tools were applied and the three primary methods of shaping such objects (i.e., flaking, grinding, or battering), it is not surprising that material selection figures prominently in the process of stone-tool production and use. For example, only certain materials are suitable for flaking, and the durability or sharpness of particular materials may favor use for one type of implement rather than another. Conversely, although material selection was not arbitrary, it was constrained by availability and, therefore, artifact production and morphology was adapted to the local lithic environment (e.g., Skinner et al. 1989).

Geological data suggested that the lithic landscape of the West Bluffs sites was diverse, indeed. Significantly, such diversity was not simply due to the "local" bedrock geology, but also to the potential transport of diverse materials into the area by both natural and cultural means. In the latter case, a variety of sedimentary, igneous, and metamorphic deposits in and around the Los Angeles basin were potentially accessible directly or through trade. In the former case, the hydrologic features of the basin—most importantly, the Los Angeles and San Gabriel Rivers and Ballona Creek itself—would have transported "exotic" lithic materials to the Ballona area. Therefore, it was not sufficient merely to identify material preferences: it was important to understand what materials were available in the lithic landscape, how cultural and natural transport might have affected material acquisition and production technology, and how both might have been integrated in the subsistence and settlement system. "Local delivery" of distant materials through natural means is significantly different than cultural acquisition, which carries further implications about mobility, territoriality, and group interactions.

Lithic Materials and Distribution

As noted in Chapter 4, the West Bluffs sites were located in dune-sand deposits, which border much of the coast from Centinela Creek to the Palos Verdes Hills (Jennings 1962). Thus, these sites were located in a zone naturally lacking stone, and lithic deposits are also absent from the Pleistocene marine deposits that characterize the Baldwin Hills to the east and areas in Santa Monica and West Hollywood just south of the Malibu Coast Fault (Jennings 1962; Jennings and Strand 1969). Lithic materials were readily at hand, however, as much of the surrounding terrain of the Los Angeles basin to the north and east, including the deposits along nearby Centinela and Ballona Creeks, is characterized by geologically recent alluvium consisting of clay, silt, sand, and gravel (Jennings 1962; Jennings and Strand 1969). In geological terms, these latter clasts encompass moderately to highly waterworn pebbles (between 4 and 64 mm in maximum dimension), cobbles (64–256 mm), and boulders (larger than 256 mm), with their origin in the bedrock deposits of the mountains surrounding the Los Angeles basin. Similarly, some pockets of Pleistocene nonmarine deposits in areas of the basin such as downtown Los Angeles also contain gravels or conglomerates that could have provided lithic material (Jennings 1962).

Although quantitative data were not available, we can anticipate that, because the clasts in the alluvial deposits in the immediate vicinity of the Ballona were far from their original source, they would have tended to be dominated by pebbles and cobbles (see below). Therefore, these relatively small and rounded clasts would have presented challenges to a flint knapper, but provided opportunities for the production of certain ground or battered stone implements. In flint knapping, the lack of acute angles for platforms and an absence of ridges to direct predictable flake removal would have influenced initial core-reduction strategies. For example, a pebble or cobble might have been split by free-hand percussion or bipolar reduction to remove flakes from the interior, in contrast to initial core-reduction by removing flakes from the entire natural, exterior surface. Moreover, such pebble or cobble reduction might have influenced the amount of dorsal cortex in the debitage (see above). In ground and battered stone technology, on the other hand, water wear and water transport might have provided stone clasts of the roughly desired size and shape for tools, thereby minimizing the effort needed. As a result, we might anticipate little to no debris from the initial shaping of such implements, including initial flaking prior to shaping through pecking and grinding (e.g., Schneider 1993).

As noted above, however, prospecting activities need not have been limited to alluvial deposits, and bedrock outcrops of sedimentary, igneous, or metamorphic stone were present at somewhat greater distances from the West Bluffs sites. We might anticipate the use of distant sources, for example, if a particular material was not available in the alluvium (e.g., steatite from Santa Catalina Island) or if the objects to be manufactured required parent pieces larger than those available in secondary deposits. To the north, the Santa Monica Mountains are composed primarily of middle to late Miocene marine sedimentary rocks, including sandstone, siltstone, conglomerate, and shale. Chert, sedimentary breccia, schist, and rare limestone are also associated with formations of this age in this area, and flow and pyroclastic Miocene volcanic rocks such as breccia, tuff, andesite, and vesicular and porphyritic basalt are also present. In contrast, to the northeast of the Los Angeles basin, the San Gabriel Mountains are dominated by Mesozoic granitic rocks—including granite, granodiorite, quartz monzonite, quartz diorite—and, to a lesser extent, gneiss. Older Precambrian granitic rocks, including quartz-rich granitics and gabbro, are also present in the northern portion of the San Gabriel Mountains. At the western end of the chain, Pre-Cretaceous metasedimentary rocks such as graphite, biotite schist, quartzite, and rare limestone and dolomite exist in formations near the Los Angeles River. To the east of West Bluffs in the Puente Hills, Miocene sandstone, conglomerate, siltstone, shale, and andesite tuff are present, and similar rocks are found extending to the south, at Newport Beach and beyond. To the southeast, the Santa Ana Mountains include Upper Jurassic marine sedimentary and metasedimentary rocks, as well as metavolcanic rocks of similar or somewhat earlier age. The latter include tuff, breccia, andesite agglomerates, and diabase, whereas the former include metashale, slate, quartzite, graywacke, conglomerate, and limestone. Closer to West Bluffs, the Palos Verdes Hills are dominated by middle Miocene marine sedimentary rocks such as shale, chert, siltstone, sandstone, and conglomerate. Intrusive basalt and some metamorphic rocks, including schist and quartzite, are constituents of relatively minor formations also present in this area. Finally, Santa Catalina Island was the potential source of diverse and distinctive lithic materials, including serpentine, talc (i.e., steatite), chlorite, dacite porphyry, schist, gneiss, andesite, and basalt. Volcanics such as tuff breccias, ash, and pumice are also present, as is limestone.

Identifying all lithic materials to their most specific classification was beyond the expertise of the author, particularly in light of the diversity of materials used. In addition, water wear or thorough grinding undermined material identification, since the dimensional quality of the crystalline structure of minerals was erased. Likewise, thermal damage and other postdepositional alteration obscured crystalline structure, cleavage planes, and other features, thus hampering identification. It was possible, however, to identify rocks at least on a general, if not more specific, level. Table 8.1 briefly summarizes the qualities of the igneous, sedimentary, and metamorphic rocks identified in the West Bluffs collection and the types of manufacturing technologies to which they are suited.

Previous Lithic Studies at LAN-63, LAN-64, LAN-206, and LAN-206A

As reviewed in Chapter 3, substantial lithic collections were recovered during the previous excavations at LAN-63, LAN-64, LAN-206, and LAN-206A as a result (Van Horn 1987; Van Horn and White 1997). These investigations provided a general picture of the artifacts and features present, and an outline of the temporal components at each site. Such components were identified on the basis of lithic and nonlithic artifact collections, stratigraphy, and such chronological data as radiocarbon dates and obsidian hydration results. Construction of cultural chronology and, to a lesser extent, definition of site function appear to have been the major goals of that research.

Therefore, these previous studies primarily described the lithic artifacts. The reports provided the general morphological attributes contributing to the definition of various functional categories or types of tools. In addition, a review of the frequency, depth of recovery, and material types for most items in each of these categories is provided. Some fragmentary specimens, however, were omitted from the analysis, given the reliance on morphology. Together, these data generally characterized the collections, defined components, and addressed site function. The reports presented only limited technological interpretations for selected artifact categories such as cores and "potato" flakes, and behavioral interpretations beyond functional ascription—which was sometimes based on unspecified criteria—were rare. Still, these reports provided an important summary of the types and distribution of lithic artifacts at each site.

A variety of flaked and ground stone implements were identified in the previous excavations at LAN-63, with a somewhat less diverse but similar collection at LAN-64 (Freeman and Van Horn 1987). In addition to debitage, flaked stone items identified at one or both of these sites included backed denticulates, bladelets, choppers, cores, crescents, drills or reamers, knives, notched flakes, potato flakes, projectile points, scrapers, "slugs" (i.e., foliate pieces possibly used for drilling [Freeman and Van Horn 1987:86]), spokeshaves, retouched flakes, and utilized flakes. Ground stone objects included abraders, anvils, a charmstone, a digging-stick weight, discoids, hammer stones, manos, metate fragments, mortars or bowls, a net weight, pestles, a stone tube, and stone pins. Finally, ornamental objects included beads, pendants, a perforated stone, and a schist ornament, and the remaining lithic items included tarring pebbles, "asphaltum-stained rocks," fire-affected rock, and a pecked pebble.

As noted above, few technological or behavioral interpretations were part of the analysis. For example, no technological data were derived for the chert debitage collection, despite the dominance of this material. Discussion was limited to the density of such flakes in various portions of the deposits. Likewise, the authors mentioned only in passing the technology that produced the obsidian flakes, noting that dorsal flake-scar morphology indicated that these pieces were related to the reduction of bifacial tools. A similar interpretation was offered with respect to fused shale debitage, although in this case, flake size was the attribute used to infer bifacial reduction (Freeman 1987:240; Freeman and Van Horn 1987:60–61).

The authors identified several types of cores, and based their distinctions between "macro" and "micro" industries on core size. "Macro" cores included single-platform, split-cobble, amorphous, tortoise, and ovate cores. "Micro" cores included pebble cores, microcores, and chisel cores. This last is a particular type of bipolar core with subsequent flake removals, whereas microcores are simply thoroughly reduced pebble cores lacking cortex. The remaining pebble cores, on the other hand, included single-platform, amorphous, spilt-pebble, tortoise, and bipolar types. Again, the horizontal and vertical distribution of these various types in the site deposits were the focus of discussion, with little or no examination of the significance of these types to technology or behavior. The authors noted, however, that split-cobble cores were used to produce distinctive "potato" flakes, and that bipolar reduction produced bladelets used for microdrills (Freeman and Van Horn 1987).

Similar to the debitage and core collections, the various kinds of flake and core tools were segregated by material and counted, with some discussion of the vertical and horizontal distribution of most categories. In addition, regional temporal information for types (e.g., of projectile points, crescents) was incorporated, if available. For some of these tools, the discussion also included reference to use wear, edge damage, and/or the presence of residues such as asphaltum on specific tools or within the class, as a whole. The mode of tool production was also sometimes discussed, particularly for those types common to the West Bluffs sites but rare or absent in many other collections from the region. For example, "potato" flakes were identified as wedge-shaped pieces with cortical platforms and lateral edges that were removed as "slices" from waterworn cobbles. Similarly, cobble heel scrapers were half or quarter sections of waterworn cobbles with steep working edges on the broken face. For many categories of flaked stone tools, however, artifact attributes such as reworking and breakage types that could address artifact use life were not identified or discussed. Analysis of ground stone implements was much the same, focusing on types, frequency, distribution, and chronology.

As noted in Chapter 3, these previous investigations concluded that LAN-63 was primarily used during the Middle period (ca. A.D. 500), as indicated by radiocarbon dates, obsidian hydration results, and the recovery of Canaliño and somewhat later Marymount points (Van Horn 1987:268). These two projectile types were small arrow points, but Gypsum Cave, Pinto, large concave base, bipointed foliate, and leaf-shaped dart points were also recovered. These other types hinted at somewhat earlier use, also (Freeman and Van Horn 1987:106; Van Horn 1987:269), although that such items might have been scavenged from elsewhere by the Middle period occupants was not considered. LAN-64 also showed roughly contemporaneous use during the Middle period, with artifacts such as Canaliño points contributing to this conclusion. Similar to LAN-63, however, Gypsum Cave, bipointed foliate, and large, convex-based dart points were present, and a Cottonwood Triangular point postdating the Middle period was also recovered. Freeman (1987:246; see also Van Horn 1987:269), however, dismissed this later specimen as intrusive.

Analysis of the lithic collections from LAN-206 and LAN-206A was much the same as those completed for LAN-63 and LAN-64 (see Van Horn and White 1997). In this case, however, the collections were much smaller and less diverse, and even fewer interpretations of technology and behavior were offered. Flaked stone items from these sites included a biface, choppers, cores, debitage, drills and microdrills, a projectile point, scrapers, and utilized flakes. Ground and battered stone tools included abraders, cogged stones, a discoidal, hammer stones, manos, and metates.

As discussed in Chapter 3, three temporal components were recognized at LAN-206, and lithic artifacts contributed to the definition of these periods of use (Van Horn and White 1997:20–22). Component C dated to the Millingstone period (ca. 4500 B.C.) and was recognized in part by the presence of cogged stones and the relative paucity of other ground or flaked stone tools. Component B dated to the early Middle period (ca. 1000 B.C.) and, though it lacked temporally diagnostic lithic artifacts, contained abundant milling equipment; some flaked scrapers first appeared in this component also. Finally, Component A dated to the late Middle period (ca. A.D. 200). This component encompassed the bulk of the debitage and ground stone tool collections, and microcores, microdrills, and obsidian are also associated with this period of use. The single projectile point from LAN-206 was a nondiagnostic base fragment. Van Horn and White (1997:25) concluded that the cultural materials at nearby LAN-206A reflected use contemporaneous with Component A, although this conclusion was based on data other than lithic artifacts.

Other sites in the vicinity of the West Bluffs sites have also been excavated and their lithic collections documented, (e.g., Altschul et al. 1992, 1999, 2003; Grenda et al. 1994; Van Horn 1983, 1984; Van Horn and Murray 1984, 1985; Van Horn and White 1983). In some cases, the discussions of the lithic artifacts were similar to those in the previous studies from LAN-63, LAN-64, and LAN-206: primarily descriptive and only peripherally addressing technology or behavior. In other cases, however, the reports went beyond simple description and considered technology, exchange, and other research issues. Therefore, although some of these sites might have been used during periods other than those represented at LAN-63, LAN-64, and LAN-206A, comparison of the lithic analysis results for the current investigation with these other sites may inform our interpretations.

Analysis Results

As noted above, only a sample of the lithic collection from each of the three sites was analyzed in detail. This study concentrated on a subset of features, with the ultimate intent to infer the full range of past activities, behavior, and practices reflected in the feature assemblages, rather than limiting the analysis to artifact description or interpretations of technology. In this way, our analysis would augment the chronological and descriptive focus of earlier investigations (e.g., Van Horn 1987; Van Horn and White 1997), which largely reflected nonfeature contexts and, thus, discussed results primarily in terms of artifact categories for each site, as a whole, or by temporal components identified therein.

Our selection of features for the current analysis sought to sample the range of potential feature types that contained sufficient lithic artifacts to represent activities; we particularly included complex features in which lithic artifacts were abundant. Due to the paucity of lithic artifacts in some features, however, possibly not all types of features were represented in the analysis. Likewise, the sample might also have underrepresented features with abundant but relatively small lithic items (e.g., flake concentrations) that would have been difficult to identify given the field discovery methods. As noted in the site-specific discussions below, additional samples from 50-by-50-cm control columns and potentially temporally diagnostic or unusual point-provenienced artifacts were also analyzed.

LAN-63 Lithic Sample

The lithic analysis sample for LAN-63 included all items from features excavated in 2000, all items from selected features excavated in 2003, a sample of items from Feature 587 excavated in 2003, all projectile points and other bifacial tools, and special items such as beads and effigies (see Table 8.4 for list of analyzed features). A total of 3,224 flaked, ground, battered, and unworked stone pieces were identified in a total collection of approximately 37,200 lithic items. The flaked stone in this collection included 58 cores; 37 edge-modified pieces; 35 bifaces or biface fragments; 32 choppers; 18 scrapers; 6 projectile points; 1 borer; 1 burin; 1 drill; 1 graver; and 1,329 flakes. The ground and battered stone collection included 72 mortar, bowl, or other vessel fragments; 55 manos or mano fragments; 41 pestles or pestle fragments; 31 metate fragments; 19 hammer stones; 6 anvils; 6 perforated "disks;" 13 beads (discussed in Chapter 8); 5 discoids; 6 pendants or pendant fragments (discussed in Chapter 8); 2 cogged stones; 2 shaft straighteners; 2 pipes; 1 effigy (discussed in Chapter 8); and 817 pieces of unclassifiable ground stone, including steatite detritus. The analysis sample include 555 manuports, 41 pieces of fire-affected rock, and 32 tarring pebbles.

Debitage

Detailed technological analysis was performed on 1,329 pieces of debitage: 316 from three 50-by-50-cm control column units, 1,008 from features, and 5 others from point-provenienced or excavation unit samples. As summarized in Table 8.2, this collection was dominated by chert, with lesser quantities of quartzite, metasedimentary rock, chalcedony, nonspecific igneous rock, rhyolite, and obsidian. Granite, limestone, and nonspecific sedimentary flakes were rare, reflecting the unsuitability of such materials for flaked stone tool production. In fact, some of these items might have been detritus from core tool or hammer stone use rather than purposeful flake production. Quartz was also rare.

The largest flake-size class contained only quartzite, metasedimentary, nonspecific igneous rock, rhyolite, and granite (see Table 8.2). Therefore, these materials were likely brought to the site in parent pieces larger than those typical of other materials. In addition, metasedimentary, nonspecific igneous, and rhyolite pieces might not have been reduced as extensively as other materials, as flakes in the smallest size class were rare for these materials. Although the higher proportion of small flakes in other materials might be explained by those materials' fragility—56 percent of the smallest chert flakes were fragments—the proportion of flake fragments in the sturdier metasedimentary, nonspecific igneous, and rhyolite collections was roughly comparable, ranging from 33 to 56 percent.

The cortex data suggested that at least some of the limestone, rhyolite, metasedimentary, nonspecific igneous, chalcedony, and chert were introduced to the site as unworked nodules, which were subsequently reduced on-site. On-site reduction was most extensive for chert and chalcedony, although it was also substantial for quartzite, nonspecific igneous rock, and metasedimentary. Diagnostic flakes (i.e., not flake fragments) with complete dorsal cortical coverage were also prevalent in these lithic materials (Table 8.3). Obsidian and quartz, on the other hand, were introduced in significantly reduced forms.

The sample size for any given feature or control column was relatively small, but these two provenience types were examined separately for general technological trends; flake fragments lacking such diagnostic traits were omitted. Figure 8.2 shows the relative representation of various toolstones in four different technological categories for the three control-column samples (n = 217). All of the materials were represented in the flake-core reduction debitage, but only obsidian, chert, chalcedony, metasedimentary, and quartzite were reduced on-site for bifacial tools. Obsidian, in particular, stood out as overrepresented in the latter category, with quartzite and, to a lesser extent, metasedimentary underrepresented in comparison to the other toolstones in the biface-thinning category. As suggested by the data for the whole site, biface-thinning flakes were mostly in the two smallest size classes (n = 65; 94 percent). Although this was likely due in part to the relatively small size of bifaces being thinned, pressure flaking was well represented in the biface-thinning sample (n = 58; 84 percent). Early pressure flaking was especially common in the pressure flake group (n = 44; 77 percent) and, in general, pressure thinning flakes tend to be smaller than percussion thinning flakes. One biface-thinning flake was a notching flake, however, further supporting the interpretation that some late-stage bifacial tool finishing was carried out on-site.

With respect to core-reduction flakes, the control-column data indicated that completely cortical flakes were rare, present only in the metasedimentary group, and most core-reduction flakes were noncortical (Figure 8.3). The cortical flakes, however, suggested many materials were brought to the site in natural or less-reduced forms. Rhyolite cobbles, in particular, might have been collected as cortical cobbles and reduced less extensively than other toolstones. Three alternate flakes—one granite and two quartzite— indicated that thick flake blanks also were reduced. Frequencies of core-reduction flakes with single- and multifaceted platforms were nearly equal in the control-column collection, although flakes with cortical platforms were also present (less than 12 percent) for all material types in the core-reduction assemblage except granite and nonspecific igneous rock. These data suggested that both early- and late-stage core reduction took place on-site.

The technological data for the debitage from the features was very similar to that of the column samples (Figure 8.4). Once again, the full suite of lithic materials was represented in core reduction, whereas only chalcedony, chert, obsidian, quartzite, and rhyolite were present in biface thinning. Obsidian was the only material more prevalent in the biface-thinning category than in the core-reduction flakes, however, and, even chert and chalcedony were relatively uncommon in the biface-thinning debitage. Biface-thinning flakes were limited to the three smallest size classes for all materials except chert, with 10.1 percent of the biface thinning flakes of this material in the next two larger size classes. No biface-thinning flakes were present in the largest size class, however, suggesting that the bifaces being thinned were no more than four inches wide and probably significantly smaller. For all material types, pressure thinning (n = 145; 80.5 percent) was more prevalent than percussion biface reduction (n = 35; 19.5 percent), with late pressure flaking (n = 79; 54.9 percent) slightly more common than early pressure reduction for all materials except chalcedony. For chalcedony, early pressure was just slightly more common (55 percent). Five of the late pressure flakes were chert notching flakes, indicating that chert bifacial tools were possibly finished in Features 10, 11, 14, 318, and 480.

In the feature collection as a whole, although core-reduction flakes with multifaceted platforms were nearly twice as common as flakes with single-facet platforms this proportion varies greatly by material. For example, core-reduction flakes with multifaceted platforms account for 83 percent of the chert faceted-platform flakes, 52 percent of the quartzite, and just 38 percent of the nonspecific igneous flakes with faceted platforms. This pattern suggests siliceous sedimentary rocks such as chert and chalcedony were highly reduced, but other materials less suitable for flake tools or bifaces less so. Likewise, cortical platforms were also common (n = 54), especially in the quartzite (n = 26; 48.1 percent), chert (n = 11; 20.4 percent), metasedimentary (n = 8; 14.8 percent), rhyolite (n = 4; 19 percent), and nonspecific igneous (n = 4; 19 percent) collections. One example of a cortical platform flake was also present in granite.

These data indicate removal of flakes from a newly exposed surface of a core or nodule, rather than simply decortication through removal of the exterior surface.

As shown in Figure 8.5, noncortical flakes were most common in the core-reduction debitage for most materials (except limestone and granite) for the feature proveniences. Completely cortical flakes were only present in the chert, nonspecific igneous, limestone, metasedimentary, and rhyolite collections, although this totals only 11 flakes. As noted above, flakes with complete or partial cortex indicated a significant proportion of the material was procured in natural or less-reduced forms, likely from a nearby source. Some pieces being reduced were tabular blocks or thick flake blanks, because alternate flakes indicative of such reduction were identified in the chalcedony, chert, nonspecific igneous, metasedimentary, and quartzite samples from the features. Evidence of large flake-blank reduction of nonspecific igneous and metasedimentary materials was shown by noncortical or partially cortical alternate flakes in the 1–2-inch class. Those in the other three materials (chert, chalcedony, and quartzite) were mostly (n = 8; 89 percent) smaller than 0.5 inches.

Table 8.4 summarizes the reduction technologies represented in the debitage samples from each feature, excluding nondiagnostic flake fragments. Core reduction accounted for more than 75 percent of the debitage from nearly all of these proveniences; of the exceptions, all but two contained fewer than 10 items. The two anomalous features were Features 14 and 468, with 17 and 27 diagnostic flakes. Both of these features had a relatively high proportion of chert debitage—in excess of 70 percent—much of which was biface-thinning flakes. Only Feature 492 contained more than 100 diagnostic flakes, and only three others (Features 7, 480, and 587) had more than 50 flakes. Such small sample sizes are more easily skewed by minor variations in the flake type distributions, and therefore, it was difficult to make definitive statements about potential differences in the activities at most features. In addition, it was not always clear if the debitage related to the feature or was simply deposited in the matrix before or after creation of the feature. Evidence for burin production was absent from the feature debitage, but some obsidian was subject to bipolar reduction, which might have been applied to scavenged bifaces rather than cores. Table 8.5 summarizes the distribution of lithic materials by feature, excluding flake fragments.

Flaked Stone Tools

Bifaces

Thirty-five bifaces were identified in the lithic analysis sample, although only 22 were complete or nearly complete. The remaining bifaces consisted of five proximal fragments, five distal fragments, and three midsections, and all of these fragmentary bifaces were mid-stage, rather than early-stage, reduction. As shown in Table 8.6, the sample included 10 Stage 2 bifaces, 15 Stage 3 bifaces, 8 Stage 4 bifaces, 1 Stage 5 biface, and 1 biface fragment of an indeterminate stage of reduction. Most of these artifacts were point-provenienced specimens from nonfeature contexts, with only 10 bifaces in the analysis sample recovered from features; however, many of these were features not subject to lithic analysis of all artifacts present. Perhaps significantly, five of the bifaces from feature contexts were Stage 2, representing a significant proportion of this particular type.

All the Stage 2 bifaces were complete, including seven items of chert and one each of andesite, quartzite, and shale. The shale biface (catalog no. 361) was a tabular piece from Feature 3, with possible light grinding from use on some edges. The andesite biface (catalog no. 2055), from Feature 404, also had some edge dulling that may indicate use; none of the other Stage 2 bifaces showed use-wear. At least five of the chert bifaces—one is shown in Figure 8.6—were reduced from tabular parent material, with primary geological cortex present on both faces. The final Stage 2 bifaces (catalog nos. 1820, 2054, 2055, and 2090) were manufactured on flake blanks. Two of these (catalog nos. 1820 and 1817) were much smaller than all other Stage 2 bifaces, averaging just 50 mm long, 21 mm wide, and 11 mm thick. In contrast, the remaining bifaces averaged 127 mm long, 80 mm wide, and 27 mm thick. Given the size of flakes produced as debitage by the occupants of LAN-63 (see above), these biface data suggested that the larger Stage 2 pieces could have served as either bifacial cores for flake production or as bifacial blanks for further reduction to tools. The smaller bifaces might have functioned as blanks or tools.

The Stage 3 bifaces included seven complete or nearly complete items, four proximal fragments, three distal fragments, and one lateral portion of a midsection. Complete pieces were predominantly foliate. Fragments were created by bending, radial, or perverse fractures, with the former two types of breaks likely related to manufacturing errors or postdepositional damage, sometimes occurring at a flaw in the material. In contrast, the perverse fractures denote solely manufacturing errors. Similar to the Stage 2 sample, chert and chalcedony were most prevalent in this group (n = 10), although obsidian bifaces were also common (n = 4) and one piece (catalog no. 1813) was of quartz. Three of the Stage 3 bifaces were made from flakes, but the rest were too reduced to determine the form of the parent material. Average size for complete or nearly complete specimens was 48 mm long, 24 mm wide, and 11 mm thick, and the fragments appear to be roughly the same size. Consistent with this stage of reduction, most Stage 3 bifaces had unpatterned or collateral flaking, although one obsidian biface (catalog no. 1685) had some oblique flaking more typical of later stages of reduction.

Despite the middle stage of reduction represented by Stage 3 bifaces, other technological evidence clearly indicated that several of these items were used or even reused as tools. For example, two obsidian specimens (catalog nos. 1684 and 1685) had facial or edge burination indicative of impact damage, five Stage 3 bifaces (catalog nos. 1685, 1686, 1688, 1811, and 1819) had reworked broken edges, and two (catalog nos. 1813 and 1819) (Figure 8.7a) had microflaking consistent with cutting or scraping. The microflaking on one of the last bifaces (catalog no. 1813) was on a broken edge, which suggested the fragment was scavenged. Two other Stage 3 bifaces (catalog nos. 1815 and 1819) retained asphaltum residue; on item no. 1815, from Feature 410, the asphaltum was restricted to the proximal one-third of the tool, which may indicate the tool had been hafted to a handle.

Seven of the Stage 4 bifaces were chert, and the eighth was obsidian. Four were complete or nearly complete, one was a proximal fragment, two were distal ends, and one was a midsection. Complete or nearly complete pieces suggested that these bifaces average approximately 50 mm long, 25 mm wide, and 9 mm thick, comparable to the Stage 3 bifaces. One Stage 4 biface was made on a flake, but the parent pieces for the remaining bifaces could not be determined. Unlike the Stage 3 sample, relatively few of the Stage 4 bifaces exhibit evidence of reworking or use damage, such as microflaking. Only the obsidian biface (catalog no. 1684) had a facial burination indicative of impact damage; breaks on the remaining incomplete Stage 4 bifaces included radial or bending breaks that may be manufacturing errors or postdepositional damage. The Stage 4 bifaces had collateral and, to a lesser extent, unpatterned flaking; one might have had initial notching or modifications to prepare concavities for use (catalog no. 1826; Figure 8.7b).

The single Stage 5 biface (catalog no. 1803; Figure 8.7c) was a nearly complete chert specimen with a bending break at the proximal end. This piece displayed parallel flaking, and fine serrations along the blade of the artifact. The piece was 14 mm long and nearly 6 mm wide; the complete specimen would have been more than 32 mm in length. This specimen might have been a "Denticulated Canaliño arrow-head," described by Freeman and Van Horn (1987:90) for a previous collection from LAN-63, although the absence of the proximal end prohibits such ascription in the current case.

Finally, the indeterminate-stage biface was a midsection fragment of chert that could have been either Stage 3 or 4. The piece was approximately 13 mm wide and 5.5 mm thick, with an overshot flake scar on one face, indicative of a manufacturing error.

Borers

The distal portion of one boring tool (catalog no. 1080) made from a tabular chert flake was recovered from Feature 480. The tool was triangular in plan view and the pointed tip had crushing and step fractures from use on a hard material. Moreover, the piece was broken by a perverse fracture, suggesting that the tool might have been used in a twisting motion. The artifact measured 47 mm long, 12 mm wide, and 13 mm thick.

Burins

One complete chert burin (catalog no. 894) was recovered from Feature 11 and was 19 mm long, 22 mm wide, and 5 mm thick. There was no evidence of use damage on the working end.

Choppers

Thirty-two choppers were identified in the lithic analysis sample, 28 of which were complete (Table 8.7). This collection included nine quartzite tools, seven of metasedimentary rock, six of nonspecific igneous rock, two andesite, two granite, one nonspecific metamorphic, and one unidentified porphyritic material. For the sample, as a whole, length for complete specimens ranged from 43 to 110 mm (mean = 76 mm; s = 18.7), width varied from 59 to 126 mm (mean = 80 mm; s = 14.5), and thickness ranged from 24 to 78 mm (mean = 45 mm; s = 11.9). These data reflect the general ellipsoid shape and size suitable for manipulation with one hand, and there were no distinct differences in size by stone type. Most of these artifacts were waterworn cobbles modified for and by use; only one quartzite specimen was small enough to be classified as a pebble rather than a cobble (see above).

The working edges of these tools were formed by either unifacial or bifacial flaking of the cortical cobble surface, with both types present in relatively equal frequency. In some cases, however, it was difficult to determine if the original working edge was unifacial or bifacial, as subsequent impacts removed additional flakes from the edge, thereby approximating bifacial modification. There might have been a preference for unifacial modification for choppers of nonspecific igneous rock (67 percent) and for bifacial modification of metasedimentary tools (57 percent), although the sample sizes were small. Such material-specific differences may reflect the desired edge sharpness that could be achieved. Angles for working edges varied from 55 to 112 degrees, although battering of the edge through use undermined such measurement somewhat. The mean edge angle was 80 degrees (s = 14), indicating that most tools had steep, acute edges capable of withstanding impact from use.

Examination of the use wear showed both spalling, and pitting or dulling from battering. Dulling and pitting were most common (n = 17), although such damage was relatively light on three of the igneous specimens (catalog nos. 1669, 1692, and 1699), likely a result of the hardness of this material. There was spalling on 14 tools, all but three of which (catalog nos. 86, 417, and 538) also were dulled. Two of the latter tools were rhyolite, and one of these (catalog no. 417) was step flaked, likely related to the fracture mechanics of this material. Two of the metasedimentary choppers (catalog nos. 409 and 410) and two of quartzite (catalog no. 370 and 918) also had step fractures. Striations perpendicular to the working edge were present on one andesite chopper (catalog no. 385) and one of metasedimentary (catalog no. 2084), and striations at a diagonal to the working edge were present on one of the granite tools (catalog no. 523) and the chopper of undetermined material (catalog no. 420). Two tools had faceting of faces adjacent to the working edge (catalog nos. 385 and 1355). In many cases, black residue—likely asphaltum—is on or adjacent to the working edge (catalog nos. 318, 407, 410, 417, 523, 909, and 918), and four other choppers (catalog nos. 409, 546, 893, and 932) had such residue elsewhere. In one case (catalog no. 538), red residue covered much of the surface of the tool. Six choppers show rounding of facial arrises or microflaking on the working edge, or both, although it was not always clear if such modification related to use or postdepositional damage. Four choppers (catalog nos. 906, 932, 1158, and 1360) exhibit fire blackening or heat fractures, also likely related to postdepositional alteration.

Cores

The collection of 58 cores in the analysis sample (Table 8.8) was dominated by quartzite (n = 19) and metasedimentary (n = 15), with lesser quantities of rhyolite (n = 8), nonspecific igneous (n = 5), andesite (n = 2), chert (n = 3), and quartz (n = 2). Diorite, siltstone, mudstone, and chalcedony were represented by just one core each and, given the poor flaking quality of all but the chalcedony (see above), might have been reduced for purposes other than to produce flakes. Both siltstone and mudstone were tabular materials, and the diorite piece might have been a split hammer stone rather than a true core. The chalcedony specimen (catalog no. 2053) from Feature 468 was a bipolar core with just one flake removed after the pebble was successfully split.

The quartzite sample included 11 multidirectional cores, 6 unidirectional cores, and 2 of undetermined reduction pattern. Nearly all specimens retain cortical surfaces that indicate that these pieces were waterworn cobbles. Many were halved or quartered cobbles with or without subsequent reduction from the exposed interior, which was consistent with cobble-reduction strategies. In some cases, such reduction might have been an attempt to shape a core tool such as a cobble heel scraper (described below) rather than produce usable flakes, and the interpretation of these objects as tools rather than cores was further supported by the presence of black residue on four specimens (catalog nos. 389, 398, 399, and 404), all from Feature 5. The size of the quartzite cores varied greatly, from less than 35 mm to nearly 110 mm in length and width, and from 28 to 70 mm in thickness.

The metasedimentary cores include seven multidirectional cores, four bidirectional cores, two unidirectional cores, one bifacial core, and one specimen of undetermined reduction pattern. All of these were waterworn cobbles, many of which were simply split on one axis by multiple blows. The size of these pieces was less variable than the quartzite sample, with an average length of 72 mm ($s = 11$), width of 69 mm ($s = 18$), and thickness of 46 mm ($s = 13$). This may reflect more extensive reduction or, more likely, smaller parent pieces. The bifacial core (catalog no. 412) from Feature 5 might have been the result of platform preparation for a unidirectional core rather than true bifacial reduction. Similar to the quartzite sample, five of the metasedimentary cores from Feature 5 (catalog nos. 388, 394, 396, 42, and 418) might have been rough core tools rather than cores, as black residue was present on each of these pieces. One additional core (catalog no. 1335) from Feature 409 might have been a hammer stone subsequently flaked opposite the working end, and two metasedimentary cores—one from Feature 337 (catalog no. 1184) and another from Feature 4 (catalog no. 383) had heat damage that might have been from secondary use.

The sample of rhyolite cores also encompassed diverse types, including four multidirectional, one unidirectional, one bifacial, and two fragments of undetermined type. Once again, waterworn cobbles served as the parent pieces, and the cores were correspondingly large, ranging from 54 to 94 mm long, 39 to 82 mm wide, and 31 to 79 mm thick. Two cores from Feature 5 (catalog nos. 406 and 414) had black residue on fractured surfaces. The nonspecific igneous cores were comparable to the rhyolite collection in parent material (i.e., waterworn cobble) and size and included four multidirectional and one unidirectional core, with the latter (catalog no. 1750) from Feature 594 exhibiting some dulling of arrises, likely due to postdepositional damage, and fire fractures and blackening.

Finally, the andesite, chert, and quartz cores were all multidirectional. The andesite cores were both waterworn cobbles—in one case (catalog no. 1076; Feature 480), the cobble was split and then subsequently worked, whereas the other cobble (catalog no. 368; Feature 3) might have been shaped or use for grinding prior to flaking. Length and width were less than 66 mm, while these pieces were less than 46 mm thick. Some of the chert cores were distinct from the other cores in the sample, as one (catalog no. 1040) from Feature 480 was a tabular piece with microflaking that might have been the result of use or edge preparation, and another (catalog no. 1081) from Feature 318 was poor-quality material for which the nature of the parent piece could not be determined. The former specimen measured 88 mm long, 81 mm wide, and 43 mm thick, whereas the latter was just 19 mm long, 24 mm wide, and 18 mm thick. The remaining chert core (catalog no. 2091) from Feature 379 had incipient cone cortex indicative of water tumbling. This piece measured 25 mm long, 27 mm wide, and 18 mm thick. The two quartz cores were also somewhat enigmatic due to postdepositional alteration, as one (catalog no. 324) from Feature 1 was poor-quality material that had been fire blackened and the other (catalog no. 988) from Feature 587 had edge dulling and possible flake removals from battering. These pieces averaged 59 mm long, 37 mm wide, and 34 mm thick.

Drills
One medial fragment of a chert drill was identified in one of the control-sample units. This artifact (catalog no. 92) was 10 mm long, 4 mm wide, and 3 mm thick. It was not sufficiently intact to determine the nature of the parent piece or any characteristics of the proximal end or working edge.

Edge-Modified Pieces
A total of 37 edge-modified pieces were identified in the lithic analysis sample, including 14 of metasedimentary, 12 quartzite, 3 andesite, 3 chert, 3 siltstone, and 1 each of rhyolite and quartz. By material, the three siltstone tools were the largest, measuring nearly 99 mm long and approximately 70 mm wide and 15 mm thick. Only one of the andesite specimens was larger at approximately 113 mm in length, with the remainder of the edge-modified piece sample averaging just 54 mm long, 52 mm wide, and 18 mm thick.

The majority of the tools were manufactured on percussion flakes removed from waterworn cobbles, as indicated by the presence of cortex. Such cortex was evident on either the flake platform (including what Freeman and Van Horn [1987] would have termed "potato" flakes) or on the dorsal surface. The former was particularly common for quartzite specimens (see also Freeman and Van Horn 1987:68), whereas the latter was prevalent for the metasedimentary sample. Such differences likely reflecting different modes of core reduction for each of these materials.

Both purposely retouched and utilized specimens were nearly equal in frequency for any given material type. In many cases, the modification was confined to a small portion of the edge or was discontinuous along one edge, suggesting that these tools were not subject to exhaustive, or even extensive, use. Lateral edges, distal and proximal ends, or broken edges were all modified, but rarely along more than one edge and either was restricted to the ventral or dorsal surface or alternating from the dorsal to ventral surface along one edge. Utilization was indicated by rounding, microflaking, or stepping, and black residue coated the working edge of one tool from Feature 444 (catalog no. 1379). Edge angles varied from approximately 40 to 80 degrees.

Gravers
One chert graver (catalog no. 2050) was recovered, from Feature 444. This piece was a core-reduction flake struck from a pebble or cobble, and cortex remained on the platform of the parent flake. The graver showed use on the dorsal surface of a pointed projection on the distal end of the parent flake. This artifact was 32 mm long, 47 mm wide, and 13 mm thick, with a working-edge angle of 74 degrees. Elsewhere on the distal end, a small notch created by the removal of a single flake may also be a working edge unrelated to graving.

Projectile Points
Six projectile points were recovered from LAN-63 (Table 8.9). Five different types or varieties were present, although none appeared to postdate ca. 1250 B.P. (A.D. 700), and most were consistent with the Middle period (ca. 4000–1000 B.P.). All of the points were chert, and all but one were point-provenienced objects from nonfeature contexts.

Possibly the oldest point in the collection was a Great Basin Stemmed point (catalog no. 1816; Figure 8.9), a type generally associated with the Western Pluvial Lakes Tradition, ca. 11,000 to 7000 B.P. (see Moratto 1984). This artifact was made of a bluish white stone with cortex on both faces, indicating its manufacture from tabular stone. The point was long and lanceolate, with a rounded base that made up approximately half the length of the tool. The blade edges were slightly serrate to denticulate, the result of fine flaking somewhat uncharacteristic of this type; therefore, this might have been a knife or bifacial tool other than a projectile point. As summarized by Justice (2002:Map 3), the "Great Basin Stemmed Cluster," of which such points are an element, extends from the southern Columbia Plateau to the Southwest, encompassing all of the Great Basin, Colorado Plateau, and portions of northern, eastern, and southern California. In southern California, Lake Mojave and Silver Lake points are the most prevalent types in the group, although some lanceolate or foliate points similar to those observed at LAN-63 have been found in the Mojave Desert (see Moratto 1984:Figure 3.5). No Great Basin Stemmed points were identified in the previous collection from LAN-63 (Van Horn 1987), although much smaller “leaf-shaped dart points” were found (Freeman and Van Horn 1987:101).

The Elko Eared point (catalog no. 1802; Figure 8.9) was nearly complete and had corner notching, a convex base, a triangular blade, parallel flaking, and minimal reworking along one blade edge. This last modification appeared to be repair after impact damage. As noted by Thomas (1981:20–21), Elko series points have a basal width greater than 10 mm and a proximal shoulder angle of 110–150 degrees, and Elko Eared points are distinguished from other points in this series by a basal indentation ratio of less than or equal to 0.93; the point from LAN-63 was consistent with all these attributes. Elko series points are found throughout the Great Basin, portions of eastern and northern California, and in some areas of coastal southern California (see Justice 2002:Map 33). Decades of research in the Great Basin have demonstrated that the initial use of such points varies greatly, however, with such specimens used earliest in the eastern and northern Great Basin and introduced much later to the west and south. As summarized by Beck (1998:Figure 2.13; see also Holmer 1986:101), Elko points are seen as early as ca. 8000 B.P. (6050 B.C.) in the northeastern Great Basin but did not appear in the Mojave Desert until approximately 3300 B.P. (1350 B.C.) and persisted in the western zone until ca. 1350 B.P. (A.D. 700) (Justice 2002:304; see also Holmer 1986:101; Thomas 1981:20). Although no Elko series points were identified in the previous collection at LAN-63 (Van Horn 1987), some of the large “side-notched” points illustrated by Freeman and Van Horn (1987; e.g., Figure 29, 0103) have metric attributes consistent with Elko series points.

Two large contracting-stem projectile points (Figure 8.10) were recovered from LAN-63. One (catalog no. 1804) was tabular chert, with minimal primary cortex still present and chevron flaking on the blade. This point had been reworked on the blade edge, and the other piece (catalog no. 1805) had also been reworked, on the distal end. In the latter case, the resulting edge was quite steep, and microflaking and minimal grinding in this area might have been the result of reuse of the tool for cutting or scraping. As discussed by Justice (2002:290) and others (e.g., Holmer 1986:105; Thomas 1981:22–23), such large contracting-stem points have been referred to variously as Elko Contracting Stem, Gypsum Cave, and Gatecliff Contracting Stem points. Although the last moniker has been commonly used in more-recent Great Basin research by those scholars following Thomas’s (1981) Monitor Valley projectile point key (e.g., Holmer 1986), the term “Gypsum Cave” continues to be used in many studies in southern California (e.g., Freeman and Van Horn 1987:96) and, thus, was favored here. These points are characterized by straight to slightly convex blade edges, contracting stems recognized by a proximal shoulder angle less than or equal to 100 degrees, and a basal indentation ratio greater than 0.97 (Thomas 1981:22–23). Justice (2002:241*ff*) suggested that these points may be distinguished from similar contracting stem points recovered primarily to the north along the central to south-central California coast, by the lack of barbs, less developed shoulders, and toolstone type, although Justice (2002:290*ff*) was somewhat vague with respect to the latter criterion because chert seems to be favored for all types of contracting stem points recovered in coastal contexts. Justice (2002:Map 32) stated that the distribution of Gypsum points extends from the central Great Basin and Southwest through to northern Mexico and, perhaps, west to the southern California coast. For the Great Basin, these points date from ca. 4450 to 1450 B.P. (2500 B.C. to A.D. 500) (Holmer 1986:105), suggesting a time range generally consistent with that of Elko series points in this region. Similar large contracting stem points from coastal contexts to the north have the same time range (see Justice 2002:257). Nine Gypsum Cave points were identified in previous excavations at LAN-63 (Freeman and Van Horn 1987:97).

One Humboldt Concave Base (catalog no. 1808; Figure 8.11) projectile point fragment was recovered from Feature 460. This proximal piece was broken along a flaw across the midsection by a crenulated break, likely reflecting postdepositional heat damage. As discussed by Justice (2002:148) and others (e.g., Holmer 1986:100–101), there is considerable morphological variability in the Humboldt group, with these concave-based points ranging from lanceolate to triangular in outline, and length and weight sometimes used to recognize variants (Justice 2002:148). Thomas (1981:17) defined such points as having a lanceolate shape (indicated by a basal width to maximum width ratio less than or equal to 0.90), a concave base (indicated by a basal indentation ratio of 0.98), length greater than 40 mm, and a thickness greater than 4 mm. Although fragmentary, the specimen from LAN-63 conformed to such characteristics and was clearly lanceolate, with convex blade edges and a basal width less than the maximum width. Grinding extends approximately 15 mm along both edges of the base, dulling the edge to facilitate binding for a haft. As reviewed by Holmer (1986:100–101), distinctions in the blade and base form and technology of these points may reflect different time periods in the Great Basin, with further temporal differences evident between the eastern and western Great Basin for similar subtypes. At Gatecliff Shelter, Humboldt Concave Base points dated to ca. 4950–1250 B.P. (3000 B.C.–A.D. 700) (Thomas 1981:17), whereas Justice (2002:156) cited studies that suggested persistence of this type as late as 1350–650 B.P. (A.D. 600–1300) in the western Great Basin. Freeman and Van Horn (1987:99) noted that at least one projectile point recovered in previous work at LAN-63 might be considered a Humboldt Concave Base point.

The final projectile point was a medium-size, side-notched point with a convex base (catalog no. 1807; Figure 8.12). It had been reworked along both sides of the blade, which reduced the size of the piece and removed portions of the distal shoulder area. In its current state, the point could not be typed; however, it could have been a corner-notched point before being reworked. Justice (2002:181) recognized somewhat larger side-notched varieties in coastal southern California, but the basal width of the point from LAN-63 was inconsistent with such types. In addition, convex bases were evident in only one of these types, Diablo Canyon Side-notched (newly named by Justice [2002:190]), and the dating of such points was inconsistent with the temporal data emerging from the other projectile points in the LAN-63 collection. Given these observations, it was more likely that the side-notched point from LAN-63 was a reworked corner-notched dart point, perhaps of the Elko series. As noted above, Freeman and Van Horn (1987:93) also identified similar large side-notched points at LAN-63 that defied ascription to a named type.

Scrapers

Eighteen scrapers were identified in the analysis sample, including seven metasedimentary pieces, three rhyolite, two quartzite, two andesite, two chert, and one each of siltstone and an unidentified lithic material. Fourteen of these implements were core tools manufactured from waterworn cobbles, the "cobble heel" planes or scrapers initially described by Van Horn and Murray (1985:110; see also Freeman and Van Horn 1987:78–79). These tools averaged 75 mm in length (s = 16.5), 65 mm in width (s = 18), and 46 mm in thickness (s = 13). The remaining scrapers were three flake scrapers and a biface fragment subsequently used for scraping along the broken edge. This latter piece (catalog no. 1039) from Feature 480 was chert and measured 28 mm long, 34 mm wide, and 14 mm thick. It had microflaking and step flaking, and an edge angle of 82 degrees. All of these tools had been used on a hard material. The flake scrapers included one andesite tool (catalog no. 979) from Feature 587 with predominantly unifacial flaking on the dorsal surface of a partially cortical flake to form an edge angle of approximately 89 degrees. A portion of the working edge was also bifacial, and faceting from use was evident on the ventral surface of the flake near the working end, indicating that more than just the edge was in contact with the material being worked. The flake scraper (catalog no. 895; Figure 8.13) from Feature 12 was a partially cortical metasedimentary flake with unifacial flaking along both lateral edges on the dorsal face. Rounding and striations from use were also evident on the distal end, and the edge angle was 60 degrees, all suggesting that the tool had been used on softer material. The last flake scraper (catalog no. 2092) from Feature 379 had invasive flaking around the entire edge of the piece, and an edge angle of 65 degrees. Two of the flake scrapers were of generally comparable size, ranging from 73 to 88 mm in length, 52 to 72 mm in width, and approximately 21 mm thick, whereas the remaining chert piece from Feature 379 was only 33 mm long, 15 mm wide, and 7 mm thick. None of these flake scrapers were the "potato" flake tools identified in the previous excavation collection from this site, although Freeman and Van Horn (1987:68) noted that quartzite was dominant for this tool category.

The remaining 14 scrapers included five halved cobbles, four quartered cobbles, one “eighthed” cobble, and four cobbles from which flakes were removed to form the working edge without first splitting the cobble. For the latter tools, flake removals were either unidirectional (n = 2) or multidirectional (n = 2), with edge angles ranging from 70 to 108 degrees. Two of these tools (catalog nos. 384 and 387)—both from Feature 5—are quartzite and exhibit step flaking and black residue on or adjacent to the working edge. The other two were andesite and metasedimentary, respectively, with the former (catalog no. 367), recovered from Feature 3 and the latter (catalog no. 967; Figure 8.14) located in Feature 19. The andesite scraper was step-fractured and battered, and the metasedimentary tool had microflaking, parallel and perpendicular striations, and black residue on the working edge.

The halved cobble scrapers had unidirectional (n = 2), bidirectional (n = 1), or no subsequent flaking (n = 1) on a fractured surface; one additional tool was flaked on the exposed surface and an adjacent face. Edge angles range from 78 to 90 degrees. Three of these tools were metasedimentary, one was rhyolite, and one was an indeterminate material. The use modification on the working edges of these tools, three of which were recovered from Feature 5 (catalog nos. 391, 393, and 413), included rounding on three tools, stepping on one implement, microflaking on one tool, and faceting and perpendicular striations on one scraper. Wear facets on one of the latter (catalog no. 393; see Figure 8.14) were at various angles, suggesting variation in the motion or position of the tool relative to the object being worked. Black residue was present on the working edge of three of these implements (catalog nos. 391, 413, and 915), and these same three tools also displayed secondary use away from the primary working edge, in the form of battering on the cortical surface opposite the working edge. Two were from Feature 5 and one was from Feature 16.

Three of the four quartered cobble scrapers were not subsequently flaked, whereas the fourth had perpendicular, bidirectional flaking on the latitudinal fracture. Edge angles varied from 54 to 103 degrees, and the siltstone scraper (catalog no. 510, in Feature 10) was battered on the cortical surface opposite the scraping edge. Primary use modification for the quartered cobbles was exhibited on the latitudinal (i.e., short-axis) split, including one tool from Feature 5 (catalog no. 415) with just rounding, one tool with rounding and perpendicular striations (catalog no. 510), one tool from Feature 587 with rounding and both parallel and perpendicular striations (catalog no. 1035), and one tool from Feature 3 with microflaking (catalog no. 373). The first of these tools (catalog no. 415; see Figure 8.14) also had stepping on the longitudinal (i.e., long-axis) fracture and was the only quartered cobble with residue; red residue was found adjacent to the working edge, and black residue was on a fractured face. Such differences in use modification may relate to tool (and feature) function, duration of use, or lithic material.

Finally, the cobble scraper (catalog no. 411; see Figure 8.14), representing about an eighth of a cobble, was unifacially flaked on both the latitudinal and longitudinal fractures. Microflaking was evident on the former face, and stepping was present on the latter. Edge angles were 82 and 97 degrees, respectively. In addition, the cortical surface opposite the scraping edges was battered and coated with a black residue. Like many of the other cobble scrapers, this metasedimentary item was recovered in Feature 5.

In summary, the LAN-63 sample contained both flake and cobble scrapers, although the latter were dominant. Steep edge angles, microflaking, and stepping suggested primary use on hard materials. In many cases, however, such use also encompassed use of asphaltum or some other liquid or viscous material that left a black residue. Freeman and Van Horn (1987:78–82) also noted abundant “cobble heel” scrapers, but flake scrapers were even more common in their collection.

Ground and/or Battered Stone Tools

Anvils

Six anvils were identified in the analysis sample from LAN-63, all of which were waterworn cobbles with one or more small battered pits on one face. Four anvils were granite (catalog nos. 285, 754, 1074, and 1123), another was nonspecific igneous, and the last was of undetermined material (catalog no. 1290;

Figure 8.15). This last anvil was complete and lacked fractured surfaces that would facilitate identification of its material type. Only one other specimen (catalog no. 1123) was also complete, and these two intact items had a mean length of 178 mm, mean width of 144 mm, and mean thickness of 67 mm. Moreover, the measurements for fragmentary items were consistent with this assessment. Four of the anvils—one from Feature 13 (catalog no. 754), two from Feature 318 (catalog nos. 1074 and 1123), and one from Feature 462 (catalog no. 2057)—had evidence of fire alteration, from minimal surface blackening on the first-listed anvil, to such more substantial heat damage on the last three as fractures and discoloration of the central core. In the case of the two anvils from Feature 318, at least, this suggested these items were incorporated into the feature for reasons other than their function as anvils. In contrast, the two specimens lacking fire alteration may reflect more intense use as anvils, as the piece from Feature 462 (catalog no. 1290) had a series of contiguous battered pits rather than simply one area of battering, and the specimen from Feature 1 may also have had slight polish.

Cogged Stones

Two cogged stones were recovered from all contexts at LAN-63. Both artifacts were point-provenienced rather than from feature context. These items were land-and-groove (Eberhart 1961) cogged stones that were round in plan view, but varied from approximately 55 to 82 mm in diameter. The former (catalog no. 1740; Figure 8.16) was of nonspecific igneous rock, was rectangular in cross section, measures 39 mm thick, and had five grooves. The latter (catalog no. 1746; see Figure 8.16) had 10 grooves, was 40 mm thick, and was made of vesicular basalt. This piece was trapezoidal in cross section, likely reflecting trampling or similar damage to one face that resulted in rounding of the edge. This piece also exhibits minimal rodent gnawing indicative of postdepositional damage.

As discussed by Eberhart (1961:367; see also Koerper and Mason 1998 and references therein), cogged stones are associated with all but the earliest portion of the Millingstone period in southern California and are restricted to the Los Angeles basin. Therefore, the presence of cogged stones at LAN-63 suggests the site was used during the Millingstone period. These artifacts and discoids were the only artifacts or other temporal data related to such early use, however, and the recovery of these pieces from nonfeature contexts indicated that such use was ephemeral, at best. In fact, it might also be that these pieces were scavenged from older deposits nearby (e.g., the lower levels of LAN-64). No scavenged cogged stones were recognized in Middle period features at LAN-63, however, despite the scavenging of other ground stone tools for such features.

Discoids

Five point-provenienced discoids were recovered from LAN-63. These objects lacked grooves characteristic of cogged stones, although they were comparable in size to the cogged specimens. Four of these discoids had plain faces and edges, ranging in size from approximately 81 to 107 mm in diameter and 43 to 51 mm in thickness. Two were of nonspecific igneous rock, and the other two were of vesicular basalt. One of the latter (catalog no. 1743) had one flake removed from a face and minor soot in the fracture, and one of the former (catalog no. 1742) also had one flake removed from a face and reddening on both faces and the edge, perhaps purposeful coloration with mineral pigment. The final discoid (catalog no. 1852; Figure 8.17) was manufactured of nonspecific igneous stone, and had a conical indentation on one face and a circular indentation on the opposite face. This artifact was approximately 57 mm in diameter and 37 mm thick.

As noted above, cogged stones are associated with all but the earliest portion of the Millingstone period in southern California. In addition, the recovery of discoids in caches with cogged stones elsewhere in the region (e.g., Moratto 1984:150) indicated that these two artifact types were contemporaneous. Therefore, the presence of discoids also suggests LAN-63 was used during the Millingstone period.

Hammer Stones

Nineteen waterworn cobble hammer stones or hammer stone fragments were identified in the analysis sample, although two pairs (catalog nos. 1089 and 1093, and 1110 and 1111) conjoined and, hence, were considered as single artifacts. This collection was dominated by granite (n = 7), with the complete artifacts in this group having a mean length of 117 mm, width of 84 mm, and thickness of 58 mm. In most cases, use wear on the granite tools was limited to minimal dulling in one small area on a side or end, although two tools had minor impact spalling (catalog nos. 452 and 1293, from Features 10 and 468, respectively). In one case, the spalling was on the opposite end from the dulled surface, and one additional granite hammer stone (catalog no. 320) from Feature 1 exhibited two distinct areas of dulling rather than just one. One of these tools (catalog no. 1736) from Feature 601 was extensively heat-damaged, and three others (catalog nos. 320, 452, and 1293) had minor surface blackening possibly related to exposure to fire or adhesive wear and oils related to handling by the user.

The three quartzite hammer stones were similar to the granite hammers in both their size and the extent of the use wear on them. These pieces ranged from 79 to 114 mm in length, 63 to 86 mm in width, and 28 to 50 in thickness, with minimal dulling on one end. One of these tools (catalog no. 770) from Feature 18 also had impact spalls. The three sandstone hammer stones, including one of the refitted specimens, were all fragmentary, likely reflecting the more fragile stone. The reconstructed size of the conjoined tool was approximately 97 mm long, 108 mm wide, and 85 mm thick, and another nearly complete sandstone tool was 87 mm long, 72 mm wide, and 81 mm thick. Each of the sandstone hammers was battered on one end, and all showed fire alteration such as fracturing and blackening. Two of these tools were from Feature 318, and the third was from Feature 337.

The two metasedimentary hammer stones reflected somewhat more complex use histories. The first (catalog no. 442) appears to be a multidirectional core subsequently used as a hammer stone along the unflaked edge. This piece was recovered from Feature 6. The other metasedimentary piece (catalog no. 925), recovered from Feature 17, exhibited pitting, spalling, and striations perpendicular to the working surface and retained red residue on the surface. The diorite hammer stone (catalog no. 767; Figure 8.18) was also recovered from Feature 17, and had dulling and rare spalling, as well. This piece also was probably repaired, as a long spall removed from the end opposite the working end had been reattached with asphaltum and coated with red mineral pigment. This tool was almost complete and measured 124 mm long, 84 mm wide, and 34 mm thick. The last hammer stone (catalog no. 1864) of undetermined lithic material was 131 mm long, 75 mm wide, and 61 mm thick. This piece had a small area of deeper pitting on one face near the end of the tool, minimal dulling was evident at the opposite end, and a narrow band of dulling from light battering was also present along a significant portion of one side of the implement.

Manos

The lithic analysis sample contained 55 manos, only 10 of which were complete or nearly complete (Table 8.10). Most were granite (n = 35), with the remainder made from conglomerate (n = 4), sandstone (n = 3), siltstone (n = 4), diorite (n = 2), and one each of andesite, quartzite, rhyolite, nonspecific igneous, and an undetermined lithic material. The metric data available for complete or nearly complete manos ranged from approximately 75 to 120 mm in length, 65 to 115 mm in width, and 25 to 90 mm in thickness. Based on both the complete and fragmentary specimens, most also appear to be waterworn cobbles that were modified little or not at all prior to use.

For those pieces sufficiently intact to determine the number and nature of working surfaces, 22 were unifacial manos and 12 were bifacial specimens. There were no evident distinctions in the distribution of such types by feature, although bifacial manos were the only type in Features 6 (n = 1), 10 (n = 1), 446 (n = 3), and 462 (n = 1). Both flat and convex surfaces were evident, with the former somewhat more common in the unifacial type than the latter shape. Wear over the edge of the tool was evident for two implements (catalog nos. 1072 and 1297), clearly indicating use in a reciprocal rather than circular motion. For those tools for which extent of use could be determined, 5 were Stage 1, 6 were Stage 2, 14 were Stage 3, 14 were Stage 5, and 8 were Stage 4 (resharpened) pieces. Significantly, for those features with two or more manos, the extent of use seems to be relatively consistent for this tool type. For example, Features 7, 14, 337, 444, 462, and, to a lesser extent, 446 contained tools in early to mid-stage use, with discard or loss prior to exhaustion. In contrast, the manos from Features 1, 10, 318, and 601 were thoroughly used and, in some cases, reroughened after initial exhaustion of the working surface.

Striations indicative of the motion of use were rare, but were observed on seven tools (catalog nos. 297, 425, 441, 1072, 1294, 1295, and 1715). Likewise, residues indicative of possible function were observed on a few manos, including three implements with red mineral residue (catalog nos. 432, 759, and 961) and two specimens (catalog nos. 1072 and 1282) with black or brown residues. Secondary use other than grinding was evident on several tools, including three manos that exhibit secondary use as hammer stones (catalog nos. 645, 759, and 1146) and one tool (catalog no. 1072) with battered pits on the face opposite grinding surface suggesting secondary use as an anvil or hammer stone. Approximately half of the manos (n = 28; 52 percent) showed fire damage, ranging from minimal surface blackening to fractures and discoloration of the central core of the stone. Such items were disproportionately represented in Features 318, 601, and to a lesser extent, Features 337 and 444. Correlating the amount of fire damage and the stages of use suggested that the manos in Features 318 and 601 had first been exhausted and discarded or lost, then scavenged for a thermal feature. Scavenging was also indicated by other evidence for at least six of the fire-altered manos, as these pieces exhibit dulling and rounding of previously fractured surfaces prior to heat fracture (catalog nos. 1140, 1147, 1276, 1283, 1715, and 1739). Such dulling and rounding might have resulted from trampling, sediment abrasion, wind blasting, or some other cultural or natural factor.

Metates

Thirty-one metates were recovered from the features subject to detailed lithic analysis (Table 8.11), although only one of these tools was complete. This latter specimen (catalog no. 763) was of granite, and measured 125 mm long, 111 mm wide, and 40 mm thick. It was minimally used—representing only Stage 2 modification—on two faces, one of which was concave and the other flat. One modified surface might have been pounded rather than ground, and the opposite face might have been resharpened.

The remaining fragments included 12 of granite, 10 of sandstone, two of conglomerate, two of diorite, and one each of breccia, siltstone, metasedimentary, schist, and nonspecific igneous rock. For those artifacts sufficiently intact to determine the number of use surfaces, most (n = 16) were worked on just one face and only two fragments had two worked faces. Working surfaces were predominantly flat to slightly concave, although one (catalog no. 1855) from Feature 14 was deeply concave and another (catalog no. 938) from Feature 587 was slightly convex. These fragments ranged from 41 to 340 mm in length, 46 to 295 mm in width, and 23 to 108 mm in thickness; the mean values for these attributes suggested that the complete metate was small in comparison.

All stages of use were represented in the sample, including four Stage 1, five Stage 2, six Stage 3, six Stage 4, and eight Stage 5. Two fragments were of undetermined stage of use due to subsequent damage of the working surface (see below). Although there were no evident distinctions in extent of use by material, some trends were visible for specific proveniences. For example, Stage 1 and Stage 2 implements dominated the collections from Features 10 and 587. Perhaps of significance, most of the tools from the latter feature were sandstone, which wears relatively rapidly compared to granite, for example. As a result, the combination of material and light use suggested that metates included in Feature 587 were not used. Conversely, the metates recovered in Feature 337 displayed more extreme wear, including two Stage 4 and one Stage 5 specimen. Stages 4 and Stage 5 items were also dominant in Features 1, 6, 21, 462, and 601. Nine metate fragments exhibited thorough shaping of the working and nonworking surfaces, with five of these implements recovered from Feature 587 (catalog nos. 955, 1009, 1010, 1855, and 2058) and two from Feature 21 (catalog nos. 939 and 941). The remaining two shaped metate fragments were recovered in Features 337 and 601. It was unclear if this sample of more extensively formed tools reflected cultural or natural processes, however, as the fragmentary nature of many other pieces might have prohibited recognition of the degree of shaping.

Only two tools (catalog nos. 938 and 941)—both from Feature 21—had macroscopic striations that were the result of milling coarser materials. Four tools (catalog nos. 763, 955, 1143, and 1288) had traces of black residue that might have been asphaltum. In one case (catalog no. 1288), however, the residue was on both the working surface and the broken faces, indicating that contact occurred after the tool was fractured. Similar to the mano sample, 13 specimens were fire damaged, including all of the fragments from Feature 337. Once again, this pattern of damage was linked to pieces that exhibited more extreme wear or resharpening (i.e., Stage 4 and 5), suggesting secondary use in thermal features at the end of the tools' use-life. Finally, nine fragments (catalog nos. 292, 755, 1125, 1143, 1150, 1129, 1137, 1286, and 1288) were rounded and dulled on fractured or working surfaces, reflecting trampling or similar damage. Feature 337 contained four such fragments, of the five in the feature; the edges of some fractures were dulled before additional breakage caused by thermal contact, suggesting that these pieces were broken and exposed—perhaps for an extended period of time— before they were used in the feature. Two of the other dulled and rounded metate fragments were the two from Feature 462.

Mortars, Bowls, and Other Vessels

A total of 72 ground stone pieces were identified as mortars, bowls, or other vessels, although the fragmentary nature of all but 6 of these undermined such functional distinctions in many cases. Thirty-three artifacts were from bowls or other vessels, 5 were from mortars, and the remaining 34 specimens were too fragmentary to determine if a mortar or vessel was represented. All of the complete or nearly complete objects (n = 7) were bowls or vessels, although several other fragments refit with one another and formed larger fragments. In fact, such refitting contributed to identification of vessels versus mortars in some cases, and material type was also of use, as soft materials such as soapstone were assumed to be vessels rather than mortars.

The vessel (Table 8.12) materials included steatite (n = 14), basalt (n = 5), sandstone (n = 4), metasedimentary (n = 4), nonspecific igneous rock (n = 3), diorite (n = 1), and granite (n = 2). For the most part, specific materials tended to be in just one or two features, suggesting both that the same vessel might often have been represented and that functional distinctions might have existed between features. For example, all but one of the steatite items were recovered from Feature 587; the exception was found in Feature 11. This latter piece was a rim sherd with black asphaltum residue on a portion of the rim and incisions on the interior edge that were oriented perpendicular to the rim. The piece was too fragmentary to determine vessel size or shape, although the portion of the rim present exhibits an arc consistent with a 350-mm-diameter vessel. It had also been gnawed by rodents. In contrast, four of the steatite vessels from Feature 587 were complete or nearly complete shallow vessels or dishes (catalog nos. 949, 992, 1848, and 1854) (Figures 8.19, 20, and 21), and two other fragments (Figure 8.22) refit to form a complete vessel. The latter vessel had a reconstructed length of 192 mm; the other complete artifact was approximately 154 mm long and 114 mm wide.

Although possibly related to the size and shape of the parent material—in at least one case, the exterior surface was the unworked cobble surface—the size and relatively shallow depth (i.e., less than approximately 15 mm) of nearly all such steatite vessels suggests construction might have been mimicking *Haliotis* shells. In addition, two pieces (catalog nos. 949 and 1848) each had a perforation near their edges that might also have been such mimicry or might have served a functional purpose (e.g., Kroeber 1925:629). The hole in the former piece was conically drilled from the exterior and was approximately 8 mm in diameter, whereas the other specimen had a biconically drilled hole 14.5–8.5 mm in diameter. For those steatite pieces that appeared to represent circular vessels, vessel diameter varied from approximately 210 mm (catalog no. 1053) to more than twice that size (catalog no. 1056), significantly larger than the smaller dish-like vessels.

Some of the steatite vessels were further embellished, one vessel (catalog no. 1062) had a decorative incision on the exterior, 17 mm below the rim; perpendicular grooves approximately 9.5 mm long were present on the exterior rim of another (catalog no. 992); and a third piece (catalog no. 1053) had an incision around the top of the rim, and red residue on one exterior area. In addition, the first two decorated pieces had blackened interior surfaces indicating burning. One of these (catalog no. 1062) was also fire-blackened on the exterior surface. Finally, three parallel asphaltum stripes were present on the exterior and one on the interior of another vessel (catalog no. 949).

All five basalt bowl fragments were recovered from Feature 11 and refit to form an incomplete vessel approximately 260 mm in diameter. The diorite bowl was also recovered from this feature, and was a nearly complete specimen measuring approximately 280 mm in diameter. Although the rim was undulating, this bowl was shaped on both the interior and exterior by pecking and grinding, including a shaped base distinctly flattened for support. Much of the base had been purposely flaked off, however, creating a hole through the bottom of the vessel. A portion of the rim was also missing, and black residue was present in this damaged area. Two of the bowl fragments of nonspecific igneous rock were from Feature 337, and the third piece was from Feature 587. The latter represented approximately half of a finely worked vessel that was slightly flattened at the base. In addition, this piece had several flakes removed from the completed vessel, representing deliberate alteration or damage. Similar to many of the steatite vessels from this feature, soot was also present inside the vessel. The two fragments from Feature 337 refit, and both showed extreme dulling and rounding of relict fractures. Fresher fractures and other damage from exposure to fire were also evident, consistent with the recycling of ground stone at Feature 337 (see above). One granitic bowl (catalog no. 1726) was recovered from Feature 521, and this complete specimen measured 250 mm in diameter. The rim was undulating and had black residue on a portion. The other granite bowl (catalog no. 2094) from Feature 379 was approximately 355 mm in diameter and 230 mm deep. A fragment of the rim of this implement was broken and reattached with asphaltum.

Three of the four sandstone bowl fragments were also recovered from Feature 11. Once again, these rim pieces refit to reveal a bowl measuring more than 230 mm in diameter. The vessel was well shaped by pecking and grinding, including slight flattening of the base to stabilize the piece during use. Similar to the diorite bowl, the rim was undulating and black residue was present on or near the rim. The remaining sandstone bowl fragment was a rim sherd from Feature 587 that also exhibits a “drip” of asphaltum over the rim. The metasedimentary bowl fragments were located in Feature 4 and likely represent the same vessel, although not all fragments refit. The rim was somewhat squared rather than rounded, and the complete vessel would have measured approximately 250 mm in diameter. One of the fragments was fire affected, but the others were not.

Only two unequivocal mortars were identified at LAN-63 (Table 8.13). The 10 refitting fragments in Feature 8 were not sufficient to determine the diameter of the vessel. The other mortar was a granitic artifact from Feature 509 with shaped and substantially ground interior and exterior. The exterior surface was also substantially fire-blackened and discolored; the restriction of such damage to the exterior may indicate it was related to primary use of the vessel rather than reuse or scavenging of the broken piece.

The materials used for the indeterminate mortars or bowls (Table 8.14) included granite (n = 9), vesicular basalt (n = 5), metavolcanic breccia (n = 4), basalt (n = 3), diorite (n = 3), sandstone (n = 3), sedimentary breccia (n = 2), nonspecific igneous (n = 2), conglomerate (n = 1), schist (n = 1), and siltstone (n = 1) fragments. Once again, multiple fragments of the same material were often present at a single feature, suggesting that a single implement was represented. Likewise, lithic materials other than granite were often restricted to just one or two features, perhaps indicating functional distinctions related to feature use. For the purposes of discussion, the objects of igneous rock were considered first, followed by those of sedimentary and metamorphic stone.

The granite fragments were recovered from five features; most (n = 4) were located in Feature 587 tended to be shaped on both the interior and exterior, although the latter was often less extensively ground. Similar to the steatite bowl fragments from this feature, one of the granite pieces (catalog no. 1015) was charcoal stained on the interior and another (catalog no. 994) had areas of red mineral pigment inside. In addition, a third fragment (catalog no. 995) had an intentional external fracture that might have been deliberate damage to render the original vessel unserviceable. The final granite fragment from this feature was heat damaged. Te granite pieces from Features 337, 409, and 521 also showed fire damage, and all also were dulled and rounded on fractured surfaces other than those related to the latest fire damage. That is, the pieces were evidently subject to postdepositional alteration after breakage and subsequently scavenged for use in these thermal features after prolonged exposure to natural or cultural damage. The remaining granite fragment, from Feature 10, was a small remnant that might also have been worn after breakage, although no subsequent fire damage was evident.

Two of the diorite fragments were also from Feature 587, and both were intentionally flaked on the exterior, again, presumably to render the vessel unusable. The estimated diameter of the complete vessel represented by one of these pieces (catalog no. 1056) was estimated to be slightly larger than 420 mm; the other vessel (catalog no. 1046) was oval, rather than circular, and its diameter could not be projected. The third diorite piece was from Feature 468 and was the only mortar or bowl fragment recovered from this feature. It lacks fire damage. Features 3 and 509 each contained a fragment of ground igneous stone; the one in Feature 3 was fire damaged, and the other had minimally dulled and rounded fractures, which indicated exposure to postdepositional processes.

All of the basalt specimens and three of the four pieces of metavolcanic breccia were recovered in Feature 587. Although none of these pieces refit, the similarity of each lithic material, particularly the breccia, suggested that each represented a single vessel. Relatively few of either the basalt or metavolcanic breccia fragments were substantially shaped or ground, particularly on the exterior. The remaining piece of metavolcanic breccia was from Feature 409 and displayed dulling and rounding of relict fractures, as well as more recent fractures and heat damage from fire. These observations suggested that the implement was scavenged for use in Feature 409 substantially after initial breakage. Three of the five vesicular basalt fragments were also recovered from this feature, and all exhibited the same pattern of postdepositional damage after breakage and subsequent use in the thermal feature. Likewise, of the two remaining pieces of vesicular basalt in Feature 337, one also had this pattern of damage and reuse.

As noted above, the pieces of sedimentary rock included breccia, conglomerate, sandstone, and siltstone. The last specimen was recovered from Feature 3 and was ground inside but only pecked on the exterior surface. One flake was removed from the rim; it was unclear if this was intentional. Two of the sandstone fragments were from Feature 587 and, as seen in other materials, one had a well-shaped exterior with a flattened base, and the other had blackening of the interior base that indicated burning of combustible material therein. The remaining sandstone piece was from Feature 318 and was fire affected. Both of the sedimentary breccia pieces were from Feature 521 and had the dulled and rounded relict fractures and subsequent fire damage seen in other ground stone across the site and typical of artifacts scavenged for thermal features. The conglomerate fragment, recovered from Feature 340, showed similar damage and reuse, although the dulling and rounding was relatively minor.

Finally, the schist specimen was recovered from Feature 587. This rim fragment was shaped by pecking and grinding on both the interior and exterior surface, although grinding was largely confined to the high points.

In summary, most of the artifacts at LAN-63 classified as mortars, bowls, and other vessels were too fragmentary to determine their function. In those cases in which function could be determined, the material type was significant in assessing function. There were clear distinctions in the proportions of lithic materials among the features, and there were also distinct patterns in the function of such pieces in these various contexts. For example, Feature 587 was dominated by pieces that likely served as bowls, with burning of materials inside such vessels common and the presence of asphaltum or mineral pigments also noteworthy. Likewise, several of these vessels were intentionally damaged to render them unserviceable. In contrast, Features 337, 340, 409, 521, and perhaps others indicate scavenging of these and other ground stone tool fragments for use in thermal features. In most cases, there was a lag between the time the vessel was initially broken and exposed to postdepositional alteration, and the time the piece was scavenged. Significantly, these pieces were not subjected to similar postdepositional alteration after this latest fire damage.

Perforated "Disks"
Six steatite items were tentatively identified as perforated "disks," although these fragmentary items were of various shapes and were grouped here simply by virtue of their perforation and material. As noted above, however, several steatite vessels also exhibited such perforation and, hence, possibly some or all of these items were vessel fragments. Three of these specimens derived from Feature 587, two were from Feature 11, and the last piece was from a control column sample. The perforations were mostly biconical, ranging from 3 to 11 mm in maximum diameter. One piece (catalog no. 956) from Feature 587 had a blackened surface, presumably from fire, and another from this feature (catalog no. 950; Figure 8.23) might have had red mineral pigmentation at one broken end. Many disks had significant rodent gnawing that hampered identification of the original shape.

Pestles
Forty-one pestles or pestle fragments were identified in the lithic analysis sample from LAN-63 (Table 8.15), with most located in Feature 587. The complete collection included one conglomerate item, one diorite, nine granite, four nonspecific igneous, three metasedimentary, five sandstone, eight schist, eight siltstone, and two of undetermined stone. Similar to the metate collection, materials were often specific to a particular feature, and single tools were often represented by multiple, refitting fragments. For example, all of the schist items were from Feature 11 and refit to form a complete pestle 1.4 m long (Figure 8.24). It had been broken in two at the midsection at the time of deposition, as indicated by a red ochre "slip" only on the fragments of the proximal end, including a heart-shaped embellishment on the end itself; such pigmentation was lacking on the other half. The tool was round in cross section and tapered from the distal to proximal end, with a maximum diameter of 97 mm. The working end was battered and rounded, with brown residue present.

The sandstone pieces were all from Feature 587, although only two medial fragments refit and multiple tools likely were represented. One of these medial pieces exhibited possible edge grinding and red pigment, and another had possible brown residue. The remaining distal ends were lightly used and lacked residues. All pieces were round in cross section.

The conglomerate, diorite, and metasedimentary pestles were also all recovered from Feature 587. The conglomerate proximal end had been pecked into shape and only minimally ground, but it was crossed by a groove that was U-shaped in cross section and dabbed/speckled/smeared with asphaltum. The diorite tool was a distal fragment shaped by pecking and grinding; the grinding was more extensive than that noted for the conglomerate pestle. An impact spall indicated use, and the entire piece was covered with red ochre. The metasedimentary pestles included two minimally ground distal fragments (catalog nos. 1057 and 1068) and one extensively shaped—but minimally used—complete conical pestle (catalog no. 951; Figure 8.25). Perpendicular striations and minimal black residue were present on the broad end of this tool, and red residue was also speckled elsewhere on the piece. Red ochre was also on one of the distal fragments (catalog no. 1068), which had been flaked to shape. The other distal fragment was only ground smooth in some areas of the side and was also fire- or residue-blackened in one such area.

Pestles in the remaining toolstones—granite, nonspecific igneous, siltstone, and undetermined—were each present in more than one feature, although Feature 587 was again the dominant provenience. For example, three of the granite pestles were from this feature, with distal fragments again common. Both of these latter implements were stained with ochre, and pitting, dulling, and spalling of the working ends indicated use. One of these tools was a thoroughly shaped cylinder with a slight taper. The other granite pestle from Feature 587, a distal fragment, was more lightly worked, although it, too, was slightly tapered. The complete granite pestle from Feature 594 was a greenish material, perhaps tourmaline granite pegmatite. This implement was embellished with a pecked hemispherical dimple in the proximal end, three impact fractures at the distal end, and two areas of black residue on the side of the tool. Another complete pestle from Feature 379 was a tapered cylinder, battered at both ends and with an impact spall at the wider end. The four remaining granite pestle fragments from Features 10 (n = 2 specimens that refit), 337, and 601 were less shaped. Only the highest points were ground on the tool from Feature 10, and the pestle from Feature 337 was roughly shaped, perhaps from a waterworn cobble. Relict fractures were evident on this tool, and subsequent thermal damage had added more fractures. Once again, scavenging for use in the thermal feature rather than primary use as a pestle was in this case. The parent piece for the pestle fragment from Feature 601 was also a waterworn cobble, and significant pitting from battering exists at one end with black residue present in this area, as well. The broken surface was dulled, suggesting exposure to postdepositional processes after fracture.

Two of the four nonspecific igneous pestle fragments were from Feature 587, with one complete and the other a proximal end. This latter tool had a conical depression pecked into the end (catalog no. 1001; Figure 8.26), and there was also a slight constriction along the body of the piece near the end. This tool was stained with red ochre. The complete pestle (catalog no. 1048; Figure 8.27) was an elongated, curved, waterworn cobble with battering on one side near the broad end. There was black staining, perhaps from adhesive wear, near the battering, and the piece was ground smooth at one end. The nonspecific igneous pestle fragment from Feature 521 had heavy mineral incrustations in addition to thermal damage and soot deposits; the final igneous pestle from Feature 594 was battered at both ends and on opposites sides near the distal end. Both ends show impact damage and there is red residue on the working surfaces.

The siltstone pestles derived from multiple features, with the two fragments from Feature 509 refitting. One of these latter pieces was discolored from heat, and both were extensively shaped by grinding. With the exception of one medial fragment from Feature 587, the remaining siltstone pestle fragments were minimally ground, although the fragments at Feature 587 also had various forms of use wear: impact damage, asphaltum, and red ochre. The complete pestle from Feature 444 had gouges in the side and working surface, although the material was very soft and, therefore, pounding with the tool seemed unlikely. The siltstone pestle from Feature 409 was thermally damaged.

Finally, two complete pestles of undetermined material were recovered from Features 8 and 587. The former was a waterworn cobble partially shaped by pecking, with a working surface at one end. A distinct angle at the edge of the working surface was evident at this end, and wear from use wrapped over edges from the working end along the long axis. There was significant blackening from adhesive wear at the proximal end, with pitting in the proximal end and blackening from residue at the distal end, which also showed impact damage. The pestle from Feature 587 also had one working surface, although this piece was an unshaped waterworn cobble used for pounding. Red ochre was embedded in the working end.

Pipes

Two steatite tubular pipe fragments were identified in the lithic analysis sample. One was a point-provenienced fragment (catalog no. 1843; Figure 8.28a) from a nonfeature context. This artifact had longitudinal striations on the interior from shaping and horizontal diamond cross hatching on the exterior. The piece measured 53 mm long and 33 wide, with 8-mm-thick walls. The maximum diameter of the perforation was 20 mm. The second pipe fragment, from Feature 587, was roughly conical, with a constricted, "nipple" tip (Figure 8.28b). This artifact was split longitudinally; the boring of the hole along the long axis of the pipe had left latitudinal striations and ridges on the interior. The pipe was 75.8 mm long and approximately 29.5 mm in maximum diameter, although the neck of the mouthpiece was just 12 mm in diameter.

Shaft Straighteners

Two shaft straighteners were identified in the collection from LAN-63. The first (catalog no. 1071; Figure 8.29), from Feature 475, was a bluish gray stone in a "turtleback" shape measuring 44 mm long, 45 mm wide, and 27 mm thick. Four V-shaped grooves were present on the dorsal surface, four additional V-shaped grooves were on the ventral surface, and eight U-shaped indentations encircled the margin of the tool. The V-shaped grooves were approximately 2.5 mm in maximum depth, whereas the U-shaped grooves were approximately 4 mm in maximum depth. Brown residue was present on the piece.

The second tool (catalog no. 1277) was a split waterworn siltstone cobble with the working surface on the broken face. A minimally used, U-shaped groove exhibited parallel striations. Located in Feature 444, this artifact measured 72 mm long, 56 mm wide, and 32 mm thick.

Other Ground Stone Objects

The functions of four other ground stone objects were enigmatic. The first artifact (catalog no. 1847; Figure 8.30) was a slate stone with a large, central perforation. The piece was triangular in plan view and rectangular in cross section, measuring 101 mm long, 83 mm wide, and 11 mm thick. It weighed 136.9 g. The cylindrical perforation was 24.8 mm diameter, and approximately three flakes had been removed from one face. This piece, which was a point-provenienced artifact from a nonfeature context, might have served as a net or digging stick weight, although it might have been too light for the latter function. Freeman and White (1987:143) cited ethnographic data suggesting that similar perforated stones might have served a ritual function, as stones hafted to sticks and decorated with feathers were noted in Gabrielino territory.

The second enigmatic ground stone piece (catalog no. 1839; Figure 8.31) was a shovel-shaped or phallic implement of schist with a projection from one side. The piece measured 245 mm long, 119 mm wide, and 47 mm thick. There was apparent impact damage at the end opposite the projection, and red ochre on the convex face. This point-provenienced piece might have been a so-called "pelican stone," although the impact damage suggested the projection might have served as a handle for use. The third implement was a longitudinally split siltstone cobble with asphaltum filling cracks along one edge of the piece. This did not appear to be repair of the tool, but rather, served to stabilize the piece to prevent breakage. Recovered from Feature 444, the specimen measured 95 mm long, 71 mm wide, and 30 mm thick. It had been broken and discolored on the interior by fire. Finally, one piece of granite (catalog no. 90) recovered from Control Column 2 exhibited incisions parallel to the long axis of the stone. This piece measured 25 mm long, 16 mm wide, and 10 mm thick.

Unclassifiable Ground Stone

A total of 817 objects in the lithic analysis sample were identified as unclassifiable ground stone. The bulk of this collection (n = 714), however, was small shavings or flakes of steatite that might have represented the postdepositional deterioration of soft steatite objects such as vessels, or debris from the manufacture of such objects. This steatite debris was limited to Features 6, 11, and 587, with most (n = 702) from Feature 11. In only four cases were pieces from Feature 11 sufficiently intact to suggest they might have been vessel or palette fragments rather than detritus; nearly all of the pieces from Feature 587 and the fragment from Feature 462 were similarly ambiguous with respect to function but were large enough to suggest that use, rather than manufacturing, was represented.

Other Lithic Objects

Fire-altered Rock

Forty-one fragments of fire-altered rock were encompassed by the lithic analysis sample, including 27 pieces of granite, 7 sandstone fragments, 1 breccia, 1 siltstone, 1 nonspecific igneous, 1 conglomerate, and 3 of undetermined lithic material. Size varied greatly, from 8 mm to approximately 90 mm. Evidence for fire damage included fractures, red discoloration, a dark central core of the rock, and/or exterior fire blackening.

Manuports

A total of 555 manuports were identified in the sample, with approximately 522 (94 percent) of these waterworn cobbles. The remaining specimens were 3 pieces of tabular stone and 30 items too fragmentary to determine the nature of the parent piece. This collection was dominated by granite (n = 298), but also includes nonspecific igneous rock (n = 73), sandstone (n = 58), rhyolite (n = 33), conglomerate (n = 14), metasedimentary (n = 14), quartzite (n = 13), diorite (n = 10), siltstone (n = 24), andesite (n = 4), sedimentary breccia (n = 2), gneiss (n = 2), chert (n = 1), quartz (n = 1), schist (n = 1), and 7 of undetermined material. These latter specimens were primarily complete waterworn cobbles that lack features necessary to establish the lithic materia.

The granite manuports include 30 complete or nearly complete specimens. The length of pieces in this sample ranges from 43 to 295 mm (mean = 141 mm), width ranges from 27 to 149 mm (mean = 94 mm), and thickness varies from 36 to 115 mm (mean = 67 mm) indicating selection of easily transportable cobbles ranging from fist- to football-size. The remaining fragments suggest that these pieces were of similar size, although the smallest fragments were substantially smaller than the smallest of the complete pieces, as one would expect. At least 60 percent of the granite manuports were fire affected, ranging from minimal surface blackening on most affected pieces from Features 1, 4, 8, 10, and 17, to substantial discoloration, cracks, and fractures for most of the remaining features with thermally altered granite manuports. These differences evidently relate to the duration and temperature of exposure. The prevalence of fire-affected rock, in general, suggests that many of these items were brought to the site to serve in thermal features. A significant proportion of the granite manuports (25 percent; n = 76) also were rounded or dulled on relict fractures, with nearly three-quarters of these pieces (n = 55) exhibiting subsequent thermal fractures that suggest scavenging of old rock. The majority of these latter items were noted in Features 318 (n = 6), 337 (n = 21), 340 (n = 11), and 409 (n = 7). In contrast, Feature 462 contains eight pieces with postdepositional dulling, but no subsequent fire damage. Seven granite manuports exhibit possible evidence of use, although such modification was sufficiently ambiguous on these fragmentary specimens to prohibit recognition of these items as tools. For example, hammer stone battering might have been present on five pieces (catalog nos. 321, 374, 515, 910, and 1898 from Features 1, 4, 10, 14, and 468, respectively); anvil battering might have been present on one piece (catalog no. 920) from Feature 16; microflaking might have been present on one item from Feature 10 (catalog no. 512); grinding might have been indicated on a piece from Feature 11 (catalog no. 540), and striations might have been present on a piece from Feature 3 (catalog no. 329). Prior use may also be indicated by the presence of black residues on at least four specimens—one each from Feature 1 (catalog no. 312), Feature 17 (catalog no. 926), Feature 318 (catalog no. 1114), and Feature 444 (catalog no. 1359).

None of the manuports of nonspecific igneous rock were complete, but nearly all appear to be waterworn cobbles ranging up to 163 mm in length, 119 mm in width, and 103 mm in thickness. Similar to the granite manuports, 69 percent of this sample was fire affected, with most exhibiting damage such as core discoloration and fractures. Minimal surface blackening is limited to just five of the fire-affected specimens. Fire-affected igneous manuports were particularly prevalent in Features 318, 337, 444, and 601 but were relatively uncommon in Feature 462. Two pairs of fire-affected rock from Feature 337 refit, and one pair from Feature 462 not subject to thermal alteration also refits. These latter observations may indicate reduction of this material at this locale. Twenty-one pieces were dulled or rounded on fractured faces and edges, and all but six had subsequent thermal damage suggesting they had been scavenged from previously discarded fractured rock for use in thermal features. These six pieces were from Features 318 (n = 2), 337 (n = 2), 444 (n = 1), and 509 (n = 1), whereas most of those demonstrating both postdepositional alteration and subsequent thermal fractures were from Features 337 (n = 6) and 601 (n = 3). None of the nonspecific igneous manuports had residues such as asphaltum, but one piece from Feature 1 (catalog no. 309) might have been polished on one face.

Four of the sandstone manuports were complete or nearly complete, with measurements suggesting these cobbles were somewhat smaller than those of granite and nonspecific igneous rock. The mean size of sandstone cobbles was 70 mm long, 77 mm wide, and 48 mm thick, but the fragment sample suggested that pieces of substantially larger size were also used. For example, the maximum length of a fragment was 154 mm. Twenty-nine sandstone manuports were fire-damaged, including all of the specimens from Features 318 and 337. Two of the three pieces from Feature 409 also exhibit fire damage, although in this case, only minimal fire blackening was present. In contrast, nearly all of the items from Features 318 and 337 were substantially damaged, including internal discoloration and fractures. This suggests exposure to more intense heat or exposure for the longer duration. Only one sandstone manuport from Feature 462 (catalog no. 1595) was splattered with asphaltum, and no other residues were on the remaining specimens. The two pieces from Feature 21 were the only sandstone fragments that refit. Twenty-one pieces exhibit dulling or rounding of fractures due to postdepositional processes, including all three pieces from Feature 409 and approximately half of the pieces from Features 318, 337, 340, and 444.

The conglomerate sample was similar to the sandstone collection, with metric data for complete cobbles indicating pieces ranging from 72 to 111 mm in length, 48 to 102 mm in width, and 31 to 51 mm in thickness. The sample of fragments suggests some of these pieces might have derived from cobbles that were slightly larger. This material derives from seven features, but only 29 percent was fire-affected and half of these items were from Feature 337. Once again, Feature 337 exhibits pieces with dulling and rounding of relict fractures prior to more recent breaks. No other such pieces were noted in other features.

The metasedimentary manuports were absent from the two major thermal features containing substantial manuports of other materials (i.e., Features 318 and 337), suggesting that transport of this material to the site was primarily for another use or that this material was not preferred for the activities carried out at Features 318 and 337. Still, fire-affected metasedimentary fragments were noted in Features 444 and 601. In the latter case, these pieces also exhibit facial dulling and edge rounding of relict fractures indicative of scavenging of stone for thermal use. Black residue splatter was present on one piece from Feature 462 (catalog no. 1592). Siltstone manuports were also notably absent from thermal features, and none of the specimens exhibit fire damage. As noted above, many of these pieces were tabular, whereas the soft stone might have been intentionally or unintentionally modified by grinding. Many of the remaining sedimentary manuports (i.e., breccia and chert) showed fire damage, and the one piece of breccia lacking such alteration was dulled and rounded from postdepositional processes. None of these stones were sufficiently complete to determine the size of the parent material.

Although often selected for their flaking qualities, even the rhyolite and quartzite manuports exhibit significant fire damage that was consistent with use in thermal features. For example, eight of the nine rhyolite specimens from Feature 337 were fire damaged, although six of these objects also exhibit dulling and rounding of relict fractures prior to use in this feature. Four of the rhyolite cobbles from Feature 337 might have been halved as cores or for use as scrapers (see above) prior to this postdepositional damage and subsequent scavenging. Fire-altered rhyolite cobbles were also present in Features 340, 444, 462, 468, and 601, and one of these items from Feature 444 also exhibits red mineral pigment on two faces. Split or quartered rhyolite cobbles were present in the sample from Features 10, 14, 444, and 587, suggesting that they were reduced as cores or for some other use not evident on the piece. In contrast, none of the quartzite cobbles exhibit similar unambiguous reduction, despite the fact that several lack heat alteration. Four of the five quartzite cobbles from Feature 601, however, were fire damaged, and two of these pieces refit. Only one quartzite manuport from Feature 12 was complete, measuring 52 mm long, 33 mm wide, and 17 mm thick.

The remaining igneous and metamorphic manuport samples of diorite, andesite, gneiss, quartz, and schist were relatively small, so few observations can be offered. Diorite seems to mirror the granite sample, however, as such pieces were prevalent in the thermal features. In addition, two of these pieces had postdepositional damage to relict fractures prior to use in these features. In contrast, andesite was notably absent from thermal features, with only one piece from Feature 444 exhibiting light fire blackening. Both of the gneiss specimens were from Feature 601, and one was fire damaged. Neither shows postdepositional damage of fractured surfaces. Four of the seven complete cobbles of undetermined material were from Feature 444 and exhibit remarkable consistency in size relative to the other materials. These pieces lack fire damage and range from 64 to 87 mm in length, 53 to 65 mm in width, and 22 to

48 mm in thickness. These data suggest that these somewhat smaller items were selected for a purpose other than inclusion in a thermal feature.

Tarring Pebbles

Thirty-two tarring pebbles were recovered, all but two of which were small, unmodified water-rounded pebbles with thin discontinuous to thicker continuous surface coverage of asphaltum. The remaining two objects include a subangular fragment of nonspecific igneous rock of approximately the same size as the pebbles, and a pebble with a few flake removals prior to use for tarring. The collection displays remarkable consistency in the size of these objects, with a mean length of 39 mm (s = 4), width of 33 mm (s = 3.5), and thickness of 25 mm (s = 4.4). Due to the water wear, lack of fractured surfaces, and asphaltum coverage, rock type could not always be determined, but granite, conglomerate, quartzite, nonspecific igneous, nonspecific metamorphic, and sandstone were present. In this case, the size rather than the nature of the material was clearly the significant factor, although siltstone and siliceous sedimentary stones were apparently avoided. The bulk of the collection derives from Feature 446 (n = 26), with two from Feature 3 and one each from Features 21, 462, 480, and 601. Three artifacts were cracked as a result of contact with the heated asphaltum.

LAN-64 Lithic Sample

The lithic analysis for LAN-64 encompassed selected features excavated in 2003 (Features 12, 17, 32, 43, 49, 50, 52, 56, 60–62, 64–66, and 76), the collection from the lower two levels of two units (Units 13 and 14), all bifacial tools, and special items such as ornaments. This sample comprises 478 items, including 316 pieces of debitage; 33 beads (discussed in Chapter 8); 28 manuports; 28 unclassifiable ground stone fragments; 11 mortars, bowls or other vessels; 10 manos or mano fragments; 7 edge-modified pieces; 5 metates; 5 hammer stones; 8 cores; 8 pieces of fire-affected rock; 4 scrapers; 4 choppers; 4 discoids or cogged stones; 2 pendants (discussed in Chapter 9); 2 perforated “disks;” 1 burin; 1 palette (discussed in Chapter 9); and 1 tarring pebble. The complete lithic assemblage from LAN-64 was composed of approximately 2,650 items.

Debitage

The analyzed debitage assemblage from LAN-64 consists of 316 items, including 6 pieces from control columns, 271 specimens from features, and 39 pieces from the two excavation unit samples. Chert, chalcedony, quartzite, metasedimentary, nonspecific igneous rock, rhyolite, and quartz were included in this assemblage. As indicated in Table 8.16, the two largest flake-size classes contained only quartzite, metasedimentary, and nonspecific igneous rock, and chert, chalcedony, and quartz were particularly prevalent in the smallest size class. Similar to LAN-63, however, many of the items in the smallest size class—regardless of material—are flake fragments. Excluding such fragments decreases the relative quantity of pieces in the smallest size class somewhat, especially for chert (down to 29.9 percent) and, to a lesser extent, chalcedony (down to 56.8 percent).

For the purposes of technological discussion, nondiagnostic flake fragments were excluded and those proveniences associated with the Millingstone component at LAN-64 will be discussed separately from the remainder of the collection, which related to later use. For the latter sample, core reduction accounted for two-thirds of the collection (n = 109; 66.9 percent) and biface thinning made up most of the remaining diagnostic flakes (n = 51; 31.3 percent). Bipolar reduction was also indicated, although only three such flakes were present (1.8 percent). All of these latter pieces were of chalcedony. Biface thinning flakes were particularly indicated in chert (41.7 percent) and chalcedony (34.3 percent); one metasedimentary biface thinning flake was also identified (8.3 percent). This last flake had been an alternate flake, however, indicating initial thinning of a thick flake blank or, perhaps, a tabular piece, rather than later-stage biface thinning. For the chert and chalcedony biface thinning collections, pressure flaking was more prevalent than percussion reduction, accounting for approximately 67 percent of the biface thinning flakes of these two reduction strategies. Early pressure was more common than late pressure thinning, however, with the former accounting for 62.1 percent of the pressure thinning debitage. This proportion was even more substantial for chalcedony than for chert, suggesting that chert tools might have been most likely to be shaped on-site. Still, three notching flakes—one of chalcedony and two of chert—indicate that both toolstones were being used to produce hafted bifaces such as projectile points. These flakes were located in Features 43, 56, and 66, although, as noted above, the association of debitage with features at the West Bluffs sites might have been fortuitous rather than actual.

Quartzite, rhyolite, and nonspecific igneous rock were present as core-reduction flakes only. Completely cortical core-reduction flakes of chalcedony (n = 3), metasedimentary (n = 1), and rhyolite (n = 1) were observed, as were partially cortical flakes of chalcedony (n = 1), chert (n = 5), nonspecific igneous (n = 1), metasedimentary (n = 1), and quartzite (n = 5). Significantly, nearly all of these partially cortical flakes had cortex on the platform rather than the dorsal surface, suggesting such flakes were removed from split-cobble faces rather than from exterior nodule surfaces. The low quantities of cortical flakes suggested that, although a few nodules or cobbles of stone arrived on the site in natural or less-reduced forms, most materials were reduced before they were brought to the site. This was also supported by the fact that noncortical flakes were the most common type for core-reduction flakes of all materials. Likewise, multifaceted platforms (n = 16; 84.2 percent) were much more prevalent than single-faceted platforms (n = 3; 15.8 percent) for the core-reduction flakes, as a whole, although the latter were dominant for the metasedimentary sample.

Samples from Features 50 and 60 and the lower two levels of Units 13 and 14 represented the Millingstone period component in the debitage analysis sample. This entire collection encompasses just 61 artifacts, and only 45 were diagnostic flakes rather than nondiagnostic flake fragments. Because such a small sample made intercomponent comparisons difficult, only general observations are offered. The earlier component contained chalcedony, chert, nonspecific igneous rock, metasedimentary, and quartzite, a diversity of materials consistent with the collection from the later component at this site. The percentage of chert was nearly equal to that noted for the later component (i.e., approximately 55 percent of the diagnostic flakes), but quartzite (22.2 percent) rather than chalcedony was the next most common toolstone. Chalcedony made up less than 5 percent of the Millingstone period component debitage—although this is a sample of just two flakes—compared to more than 21 percent of the later component. This may suggest greater reliance on local materials by these early occupants, as chalcedony was not one of the materials likely to be present in alluvial deposits close to the site.

Similar to the later assemblage, core reduction dominated the Millingstone component debitage for all materials; biface thinning is represented only in the chert debitage (n = 9; 34.6 percent). Both pressure (n = 6) and percussion (n = 3) biface-thinning flakes were present, with early pressure (n = 4; 66.7 percent) more common than late pressure. In these respects, the data were consistent with the later component. There were some differences in the proportions of cortical flakes, however, as the earlier component contained completely cortical flakes of chert, in addition to completely cortical flakes of chalcedony and nonspecific igneous rock also noted in the later component. In fact, completely cortical flakes accounted for 15.6 percent of the core-reduction debitage from the Millingstone component , whereas such flakes made up only 4.9 percent of the sample in the later component. Likewise, partially cortical flakes were relatively more abundant in the Millingstone period sample (n = 9; 28.1 percent) than later (n = 13; 12.7 percent). This suggests that early occupants might not have been reducing cores to the same extent as later residents and, again, my signal reliance on local procurement. The former conclusion was further supported by the fact that single-facet platform core-reduction flakes were relatively more abundant in the early component (n = 4; 40 percent) than multifaceted platform flakes. Bipolar reduction was also indicated by one chert flake in the Millingstone period collection.

Flaked Stone Tools

Burins

One chert burin (catalog no. 30) manufactured on a percussion flake was recovered in Feature 64. This piece measures 25 mm long, 17 mm wide, and 4 mm thick. No evidence of use damage was present.

Choppers

Four choppers were identified in the lithic analysis sample from LAN-64—one from Feature 64 and three from Feature 76. The former (catalog no. 28) was a large quartzite cortical flake from a waterworn cobble that had been flaked on the ventral surface to establish a working edge. This tool measures 56 mm long, 53 mm wide, and 26 mm thick, and the working edge was dulled and spalled from battering. Asphaltum was present on the unworked surface. The remaining choppers were of three different materials. The metasedimentary and andesite tools were unifacially flaked waterworn cobbles. The former (catalog no. 242) measures 108.6 mm long, 76.3 mm wide, and 37.2 mm thick, with both dulling, spalling and step flaking from battering on the working edge. In addition, asphaltum residue was present adjacent to the working edge and on the exterior surface of the cobble. The working edge angle varies from 60 to 70 degrees. The andesite chopper (catalog no. 238) was of very similar size (101 mm long, 121 mm wide, and 50 mm thick), and major portions of the exterior showed heat spalling followed by flaking. Finally, the chert chopper (catalog no. 255) from Feature 76 was bifacially worked and was smaller, just 83 mm long, 75 mm wide, and 57 mm thick. It had been a multidirectional core subsequently modified as a chopper. Asphaltum was present on and near the working edge and on the cortical surface, and spalling and microflaking from use were present on the working edge.

Cores

The sample contains four multidirectional, three unidirectional, and one flake core (Table 8.17). The flake core was a quartzite specimen from Unit 13. The unidirectional cores include one chert core (catalog no. 286) from Feature 32 and a quartzite specimen (catalog no. 20) from Feature 56. The latter was a cortical flake reduced around the margin. All three of the multidirectional cores were from Feature 76; one was chert, the other two were metasedimentary. There were asphaltum blobs on one of the metasedimentary cores, and on the flaked and unflaked surface of the other. In addition, this latter piece, a waterworn cobble split to an eighth and then reduced, was dulled from battering on the cortical surface away from the flaking, suggesting the core also served another function. The chert multidirectional core (catalog no. 247) still possesses cortical surfaces, and there was some minor rounding of flake-scar arrises that may reflect postdepositional damage or use.

Edge-Modified Pieces

The seven edge-modified pieces identified in the analysis sample include two from Feature 17 and one each from Features 12, 36, 52, and 65 and Unit 14. The two tools from Feature 17 consist of one chert and one quartzite piece, with the former exhibiting microflaking from use. This piece (catalog no. 65) was bifacially worked along one lateral edge of the dorsal face, resulting in an edge angle of 65 degrees. The other (catalog no. 60) was unifacially retouched along one lateral edge and the distal end, although the flaking extends further from the margin and the resulting edge angle was 70 degrees. Possible microflaking was present on this specimen. The chert tool from Feature 52 (catalog no. 134) was similar, exhibiting a unifacially worked lateral edge on a cortical flake and an edge angle of 64 degrees. The tool from Feature 36 (catalog no. 79) of chert was bifacially worked on the distal end to form an edge angle of just 40 degrees. Microflaking from use was evident on the working edge. The chert tool from Feature 65 (catalog no. 225) was only minimally worked, with two small percussion flakes removed from the bulb of the parent flake. This modification may simply reflect initial thinning of a biface base, rather than production of a working edge.

The edge-modified flake from Feature 12 (catalog no. 54) was a cortical wedge from a quartzite cobble. Two broad unifacially flaked notches measuring 4.7 and 6.4 mm in width, respectively, exist along the lateral edge, with these working areas exhibiting step flaking and an edge angle of 90 degrees. Finally, a small, thick chert core-reduction flake (catalog no. 353) from Unit 14 exhibits partial working on the ventral face of the lateral edge. This piece had an edge angle of 70 degrees. Among edge-modified pieces, the quartzite tools were slightly larger, measuring approximately 53 mm long, 28–62 mm wide, and approximately 18 mm thick. In contrast, the chert edge-modified pieces were just 19–29 mm long, 7–27 mm wide, and 6–9 mm thick.

Scrapers

The three scrapers from the LAN-64 analysis sample were all "cobble heel" planes or scrapers, although in three different materials. The first specimen (catalog no. 53) exhibited minimal rounding along the edge of the split face of a quartered cobble, forming a working edge angle of 84 degrees. Recovered from Feature 12, this granite tool measures 78 mm long, 77 mm wide, and 53 mm thick. An andesite piece form Feature 76 (catalog no. 239) was a quartered cobble measuring 62 mm long, 60 mm wide, and 45 mm thick. Stepping and microflaking from use were present along the 83 degree working edge, and battering was evident on the cortical surface opposite the scraping face. Finally, the nonspecific igneous scraper from Feature 76 (catalog no. 252) was an eighth of a cobble, with stepping and microflaking along longitudinal fracture, a battered pit on cortical surface, and asphaltum residue on the exterior surface, as well. Measuring 91 mm long, 47 mm wide, and 51 mm thick, this piece had thermal fractures that have been subject to subsequent substantial rounding and dulling due to postdepositional processes.

Shaft Straightener

One flake tool (catalog no. 37; Figure 8.32) of granite was evidently designed to straighten or smooth wooden shafts. This implement measures 82 mm long, 58 mm wide, and 23 mm wide, exhibiting with at least seven U-shaped concavities around the edge. These working surfaces were approximately 9 mm wide, and a few narrower V-shaped grooves may also be present along the edge.

Ground and/or Battered Stone Tools

Cogged Stones

Three cogged stones were recovered from LAN-64, all of which were point-provenienced objects in nonfeature contexts. These artifacts were the land-and-groove type, with the number of grooves varying from just one shallow V-shaped groove on an implement of nonspecific igneous rock (catalog no. 265) to 20 U-shaped grooves with a slight "Z" lean on a specimen of vesicular basalt (catalog no. 262). The remaining nonspecific igneous cogged stone (catalog no. 264) had 12 grooves. This latter specimen exhibits red discoloration from heating, and asphaltum on a portion of the edge, and the angle between the edge and one face had been rounded over, perhaps due to trampling or some other postdepositional process. The piece with just one groove also exhibits such rounding, asphaltum specks on one face, and a reddish tint to one face that many to due to either pigment or heat. The basalt stone had a semicircular striation on one face. The cogged stones range from approximately 88 to 97 mm in diameter and were approximately 41 mm thick.

As noted above, cogged stones and discoids were associated with the Millingstone period in southern California(Eberhart (1961:367; see also Koerper and Mason 1998 and references therein). As is discussed in Chapter 14, this temporal affiliation is also consistent with other chronological data from the site. Thus, despite the relatively small collection and recovery from nonfeature contexts, these artifacts appear to be related to Millingstone period activities rather than ping scavenged items.

Discoids
The single discoid (catalog no. 263) recovered from LAN-64 was a point-provenienced artifact. This specimen was of nonspecific igneous rock, as well, with a size comparable to the cogged stones. This implement was approximately 87 mm in diameter and 43 mm thick. One flake was removed from the edge. No residues were present. Discoids were associated with the Millingstone period in southern California (Eberhart (1961:367; see also Koerper and Mason 1998 and references therein), and this temporal affiliation was consistent with other chronological data from the site.

Hammer Stones
Four complete or nearly complete granite hammer stones and one hammer stone of nonspecific igneous material were identified in the lithic analysis sample. All of these tools were recovered from four features although four different features were represented. All represent expedient use of waterworn cobbles.

The two tools from Feature 36 were both complete specimens of granite, with one (catalog no. 73) exhibiting pitting from battering and asphaltum associated with the working surface, and the other (catalog no. 74) with light battering in the form of dulling at one end. This area also had black residue present. The tool from Feature 17 (catalog no. 55) had substantial battering at both ends and possible blackening from adhesive wear, whereas the hammer stone from Feature 76 (catalog no. 235) was battered at only one end with significant asphaltum residues on the surface of the entire tool. Finally, the igneous hammer stone from Feature 23 (catalog no. 284) had impact spalls from battering around the circumference of the tool and blackening on one face. This latter implement measures 82 mm long, 94 mm wide, and 51 mm thick. The other complete hammer stones had a mean length of 151 mm, mean width of 107 mm, and mean thickness of 60 mm.

Manos
Ten manos—five of conglomerate, four of granite, and one of sandstone—were identified in the lithic analysis sample (Table 8.18). The sandstone mano was nearly complete, while only one mano was complete and the remaining artifacts were fragmentary . Two of the pieces from Feature 76 (catalog nos. 228 and 259) appeared to be from the same tool, although they did not conjoin. As indicated in Table 8.18, both bifacial and unifacial manos were in nearly equal proportions, with their working surfaces flat rather than convex. Many were only initially to minimally ground, although one implement from Feature 17 and two from Feature 76 were thoroughly ground. Significantly, these two tools and one other from Feature 17 were also the only manos exhibiting thermal damage, suggesting the scavenging and reuse of exhausted ground stone implement for a different purpose. In fact, one piece from Feature 17 (catalog no. 57) exhibits substantial rounding of a fracture prior to thermal damage, indicating this tool was subject to postdepositional alteration before the later use. The mano from Feature 66 had an area of pitting on one face that may indicate secondary use for battering.

Metates
Five metate fragments were identified at LAN-64, including one from Feature 17, three from Feature 33, and one from Feature 36. Those from the latter two features were sandstone Stage 3 unifacial implements shaped on both fire-damaged faces. In addition, the metate from Feature 36 exhibited rounding of one broken edge that indicated postdepositional damage. The fragments from Feature 33, which might have been from the same implement, had one concave working surface. The tool from Feature 36 had one concave milling surface, and the remaining metate fragment from Feature 17 was granite and also had one flat grinding surface.

Mortars, Bowls, and Other Vessels
Eleven ground stone fragments of mortars, bowls, or other vessels were identified, with 10 recovered from Feature 76. The remaining fragment was from Feature 52 and was too small to determine the vessel form, although the estimated rim diameter was 300 mm.

Four of the specimens from Feature 76—including two conjoining fragments—are bowls, based on their material and/or shape. The conjoining specimens of diorite (catalog nos. 236 and 237) had a finely shaped exterior, exceeding the work even on the interior of the vessel. One of these pieces was thermally damaged. The bowl fragment of vesicular basalt (catalog no. 226) was also finely worked, with fractures from exposure to fire. The final fragment of steatite (catalog no. 244) was a vessel rim fragment with asphaltum blobs on the exterior.

The remaining fragments of undetermined function include two pieces of vesicular basalt and one each of diorite, granite, sandstone, and siltstone. The sandstone and siltstone fragments and one of vesicular basalt were substantially ground, whereas the diorite and granite vessel fragments were only minimally worked on interior and somewhat more substantially modified on the exterior. The remaining vesicular basalt piece was shaped to a similar degree on both the interior and exterior, and the rim was sufficiently intact to estimate a vessel diameter of 140 mm. The granite piece had the rounding of the fractured edge indicative of postdepositional damage, and ash residue might have been present inside the vessel. The siltstone fragment also had dulling of at least one relict fracture, as well as rodent gnawing and scratches. The sandstone and one vesicular basalt piece were fire damaged.

Perforated "Disks"

Two perforated steatite "disk" fragments (catalog nos. 17 and 18) were identified in the collection from Feature 56. The first measures 22 mm long, 22 mm wide, and 13 mm thick, and exhibits three parallel incisions. Two of these stripes were on the external surface and one was along the circumference, similar to vessel fragments noted in Feature 587 at LAN-63. It may be that this was an ornament made from a scavenged vessel sherd, with a biconical perforation measuring 5.2 mm in minimum diameter to hang the piece. One of the incisions bisects the perforation.

The second specimen measures 31 mm long, 31 mm wide, and 12 mm thick. It also had a V-shaped groove across a biconical perforation that was 4–8 mm in diameter. The decorative incision was approximately 3 mm wide.

Unclassifiable Ground Stone Objects

Twenty-eight items were identified only as unclassifiable ground stone, as their fragmentary nature prevented functional ascription. These included 2 items of sedimentary breccia, 1 of conglomerate, 2 of diorite, 1 of granite, 1 of metasedimentary, 5 of sandstone, 2 of siltstone, and 14 of steatite. All of the steatite derived from Features 50 and 56 and was manufacturing debris or fracture detritus. Multiple features were represented in the remainder of the unclassifiable ground stone.

One unclassifiable ground stone object of sandstone was recovered from each of Features 12 and 64 , and two such pieces were located in Feature 33. One of the latter was a moderately worked metate or mortar fragment with subsequent fire damage, and the other three were lightly worked fragments of unknown tools. The one remaining sandstone piece was from Feature 76, which also contained the conglomerate, siltstone, and diorite specimens. The latter two appear to be mano or metate fragments, as did the sandstone piece. The conglomerate tool might have been a mano, whereas the siltstone pieces might have been metate or mortar fragments. Four of the pieces from Feature 76 had evidence of fire damage, and nearly all of the unclassifiable ground stone from this feature were highly worn, suggesting scavenging of exhausted or nearly exhausted tools for use in thermal features.

The remaining unclassifiable ground stone objects include one highly worked metasedimentary fragment from Feature 66, one initially worked sedimentary breccia piece from Feature 62, a fire-affected metate or mortar fragment of sedimentary breccia from Feature 52, and a granite fragment from Feature 17. This latter object (catalog no. 59) was lightly worked and exhibits postdepositional rounding of a fractured edge and faceting of the adjacent surface. The piece was fire affected, as well.

Other Lithic Objects

Fire-Altered Rock

The eight fragments of fire-altered rock included two pieces of basalt from Feature 66, and three pieces of sedimentary breccia from each of Feature 52 and Unit 13. The nature of the parent pieces of these stones cannot be determined.

Manuports

Twenty-eight items in the analysis sample were manuports, with the majority waterworn cobbles (n = 22) or pebbles (n = 1). The remaining five were siltstone, four of which were tabular pieces. The other siltstone manuport was too damaged by rodent gnawing to determine the nature of the parent piece. Only two of the manuports were complete, including the pebble. This latter item was 28 mm long, 21 mm wide, and 6 mm thick, whereas the complete cobble was 170 mm long, 109 mm wide, and 51 mm thick.

In addition to the siltstone specimens, lithic materials in the manuport collection included granite (n = 11), nonspecific igneous (n = 4), conglomerate (n = 2), rhyolite (n = 2), andesite (n = 1), metasedimentary (n = 1), sedimentary breccia (n = 1), and undetermined lithic material (n = 1). Six of the nine pieces from Feature 76 were fire affected, suggesting they might have served in a thermal feature. Two of these also had asphaltum specks, including adhesion of such material after fire fracturing in one case . One other piece from this feature exhibits dulling and rounding of a fractured surface prior to fire damage, indicating scavenging of material subject to earlier postdepositional alteration. The only other specimens of note were two granite pieces from Feature 36 partially coated with asphaltum, including broken surfaces; another granite piece from Feature 33 with minor red ochre staining; and a granite fragment from Feature 36 with two small areas of possible pitting from battering on opposite faces. Finally, one of the rhyolite items, located in Feature 23, was a quartered cobble that might have been intended for further use as a scraper, and the remaining rhyolite piece from Feature 12 might have been a core rather than fire-affected rock.

Tarring Pebbles

One tarring pebble from recovered from Feature 17. This piece was a waterworn specimen of siltstone that measures 57 mm long, 45 mm wide, and 31 mm thick. Asphaltum was present on the surface, and there were parallel gouges at one end.

LAN-206A Lithic Sample

The lithic analysis for LAN-206A included all items from three features excavated in 2003 (Features 105, 106, and 107), as well as all bifacial tools and special items. This sample includes 56 artifacts, including 12 unclassifiable ground stone fragments, 11 pieces of debitage, 10 metates, seven manuports, four edge-modified pieces, three hammer stones, three manos, two bifaces, two tarring pebbles, one chopper, and one cogged stone. The total lithic collection from LAN-206A encompasses approximately 275 items.

Debitage

As noted above, only 11 pieces of debitage were analyzed, with all pieces recovered from features. Both biface thinning and core reduction were represented. The former group was composed of three chert percussion biface-thinning flakes, including one early percussion flake in each of the 0.25–0.5-inch and 0.5–1-inch size classes, and one late-percussion flake in the 0.5–1-inch size. The remaining flakes were core-reduction debitage, including two completely cortical chert flakes in the smallest size class and three noncortical flakes, including two in the smallest size and one in the 0.125–0.25-inch group. The final three pieces were one partially cortical chalcedony flake in the 0.25–0.5-inch size class, and one non-cortical flake fragment in the each of two smallest size classes.

Although this sample was quite small, the data suggest that, at a minimum, both biface thinning and core reduction of siliceous sedimentary stones took place. Later stages of biface thinning were absent, however, and cores were likely relatively small.

Flaked Stone

Bifaces

Two bifaces were identified in the lithic analysis sample from LAN-206A. A complete Stage 3 biface of quartzite (catalog no. 26) was recovered from Feature 107. This tool, made on a cortical flake blank from a waterworn cobble, measures 78 mm long, 59 mm wide, and 22 mm thick. It exhibits some rounding on facial arrises, perhaps due to postdepositional damage, as well as substantial dulling along one edge.

A point-provenienced Stage 4 proximal biface fragment of chert (catalog no. 43) was also located at the site. This piece measures 18 mm long, 21 mm wide, and 8 mm thick. It had collateral flaking and was broken by a radial fracture, likely related to postdepositional damage.

Choppers

One chopper was associated with Feature 107. This tool (catalog no. 29) was a bifacially worked quartzite waterworn cobble that measures 66.1 mm long, 75 mm wide, and 39.1 mm thick. Wear from battering in the form of both dulling and spalling was evident along the working edge.

Edge-Modified Pieces

Four edge-modified pieces were identified in the lithic analysis sample from LAN-206A, including one from Feature 105, two from Feature 107, and one point-provenienced specimen. The latter (catalog no. 42) was a completely cortical quartzite flake from a waterworn cobble with unifacial continuous semi-invasive flaking along both lateral edges and the dorsal end. The tool from Feature 105, on the other hand, was a minimally modified chert flake. This piece (catalog no. 55) had two contiguous pressure flakes removed from a crushed platform on the ventral surface of the piece. This may represent an initial attempt to thin the piece for a bifacial tool.

The two edge-modified pieces from Feature 107 consist of one roughly shaped specimen of granite (catalog no. 24) and another tool of siltstone (catalog no. 21). This latter tool exhibits edge rounding and microflaking from use on the lateral edges, as well as substantial faceting, polish, and longitudinal striations on ventral surface. The granite piece exhibits unifacial continuous semi-invasive flaking on one edge, and bifacial semi-invasive flaking along a portion of the opposite edge. In addition, there was possible faceting on the broken face of the flake.

Ground and Battered Stone

Cogged Stones

One land-and-groove cogged stone was recovered from LAN-206A. This artifact was made of vesicular basalt, and measures approximately 85 mm in diameter and 39 mm thick. It was trapezoidal in cross section due to rounding of one face, perhaps as a result of postdepositional damage. The piece exhibits 14 grooves, and one groove might have been reworked after facial rounding. This latter trait suggested possible scavenging of the piece.

Cogged stones are associated with the Millingstone period in southern California (Eberhart (1961:367; see also Koerper and Mason 1998 and references therein), and the presence of such specimens in the previous collections from LAN-206 was one of the factors leading Van Horn and White (1997:20) to recognize a Millingstone period component at this site. These artifacts were not recovered through controlled surface collection or excavation, however, and the authors were somewhat equivocal in stating that "*it stands to reason* that they should be associated with Component C [of the Millingstone Period]" (emphasis added). The possible evidence of reworking of the cogged stone in the current collection offers another explanation (i.e., scavenging) for the presence of this particular artifact at this site, although this activity could have also occurred in the Millingstone period.

Hammer Stones

Three hammer stones were identified in the lithic analysis sample, including two from Feature 107 and one from Feature 106. The latter tool (catalog no. 7) was of granite and exhibits extensive battering along one edge and the end. In addition, there was a central pit on convex face with black residue and possible adhesive wear on the face, as well.

The quartzite hammer stone from Feature 107 (catalog no. 27) was a longitudinally split waterworn cobble with unifacial invasive flaking on the broken face to form narrow a working edge. The working edge exhibits dulling and spalls from impact in one area, and there was rounding and facial faceting on the opposite edge. Finally, the siltstone hammer stone (catalog no. 17) was dulled and spalled from battering along the working edge. In addition, well-defined parallel striations were present on one face, and there was a pit from battering on the opposite face.

Manos

Three sandstone mano fragments were identified, including two from Feature 105 and one from Feature 107. All were Stage 2 specimens with only limited grinding evident. The piece from Feature 107 (catalog no. 10) was bifacial with black residue on one face and a central pit on this same face. This latter attribute indicated use of this tool as an anvil or hammer stone, as well as for milling. One of the specimens from Feature 105 (catalog no. 3) was also bifacial, with these working surfaces converging to a battered end. One face was deeply pecked down the center to form pits, and this feature and the battering suggests that this tool served more than one function. The remaining mano from Feature 107 (catalog no. 1) was unifacial, although the opposite surface exhibited inclined facets from wear or shaping. There was a possible impact scar on the same side, although there was no additional evidence of battering on the tool.

Metates

Ten metate fragments were recovered from Feature 105, 106, and 107, with two sufficiently intact to suggest basin metates. One of these latter metate fragments was a highly worn conglomerate specimen from Feature 105 (catalog no. 2)—the only metate from this feature—and the other (catalog no. 37) was a conglomerate specimen from Feature 107 that might have been worn completely through the base. The remaining sample includes one sandstone and one conglomerate fragment from Feature 106, and three conglomerate, one schist, one sandstone, and one nonspecific igneous fragment from Feature 107. The sandstone piece (catalog no. 40) was the only bifacial metate. Two of the metate fragments from Feature 107 exhibit burning after breakage, and one of the specimens from Feature 106 had also been damaged by fire. Black residue was present on the working surface of the other piece from Feature 106, and black residues were present on the exterior surfaces of two pieces from Feature 107. Red ochre was present on the working surface of one other tool (catalog no. 34) from this feature.

Unclassifiable Ground Stone

Twelve objects from Feature 107 were identified simply as unclassifiable ground stone. This sample includes pieces of conglomerate (n = 5), sandstone (n = 5), and nonspecific igneous rock (n = 2). Nearly all of these specimens (n = 8) had been thoroughly ground and used, and seven were fire altered. Seven might have been mortars or metates, four others might have been metates or manos, and the last was a mano or pestle fragment. Pieces range from 51 to 154 mm in length, 43 to 130 mm in width, and 15 to 79 mm in thickness.

Other Lithic Objects

Manuports

Six manuports were identified at LAN-206A, all of which were waterworn cobbles or cobble fragments. The only complete specimen was located in Feature 107, and this cobble of an undetermined lithic material measures 131 mm long, 95 mm wide, and 65 mm thick. The fragments include one of nonspecific igneous rock from Feature 100, one of granite from Feature 105, two of granite from Feature 106, and two of granite from Feature 107. Significantly, one piece from Feature 105 (catalog no. 4) and two others from Feature 106 (catalog nos. 8 and 9) exhibit a fracture angle and specks of black residue on the surface that suggest these were pieces from the same cobble. Although this cannot be taken to indicate contemporaneity of these two features, it at least suggests that objects from one feature might have been scavenged for another. One of the pieces from Feature 106 was fire affected, as was another from Feature 107.

Tarring Pebbles

Two tarring pebbles were recovered from Feature 107. Both were of conglomerate and, unlike the tarring pebbles from LAN-63, were broken ground stone fragments applied to this use rather than being unaltered waterworn pebbles. They were also somewhat larger than those typical of LAN-63, ranging from 46 to 83 mm in length and measuring approximately 37 mm in width and 52 mm thick.

Interpretations

Procurement and Exchange

As discussed at the beginning of this chapter, the lithic landscape of the immediate West Bluffs vicinity as well as the greater Los Angeles basin and surrounding mountains would have provided a diverse lithic materials to the native people of the Ballona area. A variety of sedimentary, igneous, and metamorphic rocks were present in this region, providing a wide array of options for artifact production that could take advantage of the specific manufacturing qualities of each material (see Table 8.1). Recognizing how such materials were acquired, however, was complicated by the fact that many lithic materials that exist in geological formations at some distance from the West Bluffs sites would also have been locally available in clasts of sizes similar to, or smaller than, those available at the source. That is, there was local availability of “distant” source materials due to secondary alluvial deposition.

Local Lithic Material Procurement

The importance of secondary geologic deposits to the West Bluffs residents was clearly indicated in the lithic collection by the prevalence of waterworn cobbles and cobble fragments in the manuport, anvil, and cobble tool (i.e., scraper, chopper, and hammer stone) collections from all three sites. In addition, the use of such alluvial clasts was signaled by the presence of completely or partially cortical flakes in the debitage samples. Cortex on these flakes was dominated by water wear rather than the primary geologic cortex associated with geologic formations. Materials that appeared to have been procured locally or, at least, from the alluvial deposits of the Los Angeles basin include granite, rhyolite, conglomerate, metasedimentary, quartzite, diorite, andesite, sedimentary breccia, gneiss, and schist.

As noted above, marine sedimentary rocks such as conglomerate could have derived from any one of a number of primary formations of the basin or surrounding mountains, whereas other materials such as granite likely had their origin in ranges to the north and east such as the San Gabriel or San Bernardino Mountains. This latter observation would suggest the procurement of secondary clasts of these materials from hydrologic features of the Los Angeles or San Gabriel river systems, although the Santa Ana River also could have served as a conduit for granite or other lithic materials from the San Jacinto Mountains. Hence, "local availability" in this case might be as close as Ballona Creek, since it served as a channel for the Los Angeles River at times in the past. The alluvial sample contains clasts ranging from fist to football size, indicating that individual, or perhaps even multiple, stones could have been transported to the site by one person.

Given the size of the largest clasts observed in the site-specific manuport collections and the less restrictive requirements with respect to material quality in the cultural contexts in which manuports were primarily used (i.e., thermal features), these items were almost certainly procured locally. This conclusion also applies to anvils and, perhaps, to materials used for other ground and battered stone tools. Although many of these toolstones were probably local, the same materials could have been acquired elsewhere when more specific functions for the stones were anticipated. For example, the large schist pestle recovered from LAN-63 could not have been made from locally available material, as it was more than 1 m long. This implement was likely initially or completely shaped elsewhere, perhaps by people other than the West Bluffs occupants. In this case, the size of the artifact indicated it could not have come from local deposits. The same might have been true for some of the larger bowls or mortars of basalt, diorite, granite, or other hard stone, as the rim diameters suggest that stones of such size might not have been readily available at so far from the primary sources. Secondary alluvial deposits were probably the source of water-rounded boulder "blanks," but larger clasts would probably have been procured—and potentially even worked—at these more distant locales prior to transport to the West Bluffs sites. Unfortunately, given the modern channelization of many streams and rivers in the Los Angeles Basin—including Ballona Creek—clast-size data were not available to suggest possible procurement ranges. As noted above, schist exists in primary geologic context in the western San Gabriel Mountains and Santa Catalina Island, and basalt formations are present in the Palos Verde Hills, Santa Monica Mountains, and Santa Catalina Island.

Other locally available lithic materials used by the residents of the West Bluffs sites include chert, chalcedony, sandstone, and siltstone. Much of the siltstone had been tabular and could have come from any primary bedded deposits in the coast, basin, or surrounding mountains. Sandstone procurement was equally enigmatic; because this material was softer than the igneous and metamorphic manuports, cortical surfaces were sometimes obscured or missing. Still, many waterworn cobbles were also represented in the sandstone assemblage, suggesting that at least some sandstone came from secondary alluvial deposits in the immediate or surrounding area.

Chert and chalcedony were largely restricted to the flaked stone and, hence, determining whether these materials arrived on-site already reduced or "as-is" depends on identifying technological traits of the debitage and cores. These data suggest that these materials were brought to West Bluffs both partially reduced and unreduced. Cortex was present on some flakes, although in the case of chert, some pieces clearly have primary geologic cortex associated with bedded formations. That is, chert was acquired as both waterworn pebbles and cobbles and as tabular pieces. The four exceptionally large Stage 2 bifaces from LAN-63 clearly arrived as tabular pieces, although the paucity of flakes of a comparable size indicated these bifaces were reduced elsewhere.

Perhaps significantly, such a bifacial form was consistent with the notion of a highly mobile people, who would favor cores of this type (Kelly 1988). Thus, high residential mobility may be indicated at least with respect to activities at Features 564 and 372 at LAN-63, if not elsewhere on the site. Conversely, this bifacial form may simply represent logistical acquisition of some larger chert cores or bifaces from bedded formations. For example, such material might have been acquired directly or through the exchange of partially reduced pieces from the Santa Monica Mountains or Palos Verdes Hills within approximately 20 km (12 miles) of the West Bluffs sites. Overall, the size of chert and chalcedony flakes indicated the parent clasts were smaller than the flaked quartzite, metasedimentary, rhyolite, and non-specific igneous rock. This might have been a function of anticipated use (see below). Conversely, this may relate to the nature of locally available clasts of such siliceous sedimentary stones or more-distant acquisition of raw material and initial reduction prior to introduction to the sites, or both. Waterworn clasts of chert and chalcedony would likely have been derived from coastal zones, as primary deposits of these materials were less common to the upstream zones of the Los Angeles and San Gabriel river systems.

Procurement of Lithic Materials from More-Distant Locales

In contrast to materials available adjacent to or within a one- to two-day walk of the West Bluffs sites, some toolstones such as obsidian were clearly brought to the site from some distance and in a much-reduced form. Geochemical trace-element analysis of seven obsidian flakes and five obsidian tools (Table 8.19) indicated access to material from the West Sugarloaf flow of the Coso volcanic field (n = 10), Casa Diablo (n = 1), and Mono Glass Mountain (n = 1). The latter two geochemical types were represented only by tools, suggesting they were transported as shaped items or finished tools. The disparity of the two obsidian hydration rim thicknesses on the Casa Diablo biface (catalog no. 1688; see Table 8.19) indicated that this tool was scavenged and reworked. Therefore, material for this tool was probably not obtained at the source. The same was probably true for the specimen from Mono Glass Mountain (catalog no. 1685) given the distance to this source, although obsidian hydration thin sections from two areas sampled on this tool failed to expose a time lag between damage and reworking of this too, as might be expected with scavenging. One of the Coso biface fragments (catalog no. 1687) also clearly indicated scavenging of the flake blank on which the tool was made, if not the finished tool itself. At a minimum, some obsidian specimens clearly had complicated use lives spanning centuries or millennia.

The obsidian debitage was uniformly small, precluding geochemical sourcing for many specimens. These data further support the interpretation that obsidian was only acquired in significantly reduced forms—Stage 3 to Stage 5 bifaces or projectile points—either through scavenging or exchange. Direct procurement from the Coso volcanic field was also possible, as the source is approximately 250 km (150 miles) to the north. The lack of flake tools of this material, however, suggests that this was unlikely, at least with the West Bluffs sites serving as the home base for such forays.

Another material clearly procured from some distance by the West Bluffs residents was steatite. The closest source is on Santa Catalina Island and, with the exception of ornamental objects, this material was present in only a few spatial contexts at LAN-63 and LAN-64. Although the nature of this material limits its uses, the activities in which steatite artifacts were involved were of enough importance to require this material exclusively or in addition to other materials that seem equally suitable for the task. For example, steatite vessels were used in apparently ritual contexts (see below) despite the fact that vessels of basalt and other materials were also used in these features. This may explain what would appear to be inordinate investment of time, energy, or risk in the procurement of steatite. Conversely, the apparent “value” of steatite might have been a function not only of the relatively unusual qualities of this material, but also of the difficulty in acquiring steatite directly or through trade. There was no evidence at the West Bluffs sites that raw material was brought back to the sites. Rather, similar to obsidian, this exotic material was likely introduced in significantly reduced or finished forms.

Embedded Versus Logistic Procurement

The assessment of procurement and exchange by foraging peoples has been approached in recent years through application of the heuristic model of logistical versus residential mobility proposed by Binford (1980). In the former case, task-specific groups would have made specific forays to quarries to acquire raw materials for the production of flaked and ground stone tools. In southern California, for example, procurement of stone for milling equipment is indicated at the Elephant Mountain quarry in San Bernardino County (Schneider et al. 1995; see also Schneider 1993), and fused shale for flaked stone tools might have been acquired from Grimes Canyon in southern Ventura County. In such a scenario, we might expect raw materials used by the West Bluffs residents to derive from the nearest high-quality source. Other expectations for logistically organized groups include a prevalence of complete rather than broken flakes, presence of angular shatter, rare use of bifacial cores, evidence of scavenging and bipolar reduction, and a low tool to debitage ratio (Kelly 2001:Table 4-2). Residentially mobile groups, on the other hand, would have acquired toolstone during the course of acquiring other resources, an "embedded" strategy in which no special trips would have been undertaken (e.g., Basgall 1989; Kelly 2001). In this case, tool materials would be diverse, as broken or damaged items would be discarded and replaced with new ones from the nearest appropriate source. Such items would then be transported to the subsequent residential bases until ultimate discard. Other traits of lithic assemblages in such mobile contexts include rare complete flakes, a paucity of angular shatter, use of bifacial cores, rare scavenging and bipolar reduction, and a high tool to debitage ratio (Kelly 1988, 2001:Table 4-2).

Unfortunately, such a model can only be applied with success in regions where toolstone is essentially absent from residential base areas or where each different material was both geographically limited and separate. This was clearly not the case at the Ballona. The combination of primary and secondary lithic deposits for the same materials complicated the interpretation of procurement using this model, and it was often unclear whether local or distant acquisition was represented. Even logistically organized groups would have been able to satisfy nearly all of the their toolstone needs without undertaking special procurement trips, and residentially mobile groups could have availed themselves of diverse lithic resources at one locale. Essentially all lithic materials for utilitarian items were readily available within approximately 20 km (12 miles) of the West Bluffs sites. In addition, apparent scavenging and potential caching of heavier ground stone implements hampered attempts to infer logistic versus residential mobility for any given component or feature. Nevertheless, the procurement of some raw materials or, more likely, finished items of schist, basalt, diorite, steatite, and obsidian certainly suggests that travel for the purpose of obtaining or distributing lithic items was undertaken either by the occupants of LAN-63, at least, or by people with whom they interacted. In addition, bipolar reduction, indicative of more-exhaustive use of some toolstones such as chert and obsidian, suggests a periodic lack of access to sources of, greater value placed on, or smaller implements made from such materials.

Intrasite and Intersite Comparisons at the Ballona

Comparison of SRI's lithic sample from LAN-63 and LAN-64 with those from the previous archaeological investigations indicates the data reflect relatively similar patterns. For example, Freeman and Van Horn (1987:57*ff*) noted that Monterey chert was predominant (35 percent) in the debitage, and metavolcanic rock (23 percent), chalcedony (19 percent), and quartzite (18 percent) were also common. Obsidian accounted for nearly 4 percent of the debitage sample, however, with fused shale, quartz, andesite, Franciscan chert, and banded agate each accounting for less than 1 percent of the sample. The dominant lithic materials in the debitage were also well represented in the tools, and slate, sandstone, granitic rocks, basalt, steatite, siltstone, and nonspecific sedimentary rock were also recognized in the flaked and ground stone tool collections.

At LAN-63, chert was even more common (54 percent) in SRI's sample than in that of Archaeological Associates, and quartzite and chalcedony were two of the four most common debitage materials in both excavations (see Table 8.2). It is assumed that Freeman and Van Horn's (1987) metavolcanic category subsumed rhyolite and, perhaps, schist and gneiss. The prevalence of siliceous sedimentary rocks and quartzite was consistent between the two collections. No fused shale or agate was identified in the current sample, whereas no conglomerate was identified in the previous collection. This latter observation may reflect different rock classification, but the lack of fused shale might have been accounted for by the focus on features rather than midden samples in the current analysis or by temporal differences between features and midden contexts. As noted by Van Horn (1990) and Freeman and Van Horn (1987), fused shale was particularly prevalent in the Canaliño and Marymount projectile points from LAN-63 that date to the late Middle period (ca. 1500–1000 B.P. [A.D. 500–1000]). In contrast, the radiocarbon dates from the current investigations (see Chapter 13) suggest a somewhat earlier use for the features studied in the current analysis.

At LAN-64, also, the material profiles of the two investigations were very similar. Freeman (1987:239) noted the prevalence of chert (37 percent) and chalcedony (27 percent) in the debitage, with lesser quantities of quartzite (20 percent) and metavolcanic rock (17 percent). Obsidian accounted for less than 1 percent of the collection, with most of these pieces described as "small to tiny pressure flakes that had been detached from bifacial implements" (Freeman 1987:240). Likewise, rare fused shale was also attributed to pressure flaking of bifaces. The dominant lithic materials in the debitage were also well represented in the tools, and sandstone, basalt, steatite, and nonspecific sedimentary rock were also recognized in the flaked and ground stone tool collections [what's the purpose of recognizing them when comparing profiles?]. Once again, these data show material patterns very similar to that noted in the current study (see Table 8.16), except for the notable absence of fused shale in the current sample. If fused shale was only present as late-stage biface shaping, however, the apparent absence of such flakes may simply reflect the types of features selected for analysis or the field-recovery methods, or both.

At nearby LAN-62 at the base of the bluffs, a preliminary assessment of the debitage indicated the dominance of chert, quartzite, and basalt, with rhyolite, granite, and obsidian occurring less frequently (Robert Wegener, personal communication 2004). These data also reveal an approximately 16 percent increase in chert from the Middle to Late period, wholly at the expense of quartzite. The relative representation of quartzite debitage at LAN-62 during the Middle period was even greater than at LAN-63, however, and the amounts of chert and quartzite in the Late period component at LAN-62 were most similar to those noted at LAN-63 in the current analysis. Therefore, it does not appear that definitive statements can be made with respect to possible shifts in material use through time for the Ballona as a whole.

Site LAN-211/H, in the same vicinity as LAN-62, also contained chert, chalcedony, basalt, and quartzite debitage (Rosenthal and Hintzman 2003), as did LAN-47, a Late period deposit on the northern edge of Ballona Lagoon (Towner 1992). The flaked and ground stone tool assemblage from LAN-211/H included these materials, as well as andesite, fused shale, metasedimentary and metavolcanic rock, nonspecific igneous stone, obsidian, quartz, sandstone, steatite, and rhyolite. With the exception of fused shale (see above), the earlier results for these two sites were very similar to the current analysis, despite the fact that LAN-211/H may include up to three components dating to the Middle, Late, and early-historical periods (Ciolek-Torrello 2003:244). Even though much later use was indicated at both LAN-47 and LAN-211/H, the lithic material use patterns noted in recent analyses encompassing collections from sites both on and below the bluffs were generally consistent, with differences attributable, at least in part, to classification systems used to designate specific lithic materials types (e.g., metavolcanic versus basalt or nonspecific igneous, etc.).

Lithic Technology

By necessity, discussion of the production of stone tools at the West Bluffs sites focuses on LAN-63 and LAN-64, as the sample from LAN-206A was too small to provide meaningful conclusions. As the above reviews suggest, the nature of the locally available toolstone shaped the technological strategies employed by the site residents. For example, the size and shape of the alluvial clasts strongly influences the methods of flaked stone reduction, and these same characteristics might have favored the manufacture of specific tool types or influenced the production methods for ground or battered stone tools. In particular, the availability and use of rounded or subrounded fist- to football-size waterworn cobbles was significant, whereas the use of tabular stone would have also favored a particular, but different, reduction strategy. The lithic technology practiced by the residents of the West Bluffs sites reflects adaptation to the lithic landscape of the area.

Flake-Core Reduction and Flake Tool Use

As indicated in the site-specific discussions, debitage data reveal that both flake and core tools were produced on-site, as well as bifaces that might have been manufactured from cores or flake blanks. The debitage for all materials showed that production of flakes from cores occurred on the sites, and cores of many of these same materials and a few others were also present in the site collections. Nodules or minimally reduced cores were brought to the site for subsequent percussion reduction, with both early- and late-stage percussion core reduction carried out. In addition, the cores of various types—from unidirectional to multidirectional—suggest expedient percussion reduction that took advantage of the particular shape and size of each piece, rather than seeking to produce flakes of a standard shape (e.g., blades). For cores of those materials especially suited to flaked stone reduction such as chalcedony, chert, quartzite, and metasedimentary rock, flake removal proceeded well beyond initial decortication. This was indicated, in part, by the greater amounts of noncortical flakes than partially cortical flakes, as well as the prevalence of flakes with multi- rather than single-faceted platforms.

Together, these data and the dominance of core-reduction flakes in the debitage collections highlight the importance of flake production for tool manufacture, while also indicating the relatively thorough use of many nodules or cores brought to the site. Cores were not regularly "exhausted"—reduced to very small core remnants—however, as the flakes produced would have been too small for use as handheld, rather than hafted, implements.

The flake tool samples from LAN-63 and, to a lesser extent, LAN-64, indicate that the flakes intended for tool production likely served a variety of purposes, including as flake blanks for bifaces, borers, burins, gravers, edge-modified pieces, and some scrapers. The edge-modified pieces from LAN-63, in particular, highlight the use of metasedimentary and quartzite core-reduction flakes that would have provided more durable working edges than chert or chalcedony flakes. The core data and location of cortex on edge-modified pieces of metasedimentary and quartzite, however, reveal differences in the production of such flakes that evidently relate to the nature of the parent pieces and desired flake use.

In the case of metasedimentary, smaller parent pieces were either selected or available, resulting in flake tools with cortex on their dorsal surface, and indicating that the initial flakes were those subsequently used for tools. This might have been because noncortical flakes would have been too small for the anticipated use as core size decreased with reduction or especially sharp edges more typical of noncortical flakes were not sought. In contrast, quartzite flake cores were somewhat larger and were often split to form an angle that functioned well for subsequent flake removals. That is, the smooth, rounded exterior of the quartzite cobble hindered controlled flake production, but splitting the cobble overcame this problem. Splitting might also have reduced the size of large quartzite cobbles, thus facilitating freehand percussion reduction in which the core could be easily manipulated with one hand.

As a result of the splitting technique, the quartzite flakes removed and subsequently used as tools often had cortical platforms, rather than dorsal cortex or no cortex whatsoever. This trait was recognized by Van Horn and Murray (1984:22) as “potato” flakes, which they designated as a distinctive tool type. Although they initially suggested that such flakes were produced by simply working from one end of the nodule to the other (i.e., the first flake removal would be completely cortical), the current data confirm a later hypothesis of Van Horn and Murray (1985:85). As noted above, the cobble was first split and then further reduced by removing flakes across the exposed surface. As observed by Van Horn and Murray (1985:85), this reduction strategy resulted in the production of a significant number of usable flakes and, thus, was a particularly efficient use of locally available alluvial cobbles. The relative underrepresentation of such cortical-platform flake tools for materials other than quartzite may indicate that this technique was aimed at producing flakes with a dull back and sharp working edges from waterworn cobbles. Quartzite can produce such sharp edges, whereas flakes of many of the other lithic materials available as waterworn cobbles at West Bluffs are not especially suited to cutting or other tasks requiring a sharp edge. Therefore, these other materials (e.g., nonspecific igneous, rhyolite, andesite) might have been reduced in a manner more consistent with that observed for metasedimentary cores.

There was no distinct technological strategy evident for the production of chert and chalcedony flakes from cores at the West Bluffs sites, although debitage data from LAN-64 suggest that chert-core percussion reduction might have followed the split-cobble technique noted especially for quartzite cobble cores at LAN-63. Sample size for cores from LAN-64 was small, however, and this may simply relate to the size of the nodules available. Bipolar reduction indicative of more-exhaustive use of lithic materials was also revealed in the chert debitage at LAN-63. Core-reduction debitage of chalcedony and, especially, chert tended to lack cortex, which was also indicative of more extensive reduction of such cores. Tabular chert cores were also reduced—sometimes with initial reduction occurring off-site—although the goal was biface rather than flake production (see below).

Regardless of the type of chert or chalcedony cobble core reduced or the particular strategy employed in flake production, the resulting flakes were clearly favored for some tools rather than others. For example, the analysis sample suggests that borers, burins, and gravers were made only of chert, evidently taking advantage of the sharp edges that can be produced on flakes of this material. Likewise, although chert and chalcedony were absent from the scraper assemblages, these materials were used for edge-modified pieces. These preferences were likely due to the sharpness and less durable edges of such sedimentary siliceous stones.

Production and Use of Core Tools

In contrast to the diversity of materials recognized in flake-tool production and use at the West Bluffs sites, the debitage data reveal that on-site manufacture of core tools was primarily restricted to quartzite, metasedimentary, nonspecific igneous rock, and rhyolite. Use of these materials for core tools was also confirmed by the materials recognized in the chopper, hammer stone, and cobble heel scraper collections. Initial, minimal on-site reduction in the preparation of such tools was indicated by the full range of flake sizes of these materials in the debitage, including flakes greater than 2 inches in minimum dimension. Likewise, the analysis of cortex on metasedimentary, nonspecific igneous rock, and rhyolite debitage, in particular , suggests that cortical, waterworn cobbles were initially reduced on-site. As noted above, however, some flakes of these materials might have been the inadvertent spalls from tool use rather than purposeful reduction, as numerous choppers and hammer stones exhibit impact spalls from use.

Although many core tools were simple implements with relatively little modification prior to use, many others were clearly designed. In particular, cobble heel scrapers reflected the percussion splitting of cobbles to create at least one approximately 90 degree working edge and an adjacent flat face, and this reduction strategy might also have been aimed at producing tools that could have been used one-handed. This latter goal also could have dictated the number of times the cobble was split, as some were simply split in half whereas others were broken into quarters or eighths. The ability to hold the tool with one hand likely facilitated both scraping and battering—apparently in close succession—as indicated by use-wear patterns on the opposite ends of many of these tools. Although the modification of choppers was also likely related to the desired size of the finished tool and the preparation of a working edge of the requisite length and angle for the anticipated tasks, both unifacial and bifacial percussion flaking was employed for such tools. This observation suggests more flexibility in achieving the desired goal and likely opportunistic response to the nature of the parent piece.

Bifacial Tool Production

Unlike flake- and core-tool production, bifacial flaked stone tool manufacture at West Bluffs included both percussion and pressure flaking. Only chalcedony, chert, metasedimentary, quartzite, and obsidian were subject to such activities, however, with obsidian clearly introduced only in significantly reduced forms, unlike the other materials. In some cases, flake blanks of chalcedony, chert, nonspecific igneous rock, metasedimentary, and quartzite were clearly the focus of reduction, as percussion was used to remove alternate flakes from such pieces. This activity relates to initial thinning for biface manufacture, although it was interesting to note that bulb-removal flakes also indicative of this process were absent. This combination of observations may reflect use of relatively large, thick flake blanks or, in the case of chert, use of tabular cores. Tabular flake blanks were used to produce one contracting-stem projectile point and the Great Basin Stemmed point, both at LAN-63. In addition to the debitage data, the majority of Stage 2 bifaces show relict flake scars that indicate production from flake blanks; such scars were less frequent in later stages. Rather than indicating different production strategies for different biface types, this latter pattern likely reflects more thorough working as reduction progressed and concomitant obliteration of relict surfaces.

Pressure thinning was more common than percussion flaking, indicating that substantial percussion reduction was not necessary to make pieces suitable for subsequent shaping; this was further evidence that flake blanks or tabular pieces, rather than cobble cores, were the focus of biface production. In addition, the prevalence of biface-thinning flakes in the two smallest size classes also supports the conclusion that flake blanks were employed, with most resulting bifaces no more than 10 cm wide and likely significantly smaller. Although both early- and late-stage pressure thinning were carried out on-site, early-stage pressure thinning tended to be more common. Although most tool finishing was conducted elsewhere, projectile-point notching at both LAN-63 and LAN-64 was evidence of at least some final pressure-shaping on-site .

Ground and/or Battered Stone Tool Production and Use

Multiple technologies were used to manufacture ground and battered stone tools, although there was no evidence that such production occurred on-site. Again, the ready availability of rounded to subrounded waterworn cobbles meant that sometimes only minimal modification was required to achieve the desired shape for manos, metates, pestles, bowls, mortars, and other vessels. Although most such tools were fragmentary and many were fire-damaged, many manos and metates were unshaped other than by use. Likewise, some pestles were unshaped or only minimally shaped by pecking or grinding, with the latter particularly common for softer materials such as siltstone. Other pestles, however, exhibit more extensive modification from both pecking and grinding, and at least one pestle was shaped by flaking. Flaking was probably the most expedient method to shape this implement, since it was metasedimentary. In contrast, nonsteatite bowls, mortars, and other vessels generally show significant shaping by both pecking and grinding, particularly on the interior surfaces, where the greatest modification was necessary. More extensive shaping of the exterior surfaces by pecking and, in some cases, grinding, may indicate additional functional considerations, such as extra stability during stirring or pounding. On the other hand, vessels of the much softer steatite were shaped by grinding only, and multidirectional striations suggest no particular pattern in such production. Often, steatite vessels were shaped on both faces, although some pieces appear unshaped on their exteriors . As noted above, some ground stone tools were also destroyed purposefully: either they were struck and broken into pieces (e.g., pestles), or their working surfaces were destroyed (e.g., vessels). In the latter case, one or more percussion flakes were removed at different angles across the exterior base to produce a hole.

Scavenging and Reuse of Lithic Items

Finally, it should be noted that the lithic technology at the West Bluffs sites also incorporated scavenging and recycling of some implements for secondary uses quite different from their original functions. In most cases, the piece was not significantly altered; rather, it was likely scavenged because it could serve the alternate use with little to no further modification. For example, one edge-modified piece from LAN-63 was a biface fragment reused on the broken edge. Likewise, ground and battered stone implements or cores were recycled in thermal features, and the material and size of these pieces might have been significant to their selection for this purpose. Though scavenging was not a manufacturing or production mode in the traditional sense, these activities contributed to the stone tool assemblage used by the site occupants and, therefore, factored into acquisition and production strategies.

Intersite Comparisons at the Ballona

As discussed above, equivalent technological data were not available for previous excavations at LAN-63 and LAN-64 (Van Horn 1987; Van Horn and Murray 1985) or other sites on the bluffs (e.g., Van Horn 1984; Van Horn and Murray 1984, 1985). Comparative data were available for sites located at the base of the bluff along Centinela Creek and north of Ballona Lagoon, however, and this information provides some context with which to assess the results of the current analysis. Preliminary analysis of debitage recovered from LAN-62 at the base of bluff, for example, also revealed the prevalence of core rather than biface reduction for percussion reduction (Robert Wegener, personal communication 2004). Considering both biface percussion and pressure thinning together, however, indicates that biface and core reduction were represented in nearly equal proportions at this site, as a whole. Moreover, results for the temporal components represented by Strata I, IV, and V suggest that biface production even exceeded core reduction during some occupational episodes (Wegener, personal communication 2004). Strata IV and V represent components postdating the Middle period, and these observations indicated that flake and flake-tool production was much more important than biface production in the Middle period features that were the focus of analysis at LAN-63 and LAN-64.

Biface thinning was prevalent at nearby LAN-2769, and constituted approximately half of the debitage at LAN-211/H (Rosenthal and Hintzman 2003:227, 235). Pressure flaking was dominant, and this evidently related, in part, to the dominance of chert in the assemblage and the apparent retooling of projectile points at this site. Similar to at LAN-63 and LAN-64, the results for LAN-211/H also indicate some reduction of cores prior to introduction to site and, too, large flake blanks for the production of bifaces. The LAN-211/H collection differs from those of the West Bluffs sites, however, in the significant proportion (albeit small number) of bipolar cores and the inferred “exhaustion” of many cores (Rosenthal and Hintzman 2003:232). Both of these observations suggest a more conservative or thorough use of material than practiced by the residents of the West Bluffs sites, and a similar pattern was noted at LAN-47, a Late period site north of the Ballona Lagoon (Towner 1992).

Again, the exhaustive use of cores at LAN-211/H might have been due to the prevalence of chert cores at this site and practices specific to this toolstone (i.e., the types of tools produced). This site was used predominantly during the Late period rather than the Middle period, however, so temporal factors such as changing access to toolstone should also be considered. Still, the picture revealed suggests that activities conducted at LAN-63 and LAN-64—and perhaps other bluff-top sites—were much more dependent on flake tools and the creative use of local materials in the production of such implements than those undertaken at sites at the base of the bluffs. It was unclear if this was simply a functional distinction between sites or if temporal factors were also significant.

Site and Feature Function

Assessment of site and feature function can be approached as either a qualitative or quantitative evaluation based on the representation of different functional tool categories. For both approaches, depositional integrity must be demonstrated or assumed. As discussed by many scholars (e.g., Schiffer 1976, 1996), however, such integrity is rare. Various natural and cultural formation processes alter the representation of or relationship between artifacts, thereby confounding functional interpretations based on context and association.

These observations on-site formation and artifact representation certainly apply to the West Bluffs sites, as, for example, scavenging and recycling of both flaked and ground stone implements occurred within or between sites and features on the bluffs. Such practices could have removed artifacts important to discerning site or feature function, and other tools might have been removed (i.e., curated; Binford 1979) by residents when they relocated to another site off the bluffs. In addition, use wear on tools suggests that many implements had dual or serial functions that are impossible to attribute properly to the context from which they were recovered for the functional analysis of features. Likewise, these sites might have been occupied multiple times throughout different periods, (see Van Horn 1987; this report, Chapter 14), so any generalizations of site function, in particular, may be tenuous if different components are not distinguished. Conclusions regarding site function were also hampered at West Bluffs because only a subset of features was analyzed in detail, and the full array of feature types may not be represented in this sample. Because artifact categories for the unanalyzed features have not been confirmed through detailed analysis (e.g., confirmation of ground stone use as opposed to waterworn manuports), these data cannot be incorporated into such a discussion of site function. Finally, quantitative analysis is also undermined by the fact that some collections at West Bluffs encompass artifacts that refit (e.g., the six pieces of the large schist pestle from Feature 11 at LAN-63) or may otherwise represent the same implement. Therefore, artifact frequency for certain classes of tools (e.g., ground stone) might have been inflated and, therefore, misleading with respect to site or feature function.

Despite these confounding factors, some observations are offered here about site and feature function based on both qualitative and quantitative data. Quantitative data were not emphasized, however, and statistical assessment was clearly not warranted. With respect to qualitative observations, both the morphological type and specific features of use such as wear and residues are taken into account, as appropriate. The discussion, as a whole, was informed by the model of logistically versus residentially mobile foraging peoples proposed by Binford (1980), drawing on his site types as well as additional expectations for each type subsequently developed by Thomas (1983) and Kelly (2001) in the Great Basin. For example, Kelly (2001) noted that for logistically mobile peoples, the biface to flake-tool ratio should be low, fire-affected rock should be common, and assemblage size and diversity should be high at residential bases (see also Hull 1994).

Thomas (1983) also provided a useful distinction between four classes of activities common to such sites that was considered in this synthesis, and ethnoarchaeological observations by Binford (1978, 1979, 1980, 1982) and others (e.g., Brooks and Yellen 1987; O'Connell et al. 1992) contributed to developing expectations for spatial arrangements and tool types for specific activities within each of these classes. *Procurement* consists of hunting, fishing, harvesting, and quarrying activities, and involves tools such arrows or darts, digging sticks, and hammer stones. *Processing* encompasses butchering, milling, and shelling of mass resources or shellfish, with stone tools such as knives, choppers, manos, metates, mortars, pestles, and anvils employed in such tasks. *Consumption* includes cooking, eating, and storage, with vessels, knives, and caches associated with such activities. *Manufacturing* encompasses stone tool production, basket making, woodworking, and other similar tasks, with tools such as hammer stones, gravers, borers, shaft straighteners, scrapers, and tarring pebbles related to these activities. White's (1984) concept of the "archaeology of parts" was also significant to archaeological interpretation of site function, as this model recognizes that the particular portion of the tools present may signal activities such as retooling versus production and, hence, logistical or residential site function.

LAN-63 Activities and Function

The lithic collections from the West Bluffs sites suggest that diverse activities were carried out at LAN-63, LAN-64, and, perhaps, LAN-206A. At LAN-63, the current analysis revealed the presence of a wide array of flaked, ground, and battered stone implements. Flaked stone items include bifaces, a borer, a burin, choppers, cores, debitage, a drill, a graver, edge-modified pieces, projectile points, and scrapers. The ground and battered stone at LAN-63 consists of anvils, bowls, hammer stones, manos, metates, mortars, pestles, and a shaft straightener, as well as various ornamental items or objects evidently serving nonutilitarian purposes. These latter items include beads, cogged stones and discoids, a phallic effigy, pendants, and perforated disks, and the pipes were also included in this group. Finally, other lithic objects identified in the current sample from LAN-63 include fire-affected rock, manuports primarily used in thermal features, and tarring pebbles.

Van Horn (1987; see Freeman and Van Horn 1987) recovered a similar assemblage at LAN-63, although tools were given different names. For example, Van Horn's categories of utilized, retouched, notched, and "potato" flakes and spokeshaves were included here as edge-modified pieces.. Flaked stone items identified by Van Horn (1987) included bladelets, choppers, cores, crescents, debitage, drills or reamers, knives, notched flakes, "potato" flakes, projectile points, scrapers, "slugs," spokeshaves, retouched flakes, and utilized flakes. Ground stone implements observed in the previous collection included abraders, anvils, a charmstone, a digging-stick weight, discoids, hammer stones, manos, metate fragments, mortars or bowls, a net weight, pestles, a stone tube, and stone pins. Other lithic items consisted of tarring pebbles, "asphaltum-stained rocks," fire-affected rock, and a pecked pebble. Ornamental objects included beads, pendants, a perforated stone, and a schist ornament.

Taken as a whole, the lithic assemblage from LAN-63 indicated that all four classes of activity outlined by Thomas (1983) might have taken place at the site or were carried out by site occupants. For example, procurement was indicated by the presence of projectile points and, in the previous collection, a net weight and a digging-stick weight. The latter tool indicated procurement of plant resources such as bulbs or tubers, the net weight indicated fishing, and projectile points suggest hunting by site occupants. This latter task was probably not conducted on-site. Four of the six projectile points in SRI's sample were reworked, sometimes after impact damage. This may indicate that these tools were simply discarded at LAN-63, to be replaced with new points manufactured on-site. Processing was indicated by the presence of anvils, some bifaces, choppers, manos, and metates. The ground stone implements were related to plant or mineral processing, with the latter indicated by pigment residues. The flaked stone implements, some of which had use damage, likely relate to animal resource processing. Mortars and pestles present in the assemblage also served to process plants, animals, or minerals (see Schroth 1993), although contextual data for many of these tools (see below) suggest, they were deposited at LAN-63 as part of a ritual, although it was possible that some of these implements might have been previously used for milling here or elsewhere. Representation of consumption at LAN-63 was equivocal, as this was suggested only by the presence of bowls. Once again, however, the context of these artifacts suggests that they might have served purposes such as burning of offerings or consumption of foods in a ritual, rather than domestic, setting (see below). Finally, manufacturing was well represented by drilling, engraving, scraping, chopping, and abrading tools, as well as by debitage, cores, hammer stones, the shaft straightener, and tarring pebbles. Although lithic tool manufacturing, shaft straightening, and basket tarring, at least, could be inferred from this collection, the other manufacturing activities potentially represented remain obscure because tools could have been applied to a variety of tasks. The presence of asphaltum residues on some items, however, suggested that this material was also involved in some of the manufacturing tasks undertaken.

Given the diversity of activities represented and the presence of lithic artifacts related to at least three of the four activity classes, LAN-63 likely served as a residential base. Moreover, the prevalence of flake rather than bifacial tools, the rarity of bifacial cores (see above), large site size, and other characteristics of the site and artifacts were consistent with this assessment and lead to the further conclusion that the group occupying the site was logistically organized. The presence of some nonutilitarian items was also consistent with this logistical organization, as activities incorporating such objects would have been likely with extended occupation. The relative abundance of fire-affected rock could also contribute to the conclusion of logistical organization, although much of this debris was related to particular features (see below) that evidently represented task-specific processing rather than domestic hearths.

As noted above, definitive functional determination for LAN-63 or other sites rests in large part on the assumption that such deposits represented a single-component occupation rather than serial use as either or both a residential and nonresidential locale (see Binford 1980). Although much of the temporal information for LAN-63 suggested primary use during a span of a few centuries, other information such as obsidian hydration results suggested a more complex history for the site (see Chapter 13). Since the current data were insufficient to support a conclusion of contemporaneous use throughout the site, the function of individual features, rather than just the site as a whole, will be discussed a little later.

LAN-64 Activities and Function

SRI's sample from LAN-64 indicated a somewhat less diverse collection of flaked, ground, and battered stone implements than that noted at LAN-63. As noted below, however, such decreased diversity probably relates to the small sample size rather than differences in site function. Flaked stone items consist of a burin, choppers, cores, debitage, edge-modified pieces, scrapers, and a shaft straightener. Ground and battered stone tools include bowls or mortars, cogged stones and discoids, hammer stones, manos, and metates, as well as various ornamental items such as beads, pendants, and perforated disks. Finally, other lithic objects identified in the current sample from LAN-64 include fire-affected rock, manuports, and tarring pebbles. The previous collection from LAN-64 recovered by Van Horn (1987) included backed denticulates, bladelets, choppers, cores, drills, hammer stones, manos, pestles, metate fragments, mortars or bowls, notched flakes, "potato" flakes, projectile points, scrapers, retouched flakes, utilized flakes, tarring pebbles, and "asphaltum-stained rocks."

Once again, a diverse array of activities could have taken place at LAN-64, with lithic artifacts representing at least three of the four activity classes. SRI's sample from LAN-64 lacked many of the more specialized manufacturing tools found at LAN-63, including borers, gravers, and drills (the drills were found by Archaeological Associates during previous work). In addition, pestles were absent from the current LAN-64 sample, although these tools might have been used for activities other than domestic tasks at LAN-63 and might have indicated a special form of deposition (see below). Likewise, projectile points were notably absent from the current collection from LAN-64, despite the fact that numerous points of diverse types were identified in earlier work at the site (Freeman 1987).

Procurement was at LAN-64 by the presence of projectile points and hammer stones, and processing was indicated by manos, metates, and choppers. Data on the portions of the points present were not provided by Freeman (1987:245*ff*), so it was impossible to infer more about the role of hunting at this site from these tools using White's (1984) model. In addition, hammer stones can be used for both procurement and manufacturing. In contrast, the manos and metates likely relate solely to plant food processing, as mineral-pigment residues were not visible on any of these tools. Manufacturing was indicated by drilling, engraving, chopping, hammering, and scraping tools, as well as debitage and cores. The previous collection from this site suggests more specialization with respect to some manufacturing tasks, since various types of drills and bladelets were identified. SRI's sample, however, emphasizes general-use, rather than specialized, implements. Still, LAN-64 likely served as a residential base, although the data from the current sample were insufficient to determine if a logistically or residentially mobile group occupied the site.

LAN-206A Activities and Function

The collection from LAN-206A was small, but included tools for processing, manufacturing, and perhaps, procurement. Procurement was represented only by hammer stones, however, and these implements likely related primarily to manufacturing activities rather than stone procurement. Other implements related to manufacturing included choppers, edge-modified pieces, and a tarring pebble. The latter indicated basket waterproofing, but the general nature of the other manufacturing tools prohibited identification of the tasks to which they were applied. No residues were observed on these items, although one of the edge-modified pieces had microflaking, polish, faceting, and striations consistent with intensive use on both hard and soft materials. Processing was indicated at LAN-206A by bifaces, choppers, manos, and metates. The presence of red ochre on one of the metates—but a lack of such pigmentation on other metates and manos—indicates that both mineral and plant resource processing was carried out with these implements.

The Function of Features at the West Bluffs Sites

Table 8.20 summarizes the categories and quantity of lithic items recovered from the feature proveniences selected for detailed lithic analysis at LAN-63, and similar data are presented in Tables 8.21 and 8.22 for LAN-64 and LAN-206A. Significantly, unlike the complete collection, features at LAN-63 lack projectile points, drills, pipes, discoids, and cogged stones. In addition, bifacial implements—including nondiagnostic bifaces in all stages of reduction, as well as projectile points—are essentially absent from features, and biface thinning debitage was rare. This suggests that features underrepresent the processing and manufacturing activities related to such artifacts. The relative paucity of bifacial tools at LAN-63, however, suggests that this observation could also be applied to the site in general, if scavenging was not skewing the data to result in this conclusion. Likewise, the paucity of bifacial implements at all of the West Bluffs sites might have been due to the data recovery methods employed (i.e., grading), but sample bias does not apply in this case, because all bifacial implements were analyzed regardless of their recovery context.

Ceremonial Features

Based on the feature-specific collections, some features appear to share a similar function. Most striking in this regard was the similarity of Features 11 and 587 at LAN-63, which appear to share a ceremonial function that was revealed by both the categories of artifacts present and the consistent method of use and deposition of these implements. Both of these features contain pestles, steatite vessels, other bowls, and perforated disks, as well as edge-modified pieces, cores, and steatite detritus. Steatite vessels were found only in these two features in the sample and these proveniences also account for the vast majority of the pestles. Some of these artifacts also represent extreme investment in lithic procurement and manufacture inconsistent with utilitarian use. For example, as noted above, material for the extremely large schist pestle from Feature 11 could not have been acquired locally, and steatite artifacts from both features were exotic material that would have required ocean transport or exchange with individuals who had such transport. Still, battering damage was evident on the schist pestle. Likewise, some of the pestles from Feature 587 were of materials (e.g., siltstone) unsuitable for prolonged use, as they were soft and would break or deteriorate rapidly from use. This suggested possible symbolic rather than utilitarian function. Many of the ground stone tools in both of these features also were deliberately broken or modified to render them unserviceable, and the proximal fragment of the large schist pestle was covered with ochre after breakage. Likewise, several of the vessels from these features were charred only on the interior, and drips of asphaltum were also common on bowls recovered from these features.

All of these elements of material, morphology, and function for lithic artifacts recovered from Features 11 and 587 argue for organized deposition through a sequence of actions including burning, breakage, pigmentation, and placement. The fact that these features involve artifacts typically associated with plant processing and, therefore, women's activities, may indicate that females were responsible for creating these two features or, alternately, that women were being mourned (e.g., Davis 1921; Strong 1929; Walker 1937) or otherwise recognized through this ceremony. In fact, the paucity of pestles in other contexts may suggest that these features represented a unique "disposal" practice associated with this artifact category, whereas the repair of pestles (e.g., Freeman 1987:253) and other portable milling equipment (see above) might have underscored the significance of such tools to the users. It was interesting that blunt-tipped bone tools were also only associated with Feature 587 (see Chapter 8), suggesting that these tools might have served in similar plant-processing or other activities associated with females. Stone beads were also common in this feature.

Task-Specific Processing or Production Features

At the other end of the spectrum were Features 318, 337, 340, 409, 509, and 521 at LAN-63, which appear to be thermal features associated with plant or other processing activity in which heat or fire was required. Fire-affected artifacts and rock dominate these collections, whereas flaked stone tools were rare or absent. Features 318 and 337, in particular, stand out as intensive loci of activity, given the quantity of rock incorporated, the extensive scavenging of old ground stone tool fragments to achieve the requisite mass for these features, and the high temperatures or long duration of exposure to heat indicated by the substantial alteration of rocks. As noted above, the selection of broken ground stone for such secondary use was deliberate, as many of these implements appeared to have reached the end of their use life at the time they were incorporated into these features. In addition, many of the scavenged items had been deposited at some time significantly before reuse, and apparently augmented manuports that were either newly introduced after acquisition from alluvial deposits or scavenged other cultural contexts. No similar thermal features were identified among those selected for analysis from LAN-64 or LAN-206A.

Feature 5 at LAN-63 and Feature 76 at LAN-64 also reflect similar function, indicated in this case by both the tools present and the residues preserved on them. Flaked stone implements identified in these features were limited to cobble-heel scrapers, choppers, and cores, all of which were in especially high frequency in Feature 5. At least half of the tools in each of these categories for both features also had asphaltum or some other black residue that was either viscous or liquid when it came into contact with the tool. These observations suggest that functional distinctions for such core tools are blurred in this context, and that all were involved in heavy pounding, battering, and/or scraping activities in which asphaltum was an element.

Feature 446 at LAN-63 also appears to have had a somewhat distinctive function, given the prevalence of tarring pebbles. These were observed in only seven other features at the three sites investigated, with none of these features containing more than two such items. Although Feature 446 also contained two edge-modified pieces and two mano fragments, including one with black residue, tarring of basketry appears to have been the primary activity conducted here.

Feature data suggest that hammer stones and debitage were not linked, as might be expected if hammer stones were only related to flaked stone tool manufacture. Conversely, hammer stones and Stage 3 bifaces tended to co-occur, if one excludes hammer stones that are free of residues, which would suggest use for a purpose other than flaked stone tool production. Such a criterion highlights the problem of relying only on general artifact categories when attempting to determine feature function. The co-occurrence of residue-free hammer stones and bifaces was also demonstrated in Features 7 and 468 at LAN-63, and Feature 107 at LAN-206A. Significantly, Feature 468 also had a high proportion of biface-thinning flakes in comparison to most other features and consistent with the interpretation that biface manufacturing was undertaken there. Other flaked stone implements and fire-affected rock were rare in Features 7 and 468, but manos and metate fragments were present. Feature 107 also contains mano and metate fragments, but other flaked stone tools and some fire-affected were also present.

Burials

Burial features at these three sites include Features 475, 480, 492, and 600 at LAN-63; Features 32, 43, 52, 56, 61, 62, 64–66, and 76 at LAN-64; and Feature 100 at LAN-206A. Except Feature 480 at LAN-63, flaked stone was nearly absent at all these features, except for debitage, which might not be part of the burial and might have been in the soil before the graves were excavated. Likewise, ground stone was rare or absent, with the exception of stone beads associated with one burial at LAN-63 and five burials at LAN-64. Feature 480 was unique in containing both flaked and ground stone tools, as well as one tarring pebble. The burial data indicate that deposition of utilitarian stone implements with interments was rare, and beads might have simply been deposited as items attached to perishable items such as clothing or basketry.

Other Features

Ignoring debitage, manuports, and fire-affected artifacts for the moment, the remaining features can be grouped into those that include flaked stone tools only, those with ground stone tools only, and those with both flaked and ground stone. The frequency of such objects was generally low in all such cases, and the presence or absence of specific flaked stone tool categories, in particular, varies somewhat from feature to feature. Features 3 and 16 at LAN-63 stood out somewhat in that they had a slightly higher frequency and the most diverse collections of flaked stone tools. Features with flaked stone only were Features 13, 15, and 19 at LAN-63; Feature 36 at LAN-64; and Feature 106 at LAN-206A. Those features with ground stone were limited to Features 20, 21, and 594 at LAN-63, with Feature 20 containing only one pendant; and Features 23 and 33 at LAN-64. Considering features based only on flaked versus ground stone, however, masks more subtle differences. For example, the single identifiable ground stone implement from Feature 18 was a phallic effigy, which was very different in function from the milling implements generally constituting the ground stone tool collections from the other features.

Summary

Analysis of lithic artifacts and debris had provided a picture of the activities carried out by the West Bluffs residents by incorporating data regarding lithic material; flaked, ground, or battered tool technology; and characteristics of artifact use and reuse. This picture relates primarily to occupation during the Intermediate period, and data suggest that people were engaged in a variety of tasks at these sites. Activities were facilitated by a lithic technology adapted to the local lithic landscape, and creative manufacturing strategies that took advantage of each material's traits in the creation and use of tools for one or more tasks.

Evidence from the West Bluffs sites indicated a reliance on locally available stone for most flaked and ground stone tools. A variety of sedimentary, igneous, and metamorphic rocks were available to the residents in the alluvium at the base of the bluffs and upstream along Ballona Creek. Some lithic materials, or objects made from them, however, were acquired outside the local area. Significantly, many of the ground stone objects of nonlocal materials were related to ritual activities at West Bluffs. Given the local availability of diverse lithic materials, these data do not assist with discrimination of a logistical versus residentially mobile lithic-procurement strategies, and no diachronic trends in lithic material use in the Ballona were recognized based on comparison of the West Bluffs lithic sample with those from sites at the base of the bluffs.

The flaked stone technology used at the West Bluff sites includes flake tools, core tools, and biface production, with biface manufacture less common than at sites closer to the Ballona or areas of these studies previously studied. Flake tools were made of a variety of materials, with certain production strategies restricted to particular materials. Such technological distinctions relate to the nature of the parent piece or the intended tool function, or both. Core tools were made from a less diverse array of materials. The technology of core-tool production indicated clear design related to the parent material shape and the desired characteristics of the finished tool. Bifaces were primarily manufactured on flake blanks that required minimal pressure thinning. There was little evidence for the manufacture of ground stone tools on these sites, although such tools were common and the shape of many locally available clasts meant that substantial working to create the desired form was not required. Some pestles and bowls reflect deliberate breakage. Other flaked and ground stone tools reflect recycling of objects for different uses.

Assessment of site function based on stone artifacts indicated that a variety of procurement, processing, consumption, and manufacturing tasks were undertaken by occupants of LAN-63 and LAN-64, at least. This observation was consistent with interpretation of these sites as residential bases, although this conclusion must be tempered by an appreciation for the fact that these sites were used over several centuries, and some activities might not have been coeval. LAN-63 appears to have been used by a logistically organized group, whereas data are insufficient to determine if LAN-64 was occupied by a logistically or residentially mobile group. Functional interpretation of features based on lithic collections from each site suggests ceremonial, task-specific procurement or processing locales, and burials, at least. Ceremonial use might have been related to female ritual, whereas processing locales included thermal features and areas in which tasks requiring heavy tools and asphaltum were carried out. In addition, basket-tarring and flaked stone tool-manufacturing features were identified.

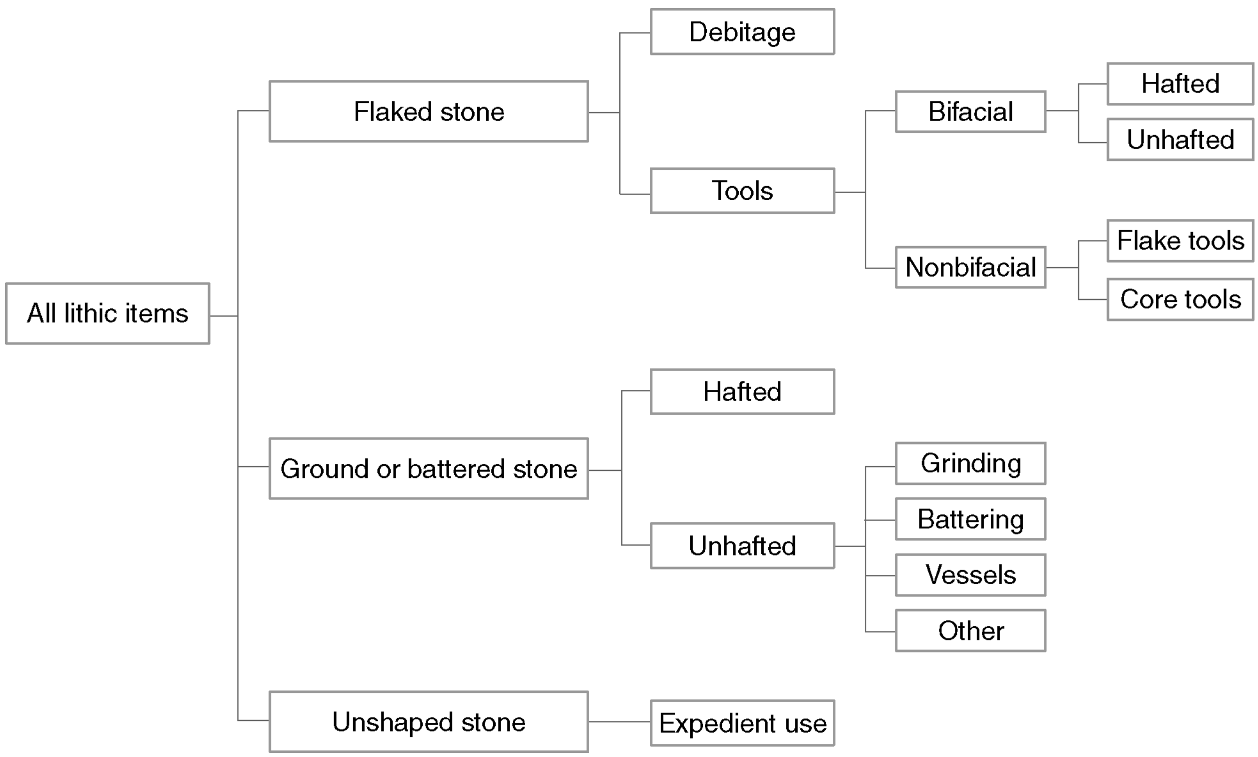


Figure 8.1. Lithic artifact classification scheme.

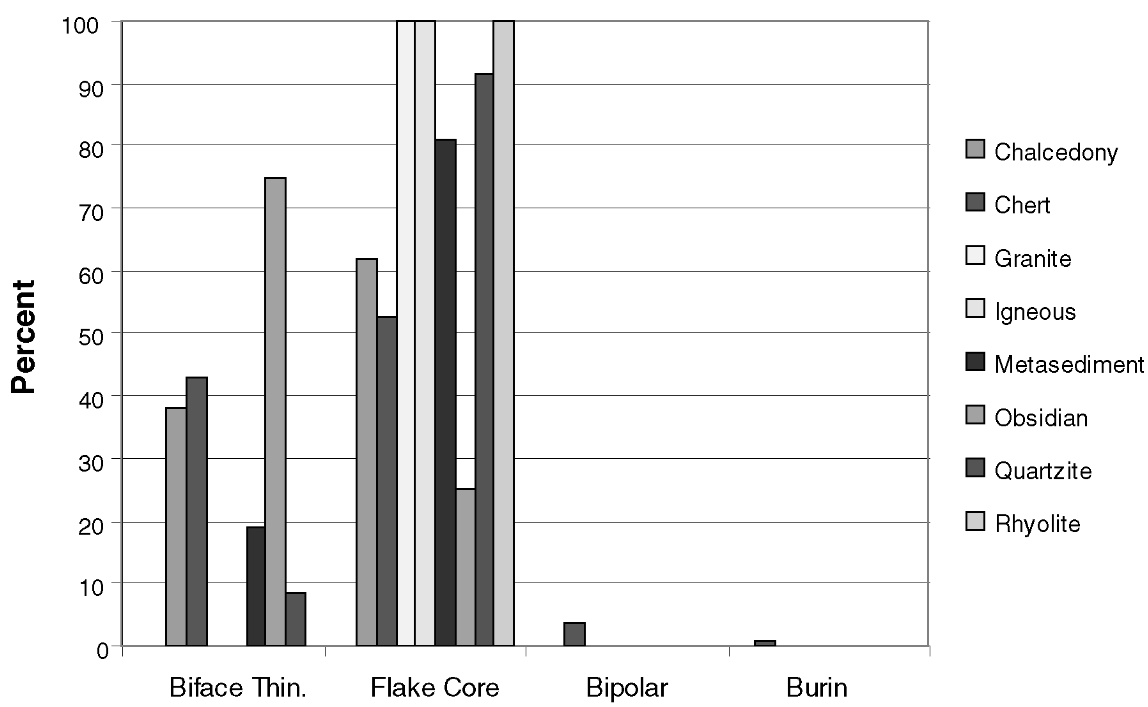


Figure 8.2. Debitage material distribution by reduction technology for control columns.

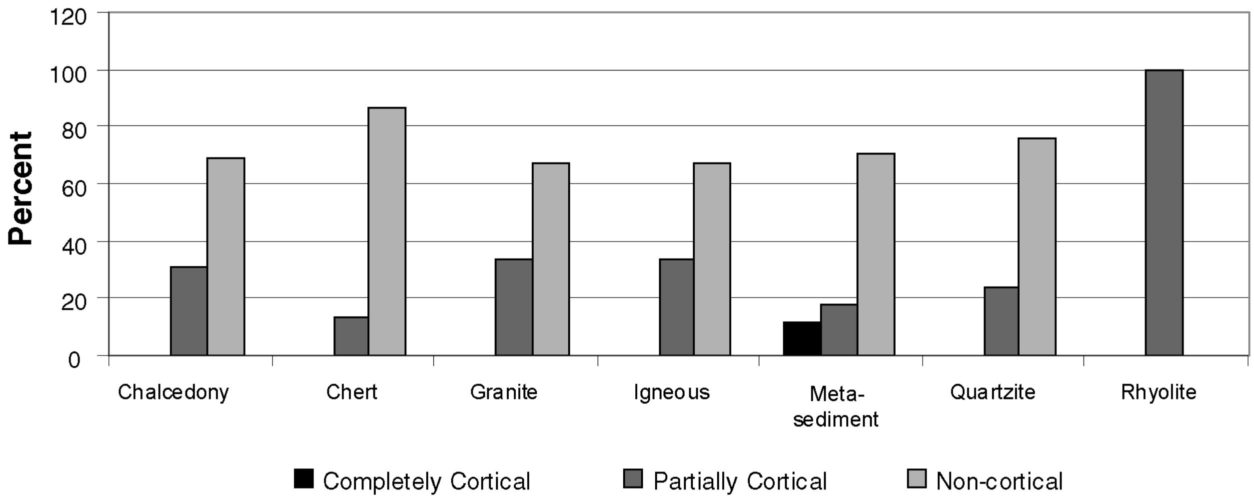


Figure 8.3. Representation of cortical and noncortical core-reduction flakes by material type for the control columns.

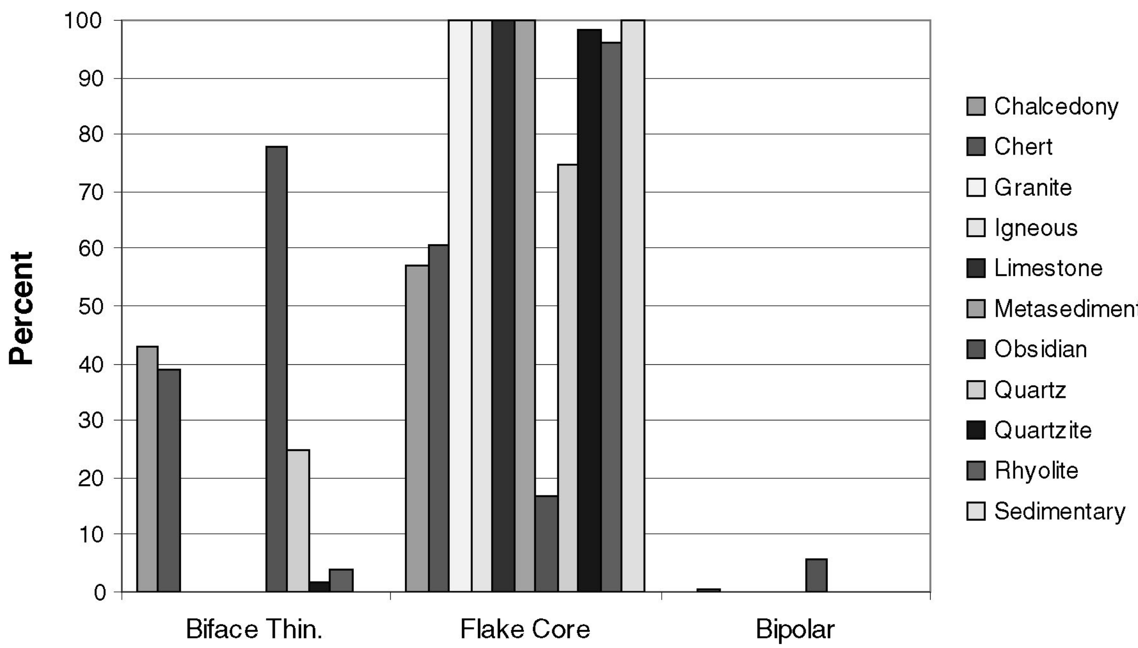


Figure 8.4. Debitage material distribution by reduction technology, in sampled features at LAN-63.

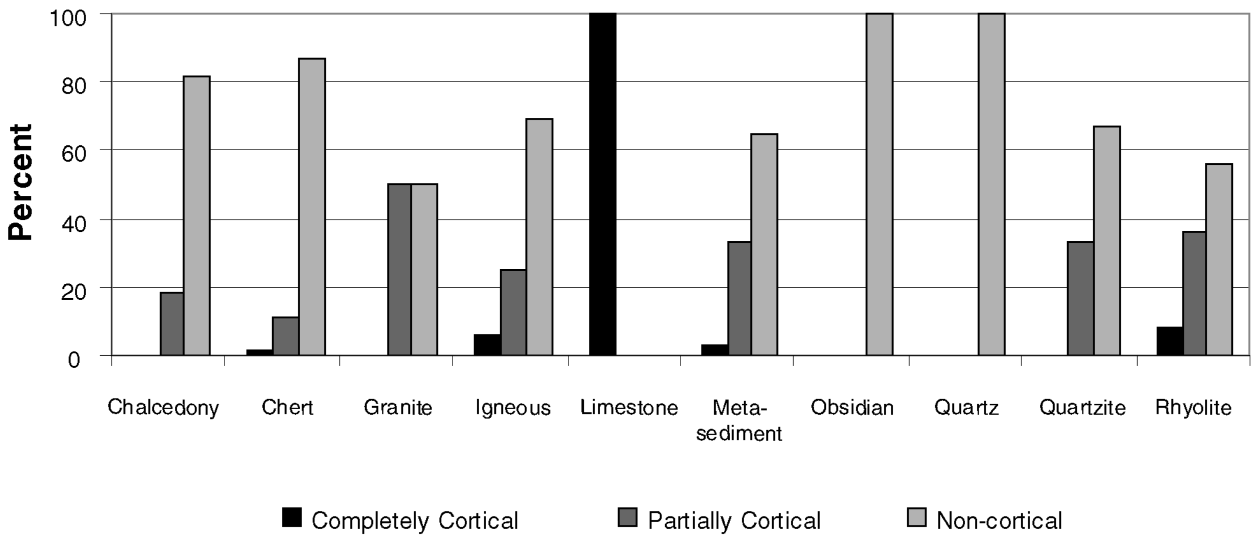


Figure 8.5. Representation of cortical and noncortical core-reduction flakes by material, in sampled features at LAN-63.

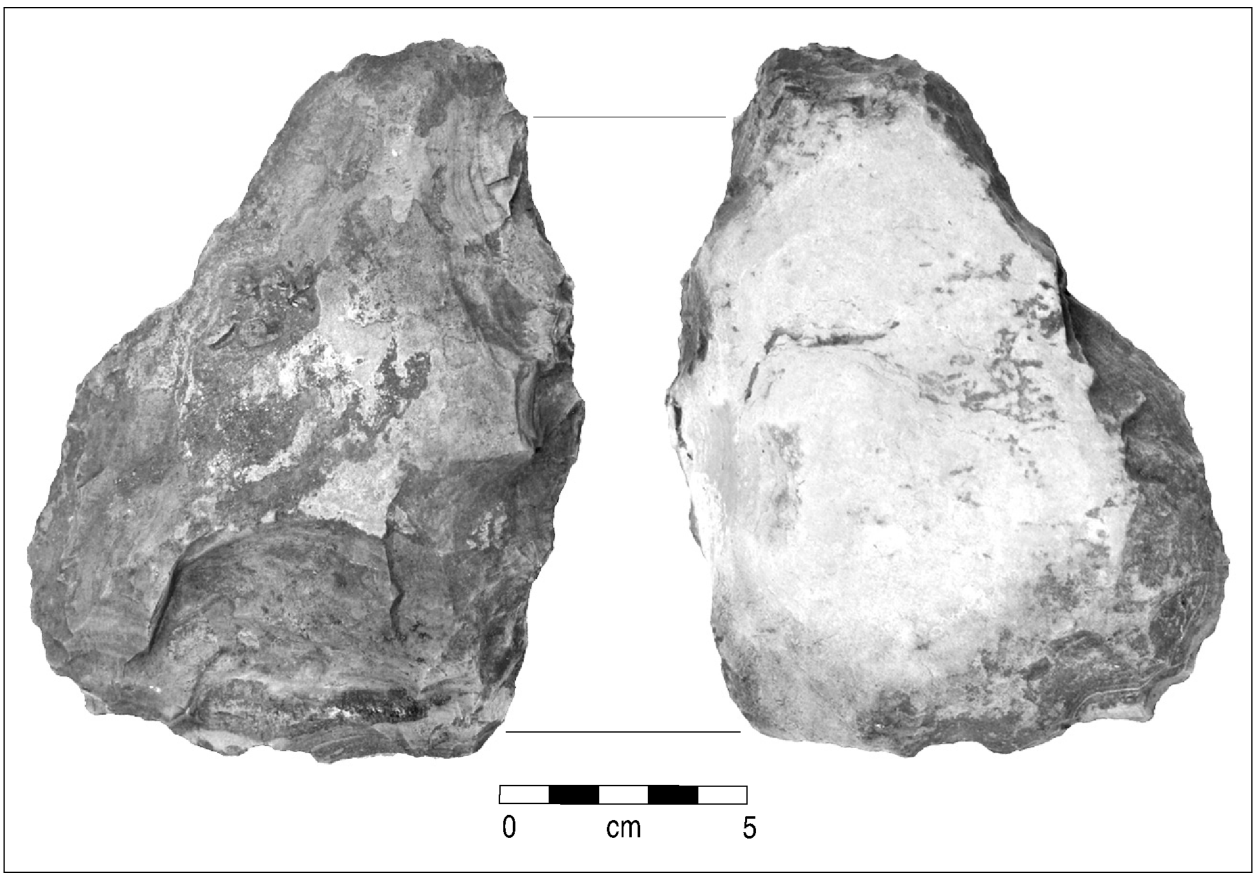


Figure 8.6. Large, tabular chert, Stage 2 biface (catalog no. 1829).

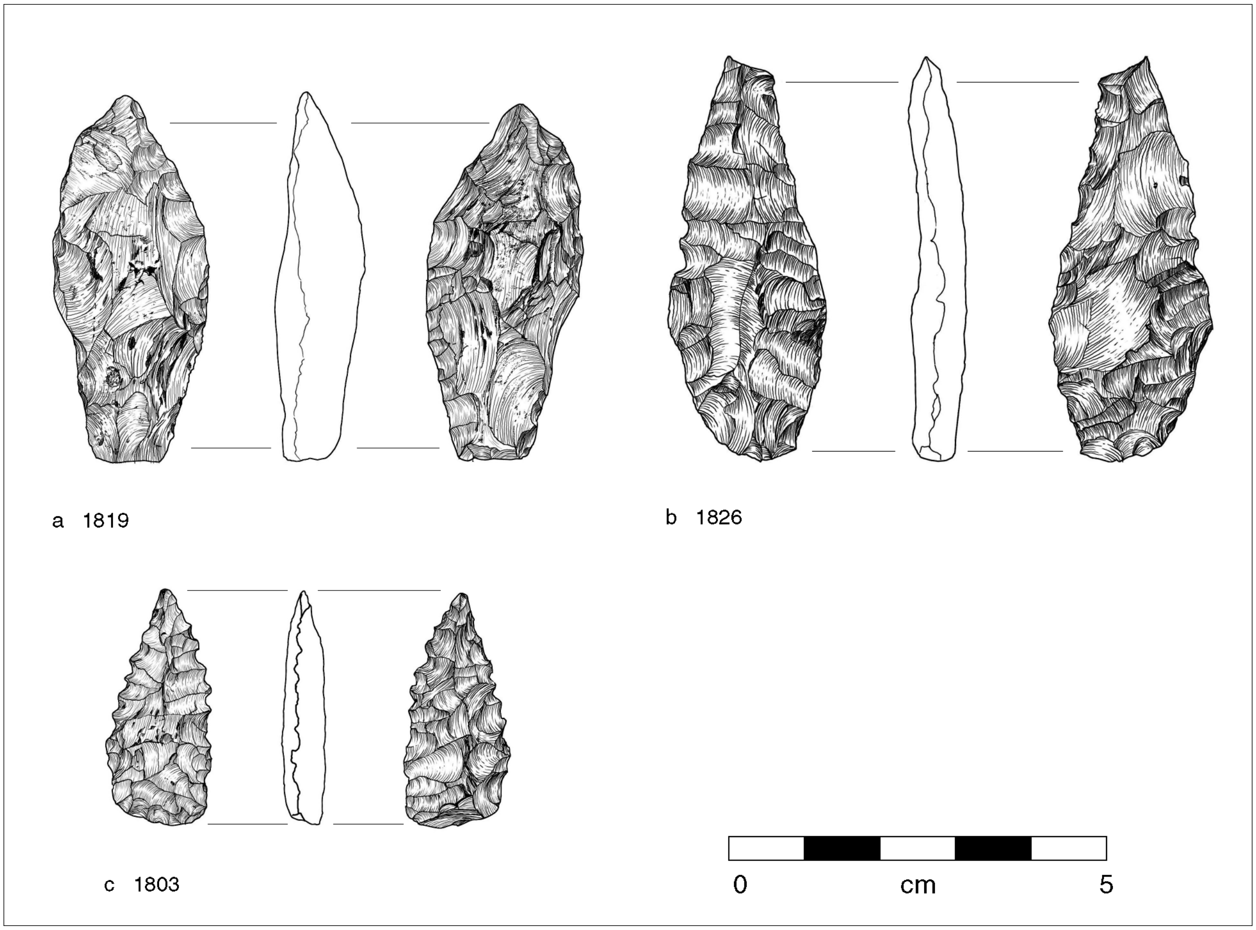


Figure 8.7. Stage 3 bifaces (catalog no. 1819), a Stage 4 biface (catalog no. 1826), and a Stage 5 biface (catalog no. 1803).

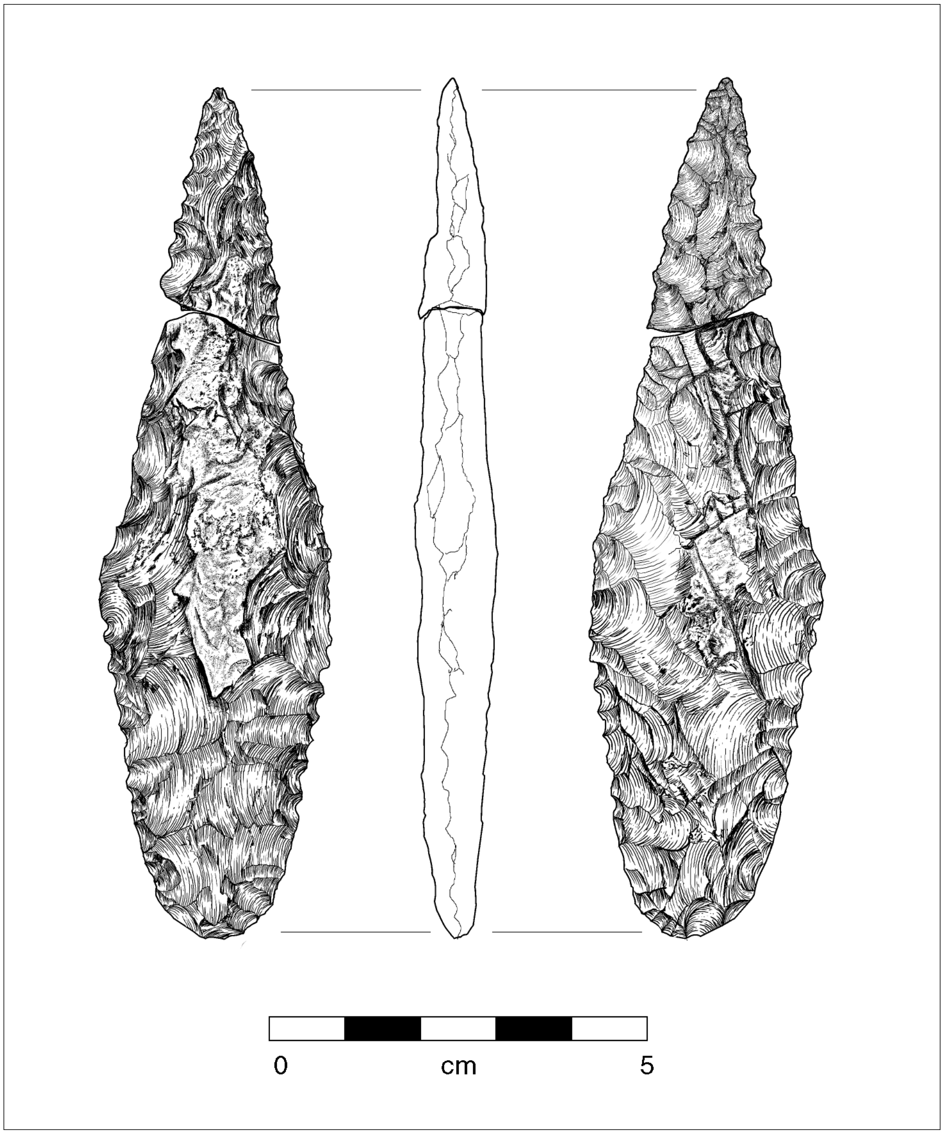


Figure 8.8. Great Basin Stemmed projectile points (catalog no. 1816).

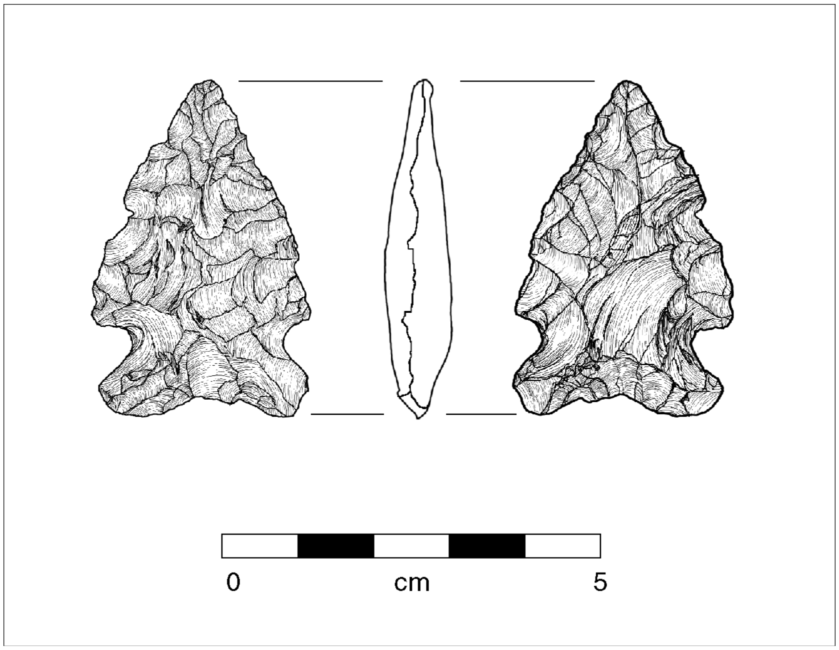


Figure 8.9. Elko Eared projectile point (catalog no. 1802).

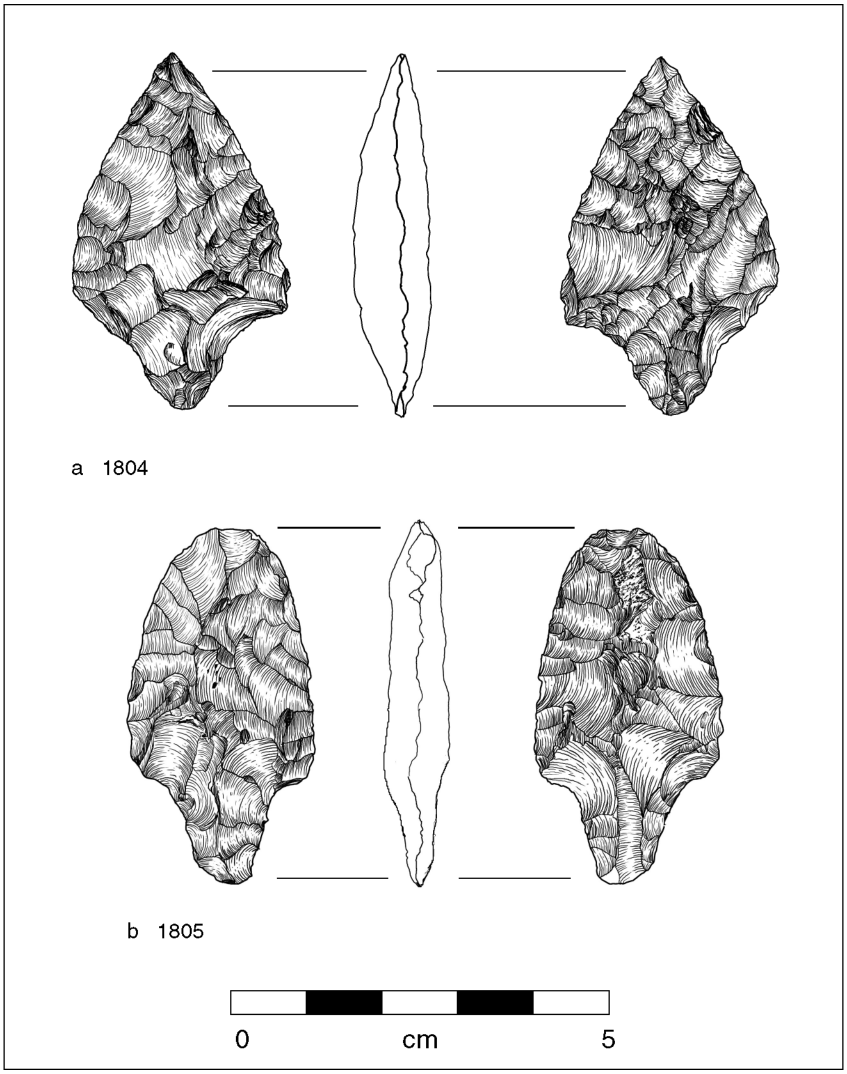


Figure 8.10. Large contracting-stem projectile points (catalog nos. 1804 and 1805).

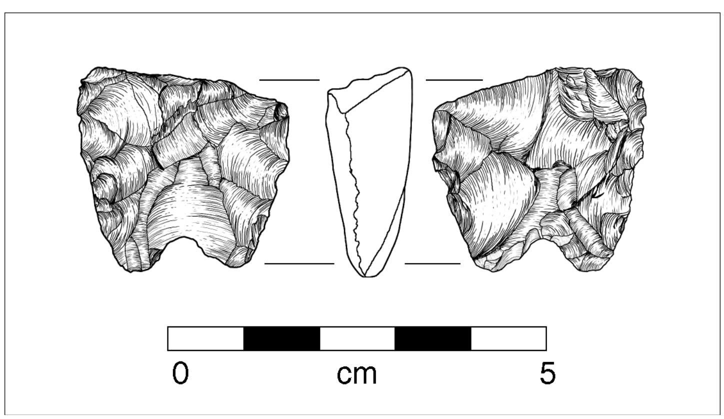


Figure 8.11. Humboldt Concave Base (catalog no. 1808).

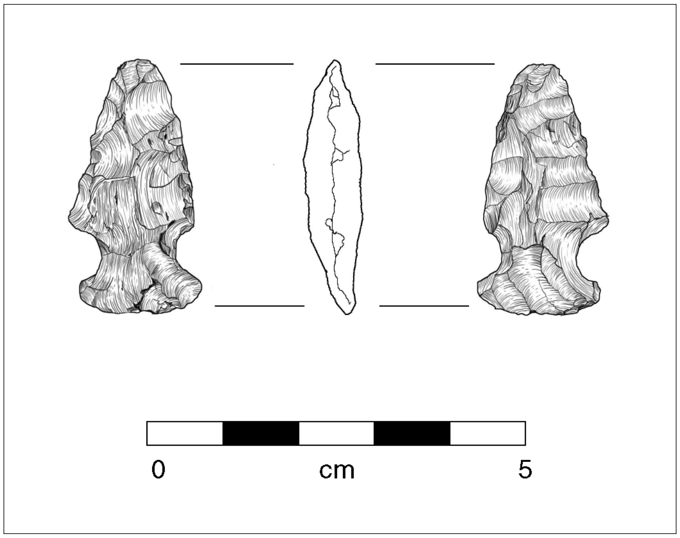


Figure 8.12. Medium-size, side-notched point (catalog no. 1807).

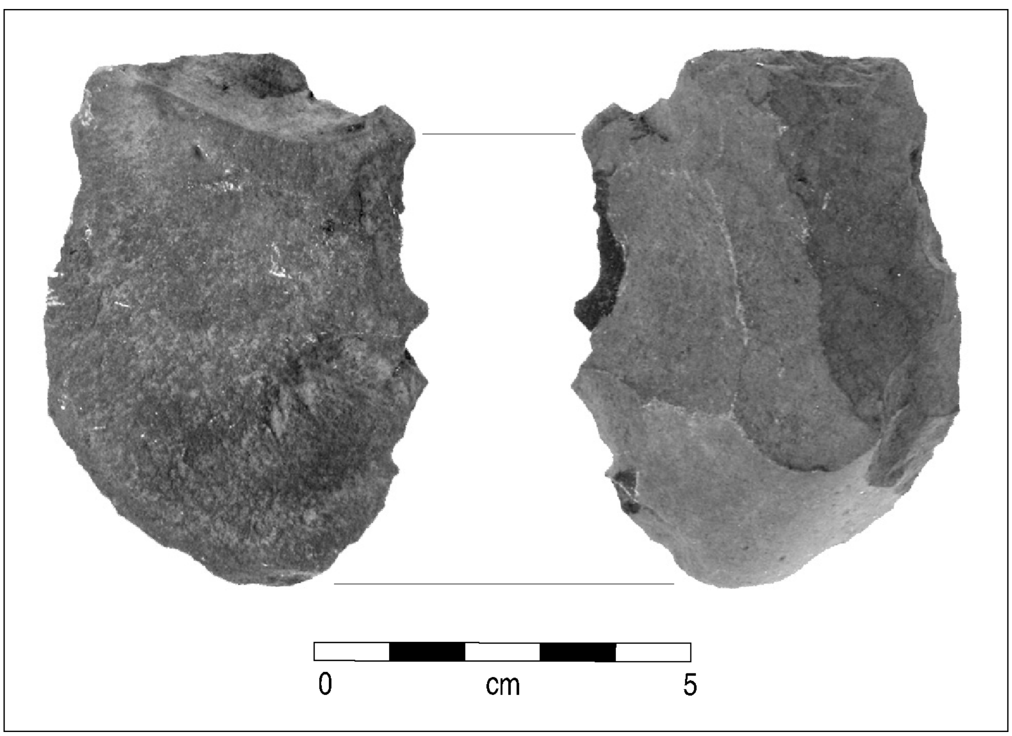


Figure 8.13. Flake scraper (catalog no. 895).

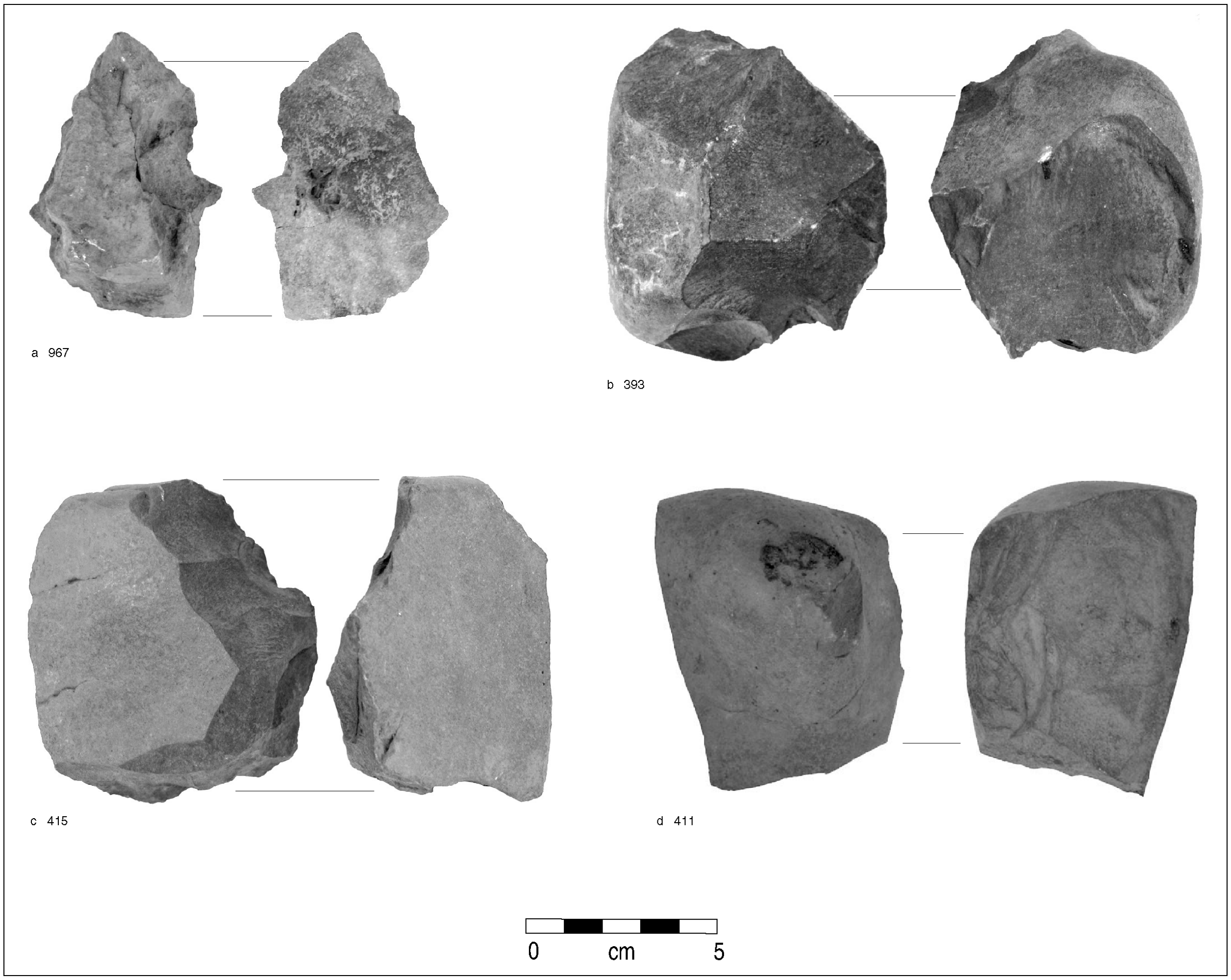


Figure 8.14. Core scrapers (catalog nos. 967, 393, 415, and 411).

Figure 8.15. Anvil (catalog no. 1290).

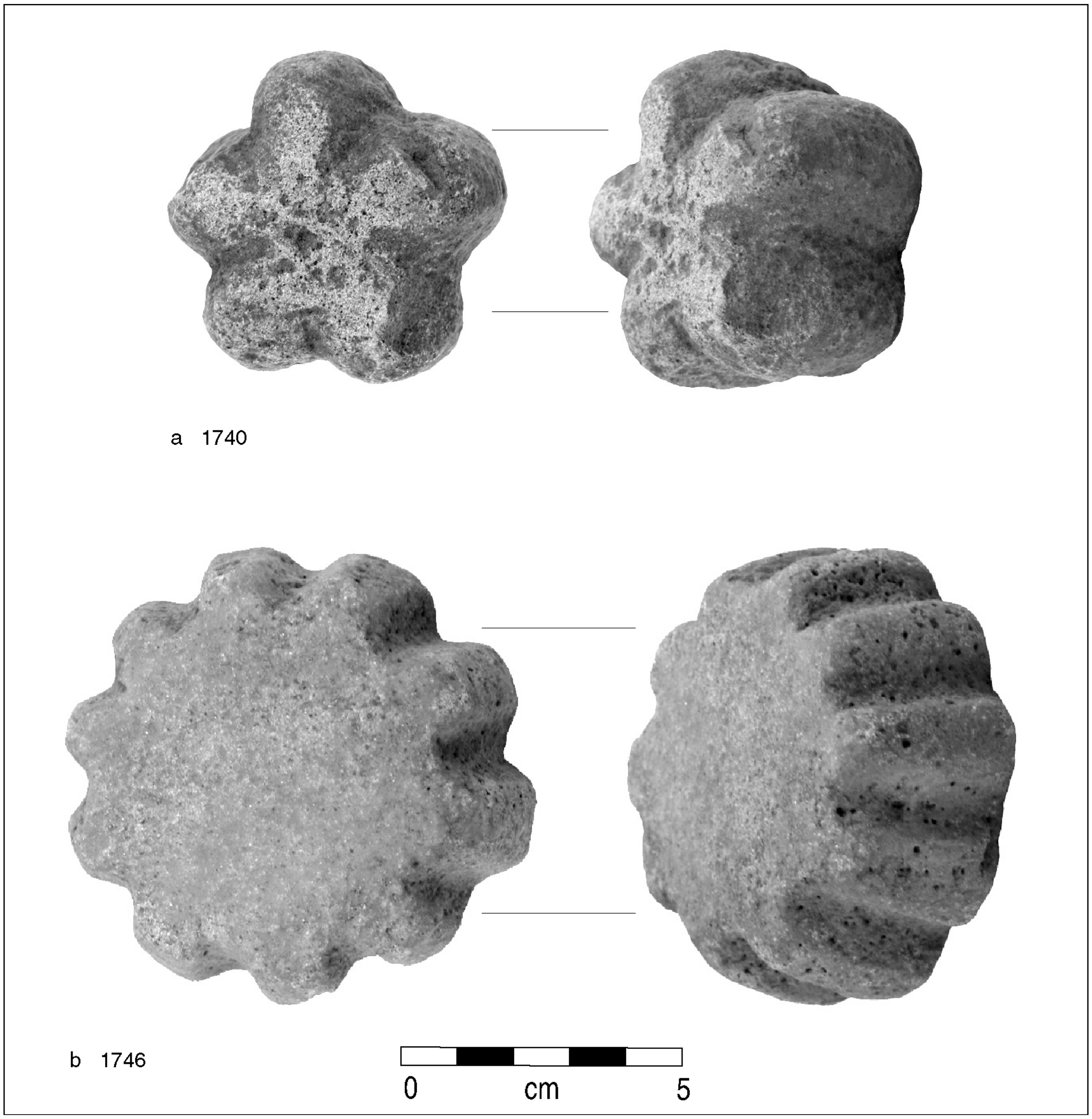


Figure 8.16. Cogged stones (catalog nos. 1740 and 1746).

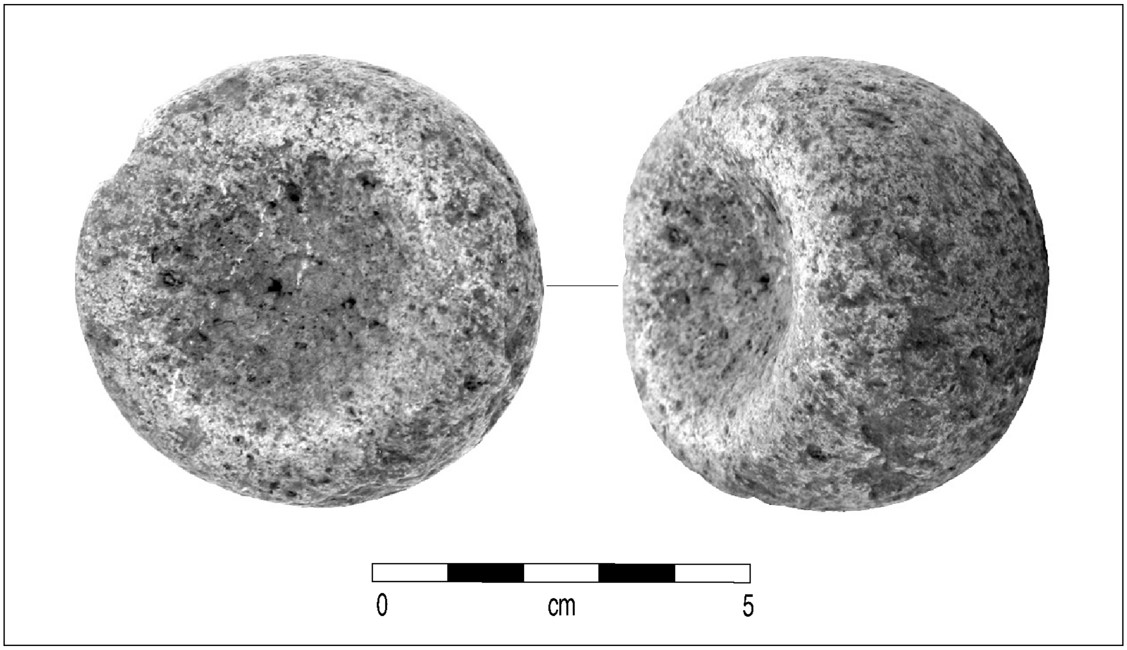


Figure 8.17. Discoid (catalog no. 1852).

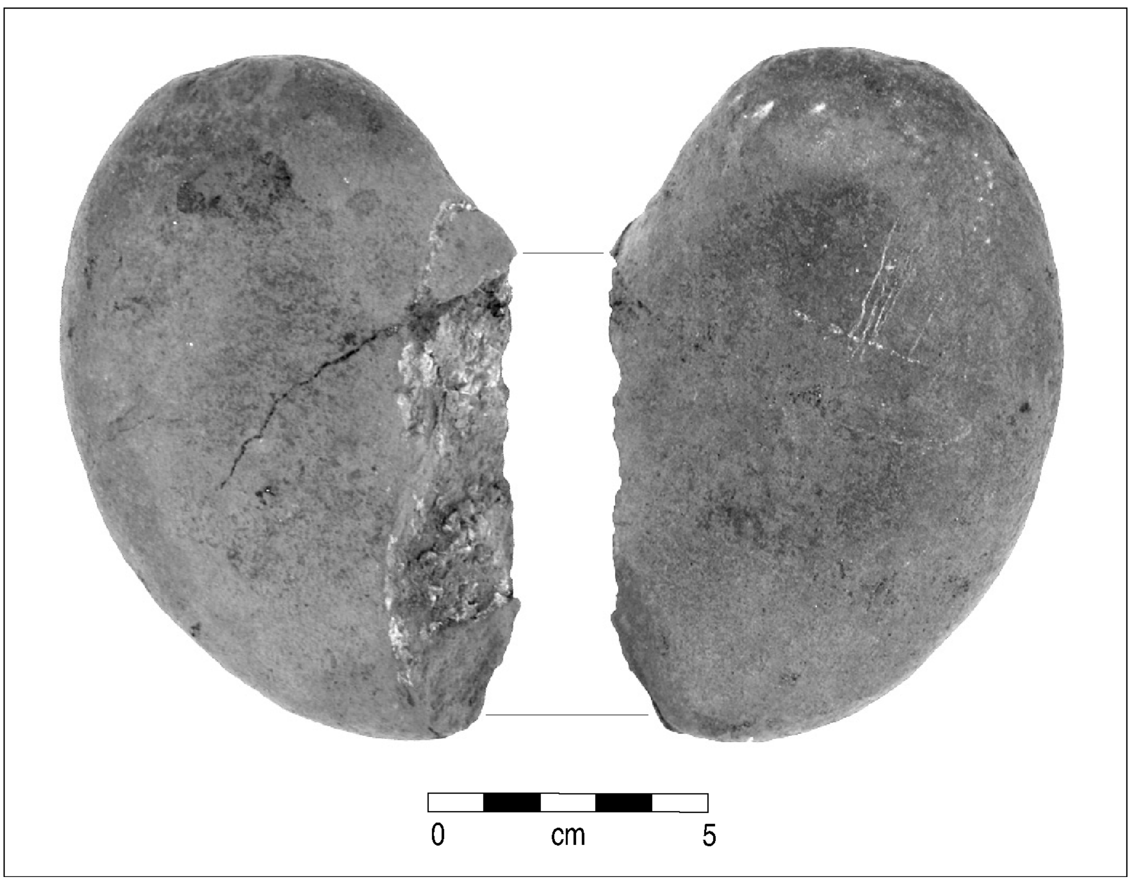


Figure 8.18. Diorite hammer stone (catalog no. 767).

Figure 8.19. Selected steatite vessel (catalog no. 1848).

Figure 8.20. Selected steatite vessel (catalog no. 1854).

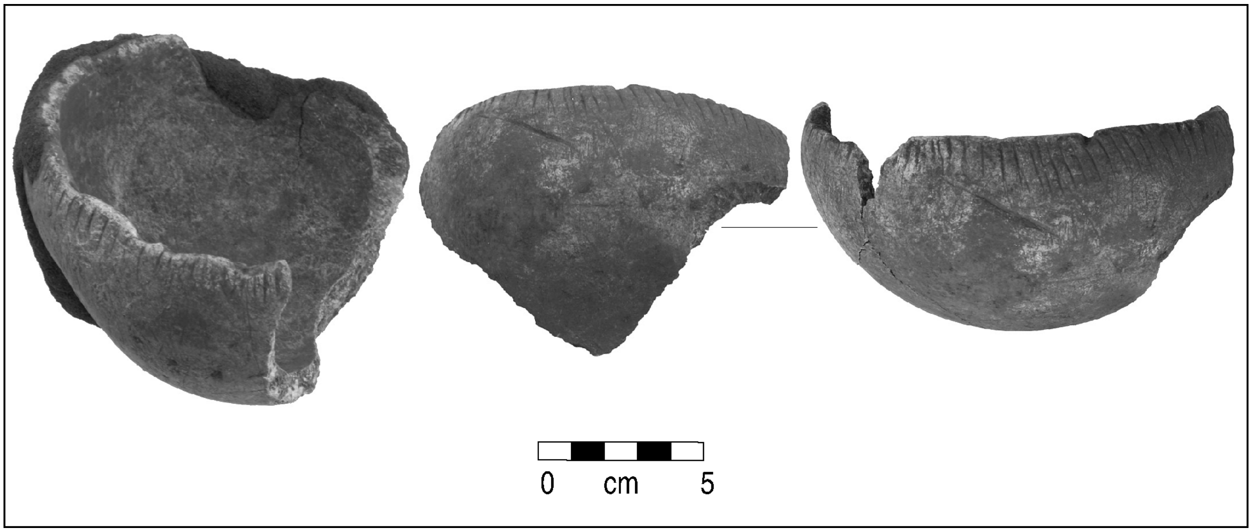


Figure 8.21. Selected steatite vessel (catalog no. 992).

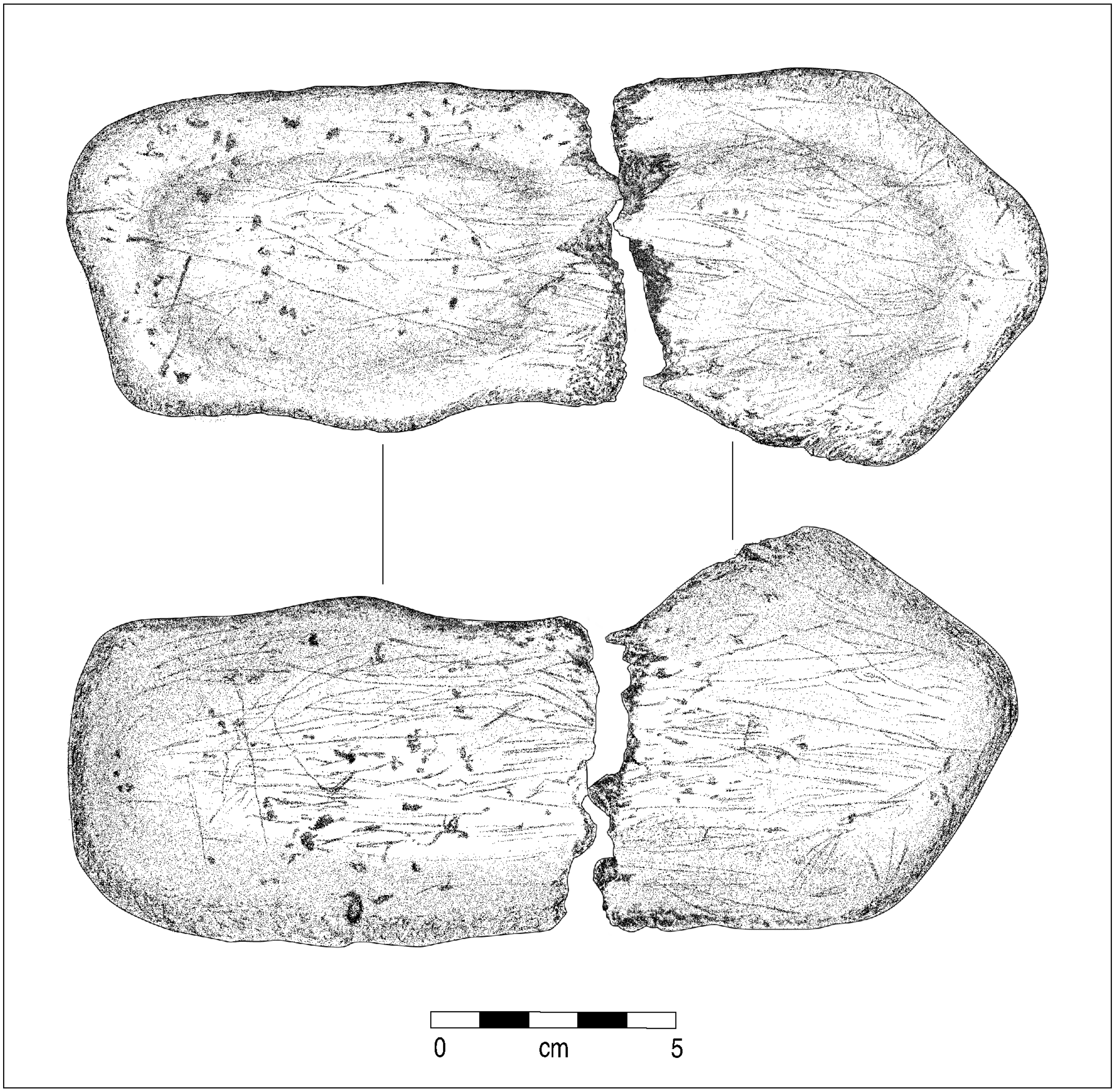


Figure 8.22. Shallow steatite vessel (catalog nos. 1020 and 1045).

Figure 8.23. Perforated steatite object (catalog no. 950).

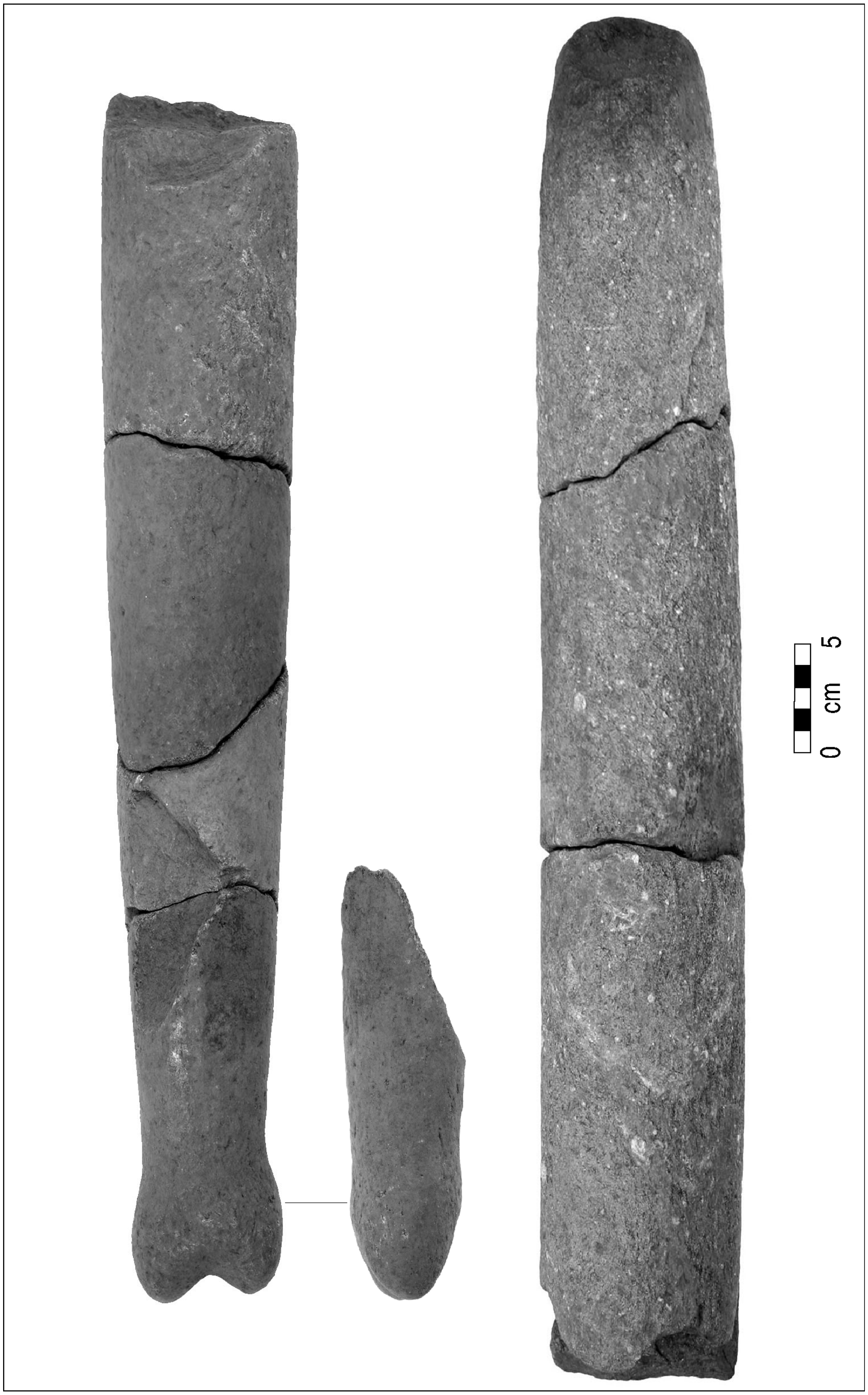


Figure 8.24. Large schist pestle from Feature 11.

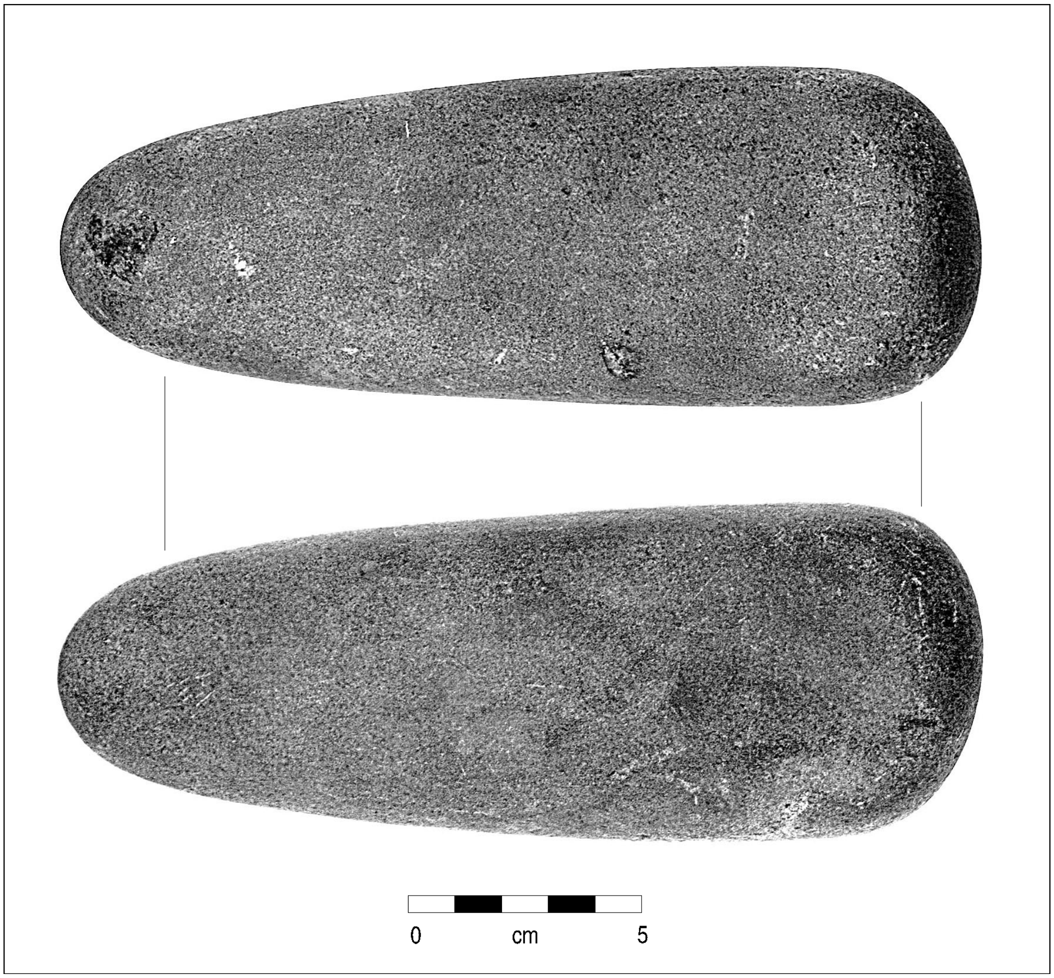


Figure 8.25. Pestle (catalog no. 951).

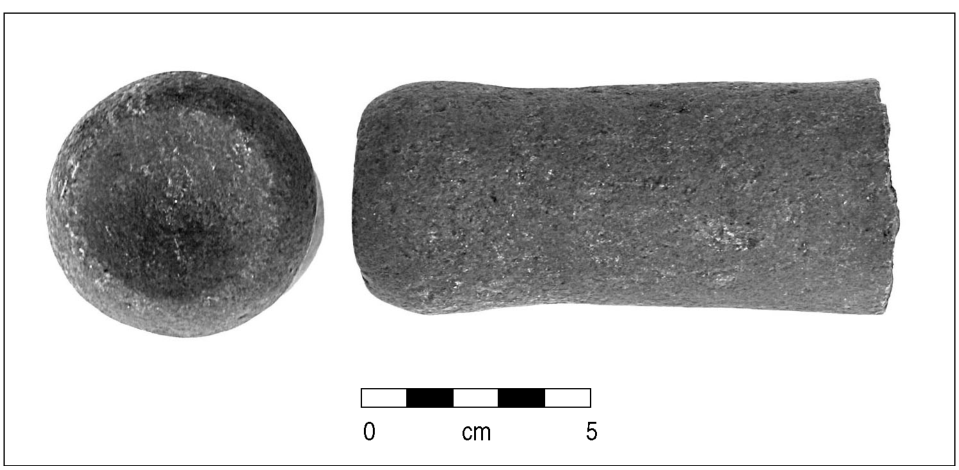


Figure 8.26. Pestle (catalog no. 1001).

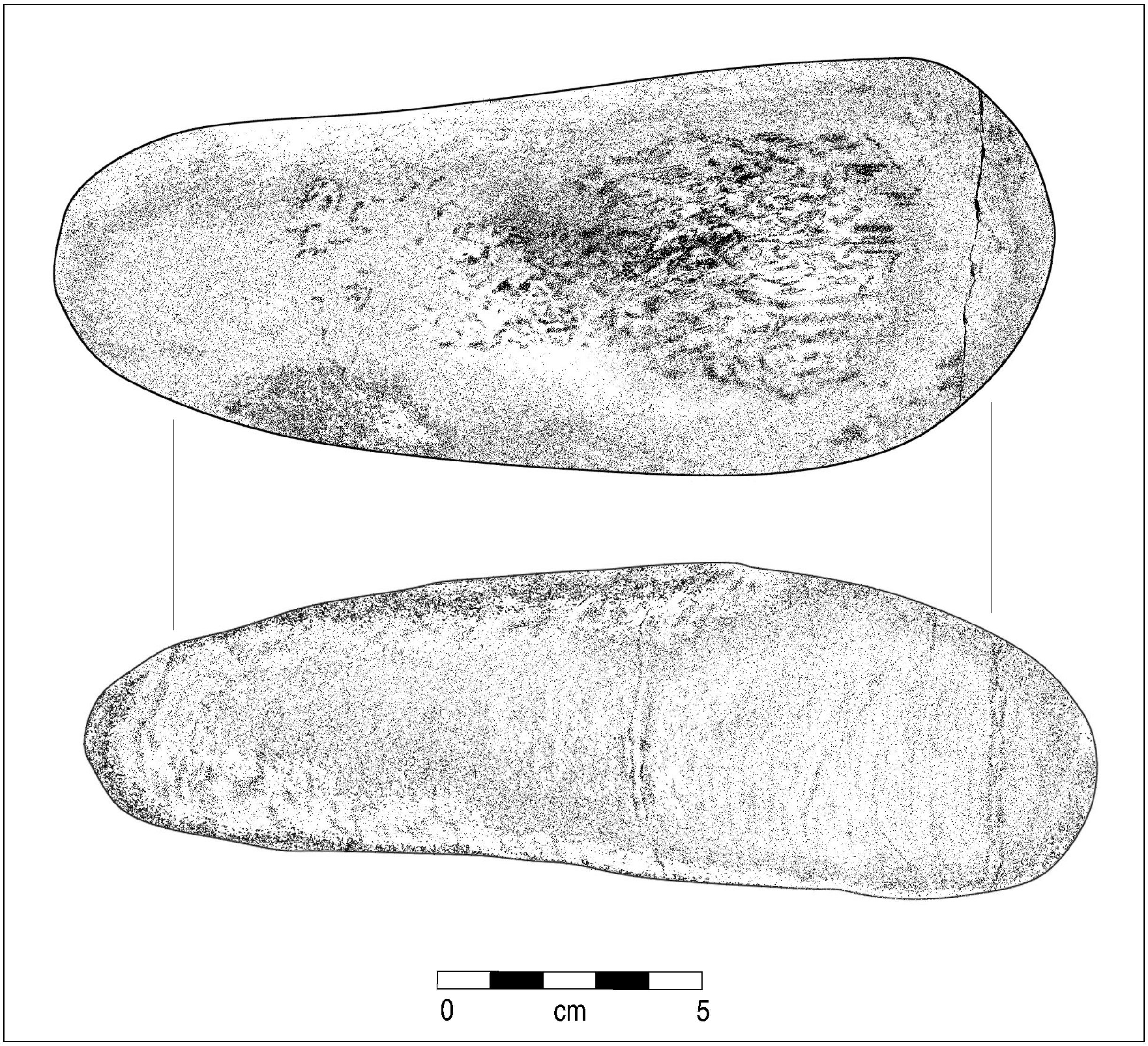


Figure 8.27. Pestle (catalog no. 1048).

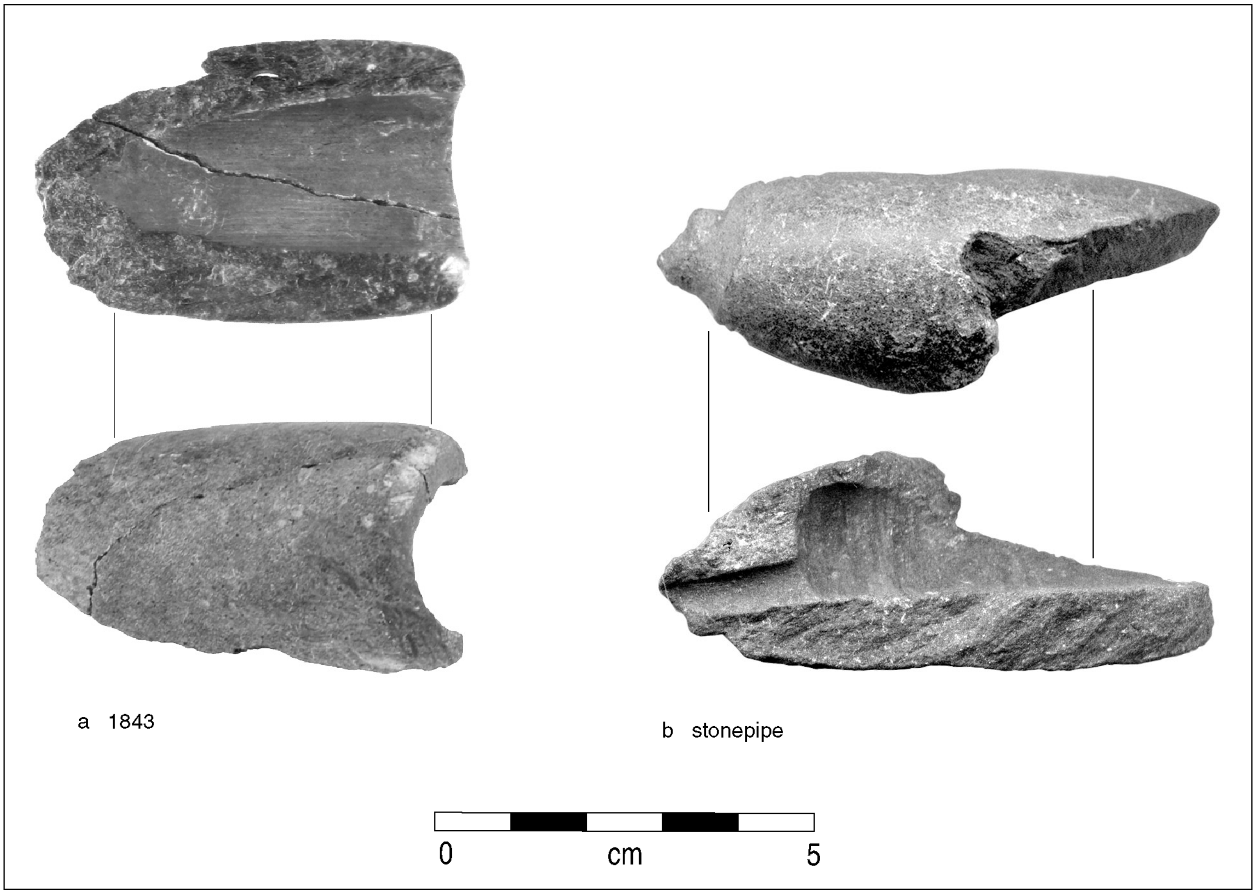


Figure 8.28. Steatite tubular pipes.

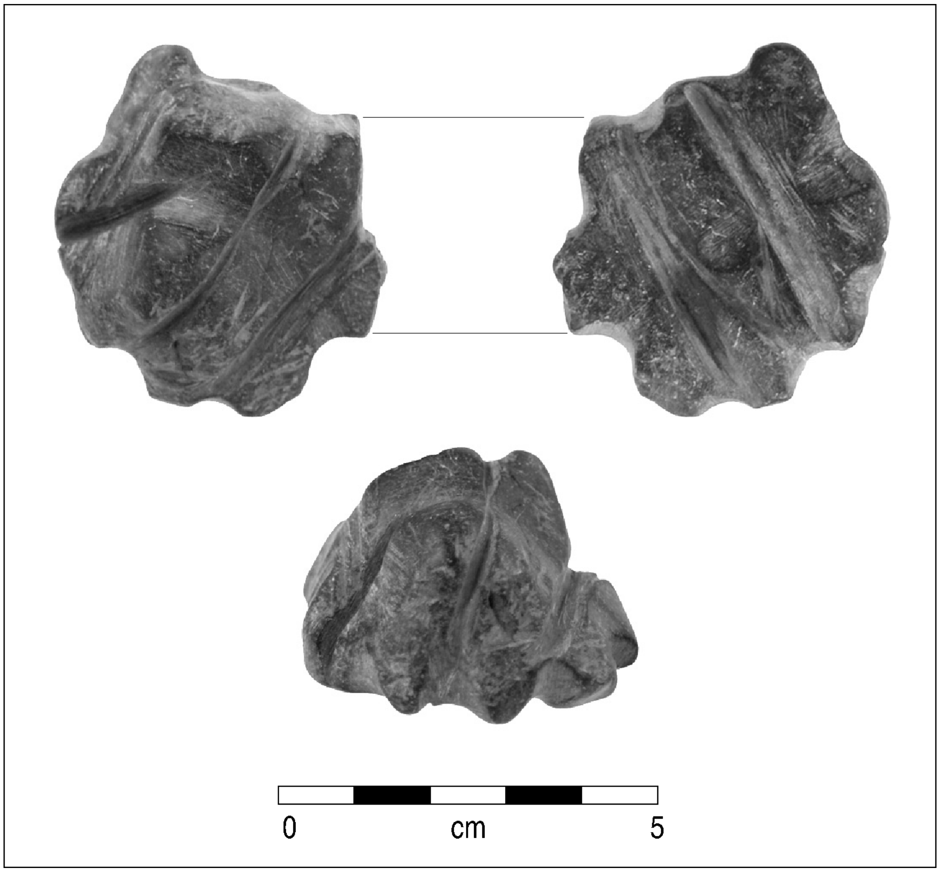


Figure 8.29. Shaft straightener (catalog no. 1071).

Figure 8.30. Perforated ground stone (catalog no. 1847).

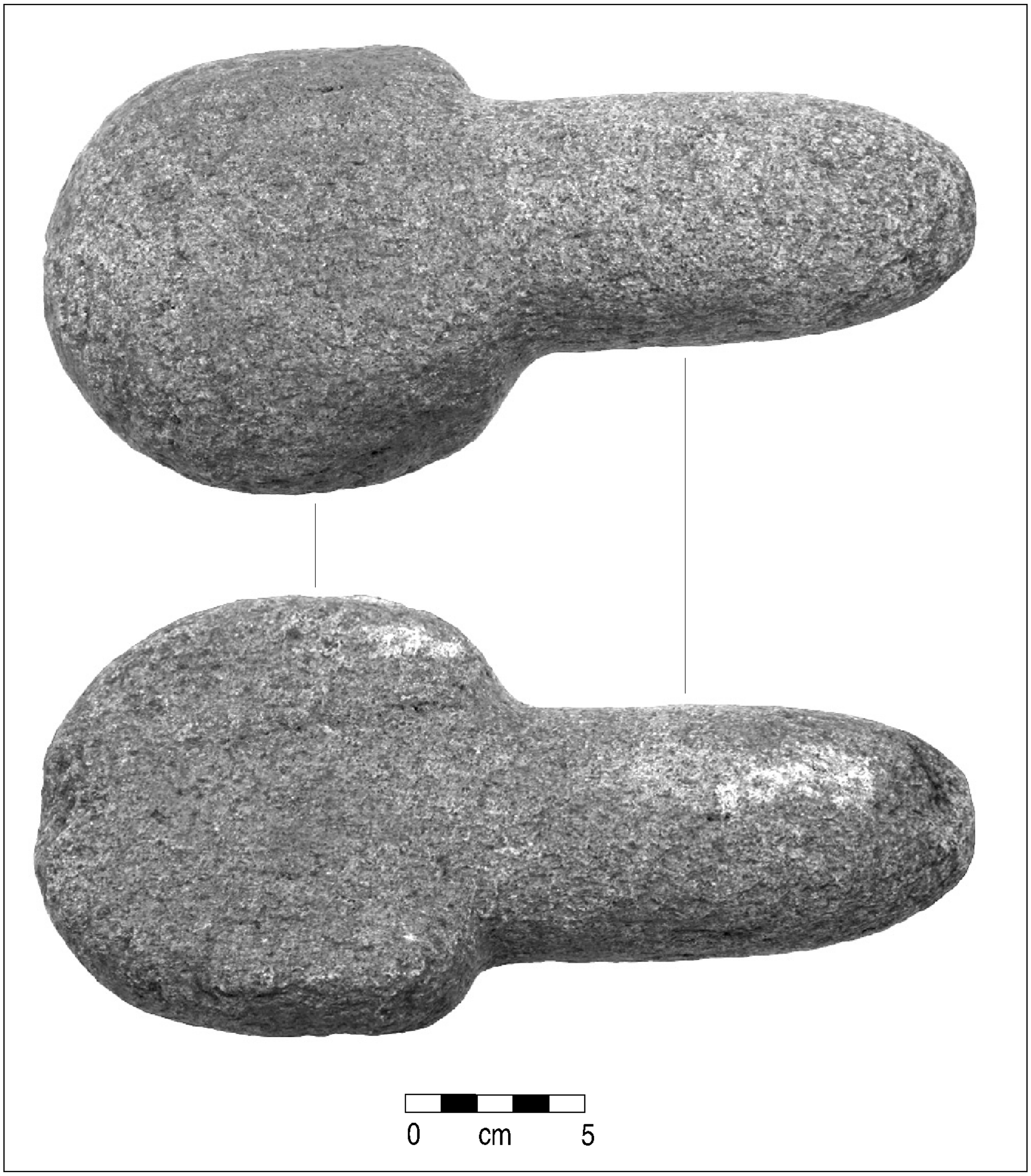


Figure 8.31. "Pelican stone" (catalog no. 1839).

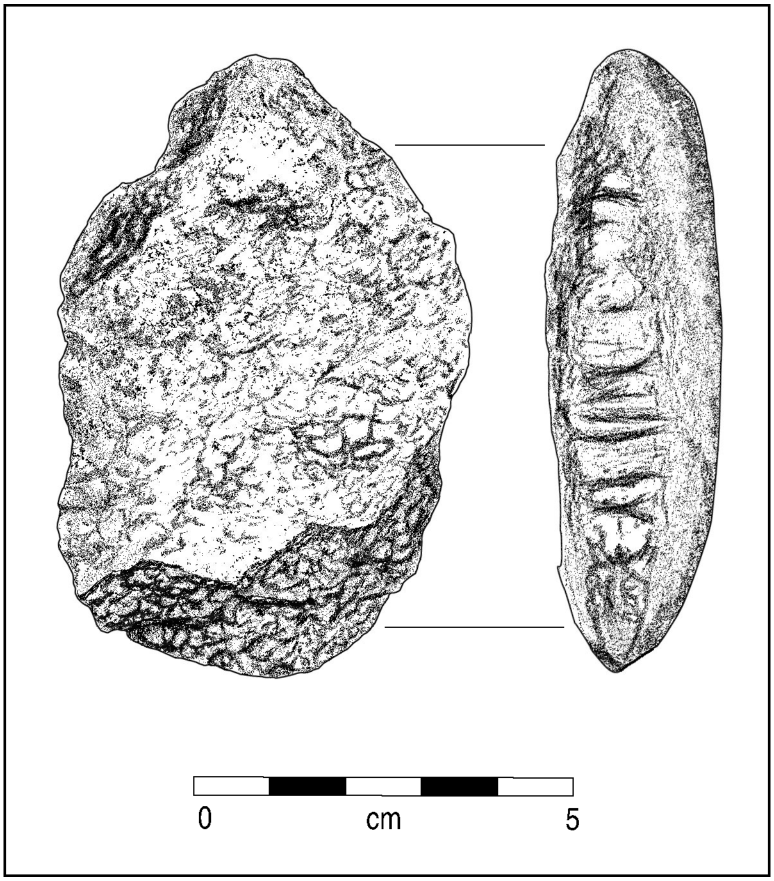


Figure 8.32. Shaft straightener (catalog no. 37).

Table 8.1. Summary of Qualities for Lithic Materials Identified in the West Bluffs Assemblages

Type Material	Hardness[a]	Characteristics	Technology
Igneous			
Andesite	hard	fine-grained; medium silica; medium color	primarily flaked
Basalt	hard	generally fine-grained; low silica; may be vesicular; dark color	flaked, ground, battered
Diorite	hard	coarse-grained; mafic; little or no quartz; medium to dark color	ground, battered
Granite	hard	coarse-grained; felsic; light color	ground, battered
Obsidian	hard	fine-grained; glassy; usually red, black, and/or clear	flaked
Rhyolite	hard	fine-grained; sometimes porphrytic; generally light color	primarily flaked
Volcanic breccia	hard	fine- to medium-grained with angular inclusions; dark color	ground, battered
Sedimentary			
Breccia	hard or soft	fine- to medium-grained with angular inclusions	ground, battered
Chalcedony	hard	fine-grained; smooth; translucent white to brown	flaked
Chert	hard	fine-grained; various colors	flaked
Conglomerate	hard	variable grain size with waterworn pebble inclusions; various colors	ground, battered
Limestone	soft	sedimentary; fine granular texture; light color	ground, battered
Sandstone	hard	coarse-grained; light color	ground, battered
Shale	soft	sedimentary; fine-grained; layered; medium color	flaked, ground
Siltstone	hard or soft	fine-grained; generally light color	ground
Metamorphic			
Gneiss	hard	igneous; coarse-grained; banded; foliated; various colors	ground, battered
Metasediment	hard	sedimentary; fine- to medium-grained; variable color	flaked, ground, battered
Quartzite	hard	sedimentary; coarse-grained; light color	flaked, ground, battered
Schist	hard	sedimentary; coarse-grained; foliated; mottled color	ground, battered
Mineral			
Quartz	hard	hexagonal crystals; colorless, pink, to brown	flaked
Talc (steatite)	very soft	fine-grained; sometimes foliated; gray to black	ground

[a]Based on Mohs' scale: hard ≥ 6; soft = 3–5; very soft ≤ 2

Table 8.2. Frequency and Percentage of Lithic Material Types by Debitage Size Class for LAN-63

Material	0.0625–0.125 in.	0.125–0.25 in.	0.25–0.5 in.	0.5–1 in.	1–2 in.	> 2 in.	Total
Chert	341 (47.6)	260 (36.3)	85 (11.9)	30 (4.2)	1 (0.1)	—	717
Quartzite	75 (32.6)	70 (30.4)	37 (16.0)	22 (9.6)	17 (7.4)	9 (3.9)	230
Metasediment	16 (12.5)	46 (35.9)	42 (32.8)	14 (10.9)	9 (7.0)	1 (0.8)	128
Chalcedony	72 (59.5)	39 (32.2)	9 (7.5)	1 (0.8)	—	—	122
Nonspecific igneous	6 (11.38)	14 (26.4)	14 (26.4)	8 (15.1)	6 (11.3)	5 (9.4)	53
Rhyolite	3 (9.4)	10 (31.3)	8 (25)	2 (6.3)	6 (18.8)	3 (9.4)	32
Obsidian	11 (37.9)	9 (31.0)	7 (24.1)	2 (6.9)	—	—	29
Granite	—	1 (12.5)	4 (50)	1 (12.5)	1 (12.5)	1 (12.5)	8
Quartz	2 (28.6)	2 (28.56)	3 (43)	—	—	—	7
Limestone	—	—	1 (50)	—	1 (50)	—	2
Nonspecific sedimentary	—	—	—	—	1 (100)	—	1
Total	526 (36.6)	451 (33.9)	211 (15.9)	80 (6.0)	42 (3.2)	19 (1.4)	1,329

Note: Percentages by material are presented in parentheses.

Table 8.3. Percentages of Cortical Diagnostic Flakes at LAN-63, by Material Type

Material	Complete Cortex	Partial Cortex	No Cortex
Limestone	100.0	—	—
Nonspecific sedimentary	—	100.0	—
Rhyolite	7.4	40.7	51.9
Granite	—	42.9	57.1
Metasedimentary	4.4	30.0	65.6
Nonspecific igneous	5.1	25.6	69.2
Quartzite	—	29.8	70.2
Chalcedony	2.0	22.5	77.5
Chert	1.4	11.8	86.8
Obsidian	—	—	100.0
Quartz	—	—	100.0

Table 8.4. Frequency and Percentage of Diagnostic Debitage by Reduction Technology for Individual Features at LAN-63

Feature	Biface Thinning	Core Reduction	Bipolar Reduction	Total
1	2 (20.0)	8 (80.0)	—	10
3	1 (11.1)	8 (88.9)	—	9
4	—	2 (100.0)	—	2
5	10 (25.6)	29 (74.4)	—	39
6	1 (3.4)	28 (96.6)	—	29
7	10 (14.5)	59 (85.5)	—	69
8	4 (44.4)	5 (55.6)	—	9
9	3 (42.9)	4 (57.1)	—	7
10	5 (35.7)	9 (64.3)	—	14
11	9 (20.9)	34 (79.1)	—	43
12	4 (18.2)	18 (81.8)	—	22
13	2 (22.2)	7 (77.8)	—	9
14	8 (47.1)	9 (52.9)	—	17
15	—	4 (100.0)	—	4
16	—	2 (100.0)	—	2
17	3 (50.0)	3 (50.0)	—	6
18	—	6 (100.0)	—	6
21	2 (10.5)	17 (89.5)	—	19
318	7 (26.9)	19 (73.1)	—	26
379	3 (42.9)	4 (57.1)	—	7
409	—	2 (100.0)	—	2
444	4 (26.7)	11 (73.3)	—	15
446	2 (22.2)	7 (77.8)	—	9
462	8 (33.3)	16 (66.7)	—	24
468	17 (63.0)	10 (37.0)	—	27
475	2 (22.2)	6 (66.7)	1 (11.1)	9
480	20 (27.4)	53 (72.6)	—	73
492	30 (26.3)	84 (73.7)	—	114
509	6 (75.0)	2 (25.0)	—	8
521	—	3 (100.0)	—	3
587	20 (29.9)	46 (68.7)	1 (1.5)	67
594	1 (100.0)	—	—	1
600	4 (44.4)	5 (55.6)	—	9
601	2 (18.2)	9 (81.8)	—	11

Table 8.5. Frequency of Lithic Material Types at LAN-63, by Feature

Material	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21	379	318	409	444	446	462	468	475	480	492	509	521	587	594	600	601
Chalcedony	1	—	—	1	4	3	1	—	—	6	—	1	—	—	—	—	—	2	1	5	—	—	—	2	—	—	5	10	2	—	6	—	—	1
Chert	4	1	—	10	12	27	4	4	8	17	11	4	12	2	1	4	1	5	5	16	—	9	3	15	24	7	53	78	3	1	33	1	6	5
Granite	—	—	1	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—
Nonspecific Igneous	—	1	—	—	1	4	1	—	—	7	1	—	2	—	1	—	2	3	—	—	—	3	1	3	—	—	1	1	—	—	4	—	—	4
Limestone	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Metasediment	1	3	—	3	4	13	2	1	3	6	3	1	3	1	—	—	3	4	—	—	—	1	1		1	1	3	8	1	—	4	—	3	—
Obsidian	—	—	—	2	1	—	1	—	—	1	—	—	—	—	—	—	—	—	1	—	—	1	1	1	1	—	—	2	1	—	5	—	—	—
Quartz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	3	—	—	—
Quartzite	3	2	1	17	5	17	—	2	3	3	7	2	—	—	—	2	—	5	—	3	2	1	2	3	1	1	8	12	—	2	8	—	—	—
Rhyolite	1	2	—	6	2	2	—	—	—	2	—	1	—	—	—	—	—	—	—	2	—	—	—	—	—	—	3	2	1	—	1	—	—	1
Nonspecific Sedimentary	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 8.6. Biface Data for LAN-63

Catalog No.	Provenience	Stage	Portion	Material	Length (mm)	Width (mm)	Thick (mm)
361	F 3	2	complete	shale	126.0	71.4	20.1
530	F 7	3	lateral	chert	8.8	13.1	5.4
1829	F 372	2	complete	chert	144.1	102.1	35.4
2090	F 379	2	complete	chert	60.7	61.7	21.6
2055	F 404	2	complete	andesite	177.0	103.7	30.6
1815	F 410	3	nearly complete	chert	99.7	36.4	17.7
2051	F 468	3	midsection	chert	15.4	21.7	7.4
1809	F 469	4	distal	chert	13.6	17.3	4.2
1817	F 564	2	complete	chert	58.4	24.7	14.3
1813	F 643	3	nearly complete	quartz	31.7	13.9	10.7
1684	PP	4	nearly complete	obsidian	36.2	26.6	11.4
1685	PP	3	distal	obsidian	47.2	27.4	7.5
1686	PP	3	nearly complete	obsidian	37.3	22.6	7.4
1687	PP	3	distal	obsidian	27.3	8.9	6.6
1688	PP	3	complete	obsidian	48.6	22.8	9.1
1803	PP	5	nearly complete	chert	31.7	14.2	5.7
1806	PP	3	complete	chalcedony	26.5	17.1	6
1810	PP	3	midsection	chert	26.7	32.6	10.8
1811	PP	3	midsection	chert	29.5	29.1	7.8
1812	PP	3	midsection	chert	36.6	28.6	8.4
1814	PP	3	distal	chert	32.1	22.6	11.8
1818	PP	4	complete	chert	76.7	36.2	12.7
1819	PP	3	nearly complete	chert	49.3	20.5	11.5
1820	PP	2	complete	chert	41.9	17.2	8.3
1821	PP	4	midsection	chert	32.7	26.9	11.1
1822	PP	4	midsection	chert	31.6	26.4	10.9
1823	PP	3	midsection	chert	33.9	28.7	9.8
1824	PP	4	nearly complete	chert	49.8	24.1	9.3
1825	PP	4	distal	chert	58.9	32.5	13.7
1826	PP	4	nearly complete	chert	54.7	21.7	8.0
1828	PP	2	complete	chert	124.6	78.0	34.1
1830	PP	2	complete	chert	165.0	92.8	27.0
1831	T	2	complete	chert	240.0	101.9	32.6
2054	PP	2	complete	quartzite	93.0	48.9	19.4
2059	PP	3	complete	chert	42.7	36.0	12.7

Key: F = Feature; PP = point-provenienced artifact; T = trench

Table 8.7. Chopper Data for LAN-63

Feature No.	Catalog No.	Condition	Material	Length (mm)	Width (mm)	Thickness (mm)	Fire Affected?
1	318	complete	granite	105.6	93.3	49.2	
3	370	complete	quartzite	87.1	72.5	49.1	
4	379	complete	andesite	81.1	73.7	33.3	
5	385	complete	andesite	63.6	85.8	63.5	
5	397	complete	quartzite	56.8	62.5	24.3	
5	403	complete	quartzite	99.5	92.8	36.2	
5	407	complete	quartzite	78.0	84.3	34.0	
5	409	complete	metasediment	55.1	87.1	51.4	
5	410	complete	metasediment	81.9	73.0	47.0	
5	417	complete	rhyolite	58.1	100.4	71.1	
5	893	complete	quartzite	64.0	83.8	39.0	
6	420	complete	undetermined	87.3	81.0	46.2	
10	523	complete	granite	76.1	77.0	39.9	
11	538	complete	rhyolite	59.2	125.8	45.3	
13	546	complete	rhyolite	86.3	60.6	46.7	
14	905	complete	quartzite	58.8	59.4	35.7	
14	906	complete	igneous	74.4	63.5	33.5	Y
14	909	complete	igneous	65.0	61.1	27.4	
15	913	complete	metasediment	42.6	99.1	48.6	
16	918	complete	quartzite	109.9	89.3	77.5	
17	928	complete	metasediment	60.7	78.0	43.0	
19	932	complete	quartzite	89.5	68.9	52.6	Y
337	1158	fragment	quartzite	106.1	90.7	70.8	Y
337	1197	fragment	metasediment	78.0	87.9	33.0	
379	2084	complete	metasediment	52.4	71.9	48.2	
379	2089	fragment	metamorphic	50.6	59.5	41.2	
409	1336	complete	metasediment	101.3	79.0	39.6	Y
444	1355	complete	igneous	101.7	81.9	34.4	
444	1360	complete	rhyolite	88.6	69.4	40.4	Y
462	1669	complete	igneous	94.7	84.8	48.9	
480	1692	complete	igneous	54.4	78.0	51.7	
509	1699	fragment	igneous	81.5	42.9	22.7	

Table 8.8. Core Data for LAN-63

Provenience	Catalog No.	Type	Material	Length (mm)	Width (mm)	Thickness (mm)	Fire Affected?
Feature 1	323	multidirectional	quartzite	107.2	70.5	60.2	
	324	multidirectional	quartz	69.0	38.6	43.7	
	327	undetermined	rhyolite	89.1	51.1	35.3	
Feature 3	362	unidirectional	rhyolite	68.5	56.4	30.9	
	363	multidirectional	diorite	55.0	62.9	30.0	
	366	multidirectional	quartzite	44.9	37.6	35.3	
	368	multidirectional	andesite	44.7	65.6	45.8	
	369	multidirectional	rhyolite	54.9	56.4	32.3	
	371	multidirectional	quartzite	33.9	57.7	56.0	
Feature 4	383	undetermined	metasediment	68.7	37.3	45.8	Y
Feature 5	386	multidirectional	quartzite	54.8	82.9	66.3	
	388	bidirectional	metasediment	57.1	71.1	47.2	
	389	multidirectional	quartzite	93.5	79.4	43.3	
	390	multidirectional	quartzite	109.9	98.0	55.7	
	392	undetermined	quartzite	79.8	38.9	31.5	
	394	multidirectional	metasediment	63.2	75.5	64.0	
	395	multidirectional	siltstone	62.1	76.8	52.3	
	396	unidirectional	metasediment	71.9	69.7	56.3	
	398	unidirectional	quartzite	91.6	65.6	50.6	
	399	unidirectional	quartzite	74.6	88.3	35.8	
	404	unidirectional	quartzite	82.2	105.4	59.1	
	405	bidirectional	metasediment	78.3	88.9	58.3	
	406	multidirectional	rhyolite	94.0	70.4	52.5	
	408	multidirectional	metasediment	74.4	64.0	49.4	
	412	bifacial	metasediment	82.7	66.1	41.0	
	414	bifacial	rhyolite	65.1	74.8	61.1	
	416	multidirectional	rhyolite	83.2	82.5	41.7	
	418	multidirectional	metasediment	65.4	79.2	63.9	
	1903	multidirectional	igneous	40.6	68.7	37.1	
Feature 8	531	multidirectional	quartzite	51.9	79.9	66.8	
Feature 11	539	unidirectional	metasediment	69	49.9	18.9	
	541	multidirectional	rhyolite	64.4	50.3	42.4	
	542	multidirectional	quartzite	41.6	41.9	32.1	

Provenience	Catalog No.	Type	Material	Length (mm)	Width (mm)	Thickness (mm)	Fire Affected?
Feature 13	888	bidirectional	metasediment	91.8	57.1	56.0	
Feature 14	902	multidirectional	quartzite	55.5	30.1	27.5	
Feature 16	924	bidirectional	metasediment	86.5	101.5	49.9	
Feature 318	1081	multidirectional	chert	88.1	80.8	43.2	
Feature 337	1184	multidirectional	metasediment	59.7	55.6	43.4	
	1223	unidirectional	quartzite	99.3	73.9	56.1	
Feature 379	2086	multidirectional	quartzite	78.9	82.8	69.9	
	2091	multidirectional	chert	25.2	27.1	17.9	
Feature 409	1330	unidirectional	quartzite	53.5	45.6	31.3	
	1335	multidirectional	metasediment	83.4	86.1	24.3	
Feature 444	1347	multidirectional	quartzite	109.6	80.3	48.9	
	1384	multidirectional	igneous	98.4	62.8	38.2	
Feature 468	2053	bipolar	chalcedony	41.9	20.0	11.4	
Feature 480	1040	multidirectional	chert	18.8	24.4	18.4	
	1076	multidirectional	andesite	53.4	39.5	35.9	
	1079	multidirectional	metasediment	53.8	45.2	34.4	
	1693	multidirectional	igneous	56.4	65.9	27.7	
	1694	undetermined	quartzite	49.5	55.7	30.1	
Feature 509	1696	multidirectional	igneous	56.4	48.0	26.0	
	1698	unidirectional	quartzite	36.0	37.2	42.9	Y
	1707	undetermined	rhyolite	84.1	38.8	78.6	Y
Feature 587	988	multidirectional	quartz	48.7	34.6	24.0	
Feature 594	1750	unidirectional	igneous	67.5	42.0	82.3	Y
Feature 601	1783	multidirectional	metasediment	71.6	82.1	38.7	
PP	1832	bidirectional	mudstone				

Key: PP = point-provenienced artifact

Table 8.9. Projectile Point Data for LAN-63

Catalog No.	Type	Length	Width	Thickness	DSA (deg.)	PSA (deg.)	Stem Length	Neck Width	Basal Width
1802	Elko Eared	42.8	27.1	7.7	193	133	9.3	18.4	26.0
1804	Gypsum Cave	48.5	29.1	11.0	201	62	8.6	12.2	—
1805	Gypsum Cave	48.3	24.8	9.7	201	82	11.9	12.2	7.3
1807	Medium Side-notched	34.2	16.7	8.3	206	138	7.9	9.9	16.3
1808	Humboldt Concave Base	27.9	29.0	11.7	n/a	n/a	n/a	n/a	17.4
1816	Great Basin Stemmed	114.9	31.0	10.9	n/a	n/a	48.8	n/a	15.6

Note: All measurements in millimeters, unless specified. DSA = distal shoulder angle; PSA = proximal shoulder angle; n/a = not applicable.

Table 8.10. Mano Data for LAN-63

Collection No.	Catalog No.	Portion	Material	Use Stage	Length (mm)	Width (mm)	Thickness (mm)	Surfaces (n)	Fire Alteration
Point provenienced									
—	1745	complete	granite	5	77.6	80.5	44.5	1	
Stripping Unit									
480	1072	complete	metasedimentary	5	114.1	94.7	49.5	1	
Feature									
1	278	fragment	granite	2	90.2	44.0	50.0	2	Y
	280	fragment	granite	5	114.8	87.5	62.3	1	
	283	fragment	andesite	4	83.7	43.1	34.3	1	
	289	fragment	granite	5	82.4	50.2	53.5	1	
	293	fragment	granite	5	47.3	40.4	33.7		Y
3	297	fragment	granite	5	60.5	45.2	68.6		Y
	298	fragment	granite	3	66.5	49.9	27.8		
5	424	fragment	diorite	unknown	105.1	75.5	75.1		
6	425	fragment	granite	unknown	60.5	59.7	39.8		Y
	426	fragment	siltstone	unknown	40.9	72.8	51.6	2	
7	429	fragment	diorite	unknown	42.1	46.8	42.1		
	432	complete	quartzite	—	108.2	64.4	47.9	1	
	440	fragment	granite	3	51.9	33.8	16.9	2	
	441	fragment	granite	3	70.5	21.2	55.3	1	
8	446	nearly compete	granite	2	83.4	87.4	52.8	1	
9	449	fragment	siltstone	1	92.4	83.4	53.0		
10	455	fragment	granite	4	64.5	74.3	41.4	2	Y
	645	fragment	metasedimentary	5	41.8	74.6	45.8		Y
14	758	fragment	granite	3	72.9	40.2	41.1		Y
	759	complete	granite	3	106.5	87.3	51.8	1	
	762	fragment	granite	3	55.8	44.3	49.8	2	Y
17	766	fragment	conglomerate	1	69.4	85.8	37.4		Y
318	1075	undetermined	granite	5	81.5	82.0	81.8		Y
	1124	fragment	granite	5	42.5	99.1	46.3	1	Y
	1126	fragment	granite	5	136.8	97.7	63.9		Y
	1860	fragment	granite	5	79.0	29.5	55.6	1	Y
337	1134	fragment	conglomerate	1	95.2	78.2	36.3	1	
	1140	fragment	granite	2	97.6	112.1	53.8	2	Y
	1146	fragment	granite	3	98.9	77.7	68.5	1	Y

Collection No.	Catalog No.	Portion	Material	Use Stage	Length (mm)	Width (mm)	Thickness (mm)	Surfaces (n)	Fire Alteration
	1147	fragment	siltstone	unknown	61.7	54.5	45.1		Y
379	2083	complete	siltstone	unknown	83.7	73.3	25.5	1	
444	1275	fragment	granite	2	78.7	58.6	36.8	1	
	1276	fragment	granite	1	81.0	63.5	29.0		Y
	1278	fragment	rhyolite	2	52.0	67.9	27.9		
	1279	fragment	granite	5	115.4	79.4	45.9	1	Y
	1280	fragment	igneous	3	—	—	—	1	Y
446	1281	fragment	granite	3	65.2	94.1	49.4	2	
	1282	fragment	granite	3	134.5	52.3	47.3	2	
	1283	fragment	granite	4	61.0	30.2	49.0	2	Y
462	1289	fragment	granite	3	136.4	84.5	32.3		
	1291	fragment	granite	3	103.4	42.0	61.6	2	
468	1292	complete	UND	3	117.5	94.4	40.8	1	Y
	1294	fragment	granite	2	78.6	62.5	36.5	1	Y
	1295	complete	conglomerate	1	100.8	88.1	88.5	2	
	1297	nearly complete	sandstone	4	107.2	94.8	49.7	2	Y
	1863	fragment	conglomerate	unknown	88.2	89.8	52.8	1	
509	1715	fragment	granite	4	79.9	115.5	41.0		Y
521	1724	fragment	granite	3	44.5	30.3	48.7		
587	961	medial	sandstone	5	97.2	48.9	45.6	1	
601	1733	fragment	sandstone	5	71.6	106.2	43.2		Y
	1735	complete	granite	4	157.0	112.4	60.7	1	Y
	1737	fragment	granite	4	64.4	35.5	31.8		Y
	1739	fragment	granite	4	75.6	122.5	75.6		Y

Table 8.11. Metate Data for LAN-63

Feature No.	Catalog No.	Stage	Portion	Material	Length (mm)	Width (mm)	Thickness (mm)	Surfaces (n)	Fire alteration?
1	277	5	fragment	granite	116.7	84.9	50.5		Y
	279	5	fragment	granite	74.7	45.9	72.8		
	292	—	fragment	granite	111.6	69.3	45.5	1	
6	427	5	fragment	granite	40.7	55.1	38.5		
7	439	3	fragment	sandstone	74.4	46.5	87.3		
10	451	1	fragment	granite	126.1	98.8	81.8	1	
	641	1	fragment	granite	101.3	56.1	64.7		Y
13	755	—	fragment	granite	81.1	69.9	47.1		Y
14	757	5	fragment	granite	86.1	59.7	63.3		Y
	760	3	fragment	sandstone	160.0	109.2	41.1	1	Y
	763	2	complete	granite	124.6	111.1	39.8	2	
21	938	2	fragment	sandstone	112.1	77.5	76.3	1	Y
	939	4	fragment	siltstone	153.6	113.0	108.2	1	
	941	4	fragment	metasedimentary	154.0	107.0	69.0	2	
318	1073	3	fragment	conglomerate	68.3	66.2	69.0		Y
	1125	5	fragment	sandstone	93.7	74.6	27.3		
337	1128	3	fragment	breccia	93.6	45.5	80.4	1	Y
	1129	4	fragment	sandstone	138.5	77.2	54.1	1	Y
	1137	5	fragment	diorite	72.2	55.4	52.7	1	Y
	1143	3	fragment	granite	139.8	90.8	96.3	1	Y
	1150	4	fragment	diorite	107.5	67.6	39.4	1	Y
462	1286	4	fragment	granite	137.6	81.1	77.3		Y
	1288	5	fragment	igneous	97.5	82.9	55.8		
587	955	2	fragment	sandstone	182.0	118.2	97.1		
	1009	1	fragment	granite	220.0	101.4	105.8	1	
	1010	1	fragment	sandstone	340.0	295.0	87.8	1	
	1065	5	fragment	sandstone	69.2	58.9	22.6	1	
	1067	2	fragment	sandstone	175.0	155.0	75.1	1	
	1855	2	fragment	conglomerate	137.0	132.1	81.9	1	
	2058	3	fragment	schist	101.0	81.7	29.5	1	
601	1730	4	fragment	sandstone	138.6	81.9	67.3		

Table 8.12. Bowl and Other Vessel Data for LAN-63

Feature No.	Catalog No.	Type	Portion	Material	No.	Length (mm)	Width (mm)	Thick (mm)	Fire Affected?
4	304	bowl	fragment	metasedimentary	3	114.4	35.0	30.9	
	305	bowl	fragment	metasedimentary	1	105.1	44.6	36.1	Y
	306	bowl	fragment	metasedimentary	1	225.0	43.4	67.2	
	307	bowl	fragment	metasedimentary	3	—	—	—	
11	654	bowl	fragment	steatite	1	125.6	25.4	28.4	
	667	bowl	fragment	basalt	1	—	—	—	
	668	bowl	fragment	basalt	1	—	—	—	
	669	bowl	fragment	basalt	1	260.0	260.0	24.0	
	670	bowl	fragment	basalt	1	—	—	—	
	671	bowl	fragment	basalt	1	—	—	—	
	741	bowl	fragment	sandstone	1	—	—	—	
	742	bowl	fragment	sandstone	1	230.0	140.0	25.0	
	743	bowl	fragment	sandstone	1	—	—	—	
	753	bowl	nearly complete	diorite	1	280.0	275.0	—	
337	1145	bowl	fragment	igneous	1	88.9	55.3	63.0	Y
	1148	bowl	fragment	igneous	1	82.8	70.4	60.0	Y
379	2094	bowl	nearly complete	granite	1	360.0	350.0	290.0	
521	1726	bowl	complete	granite	1	250.0	250.0	165.0	
587	949	bowl	complete	steatite	1	153.8	114.1	45.6	
	957	bowl	fragment	steatite	1	191.0	75.4	20.5	
	992	bowl	nearly complete	steatite	1	139.0	125.0	10.4	
	993	bowl	fragment	sandstone	1	210.0	225.0	90.0	
	997	bowl	fragment	steatite	1	205.0	95.0	35.5	
	1012	bowl	fragment	igneous	1	210.0	145.0	46.7	
	1017	bowl	medial	steatite	1	89.4	88.3	25.5	
	1020	bowl	fragment	steatite	1	98.1	80.8	30.0	
	1045	bowl	end	steatite	1	114.3	71.0	19.7	
	1053	bowl	fragment	steatite	1	74.9	63.3	14.7	
	1061	bowl	fragment	steatite	1	147.7	129.8	33.9	
	1062	bowl	fragment	steatite	1	179.0	140.0	28.4	
	1848	bowl	nearly complete	steatite	1	179.0	104.7	23.4	
	1854	bowl	nearly complete	steatite	1	117.3	50.7	16.0	
	2063	bowl	fragment	steatite	1	80.7	68.3	33.1	

Table 8.13. Mortar Data for LAN-63

Feature No.	Catalog No.	Material	No.	Length (mm)	Width (mm)	Thick (mm)
8	442	basalt	1	111.6	92.4	49.6
	443	basalt	4	—	—	—
	445	basalt	1	140.0	157.0	55.3
	444	basalt	4	—	—	—
509	1865	granite	1	176.0	176.0	53.1

Note: All mortars are fragmentary.

Table 8.14. Indeterminate Mortar, Bowl, or Other Vessel data for LAN-63

Feature No.	Catalog No.	Material	Length (mm)	Width (mm)	Thick (mm)	Fire Affected?
3	294	siltstone	73.9	94.5	25.3	
	295	igneous	82.3	64.6	77.2	Y
10	648	granite	71.4	50.3	44.8	
318	1122	sandstone	132.6	56.7	69.0	Y
337	1138	granite	163.0	112.1	54.2	Y
	1139	vesicular basalt	72.6	62.5	77.0	Y
	1142	vesicular basalt	81.3	46.1	53.5	
	1144	granite	117.9	66.9	91.8	Y
340	1151	conglomerate	102.2	84.4	29.7	Y
409	1152	vesicular basalt	146.1	114.7	42.7	Y
	1153	vesicular basalt	149.2	93.8	56.0	Y
	1269	metavolcanic breccia	71.0	47.3	44.8	Y
	1270	vesicular basalt	69.9	35.3	50.5	Y
	1273	granite	80.4	65.3	86.1	Y
468	1298	diorite	70.1	57.7	28.9	
509	1717	igneous	40.2	30.5	39.2	
521	1721	breccia	205.0	118.2	80.3	Y
	1722	breccia	147.1	124.9	107.8	Y
	1723	granite	180.0	164.0	63.7	Y
587	952	sandstone	177.0	123.2	63.6	
	954	basalt	81.1	49.8	37.6	
	959	schist	207.0	132.1	31.6	
	960	sandstone	94.1	121.1	81.6	Y
	994	granite	190.0	230.0	53.9	
	995	granite	370.0	175.0	77.3	
	998	metavolcanic breccia	158.0	75.0	57.7	
	1011	metavolcanic breccia	116.5	66.1	39.8	
	1015	granite	180.0	132.5	62.6	
	1046	diorite	240.0	145.0	55.2	
	1051	basalt	125.6	77.4	64.9	
	1055	basalt	100.6	73.7	34.0	
	1056	diorite	180.0	102.3	54.4	
	1058	metavolcanic breccia	160.0	101.8	38.2	
	1059	granite	130.8	190.0	76.3	

Note: All artifacts are fragments and of unknown type.

Table 8.15. Pestle Data for LAN-63

Feature No.	Catalog No.	Portion	Material	Length (mm)	Width (mm)	Thickness (mm)	Stage of Use
8	1859	complete	undetermined	162.0	77.8	60.7	3
10	640	midsection	granite	41.2	44.5	41.6	unknown
	646	midsection	granite	42.3	49.5	47.8	unknown
11	659	distal	schist	—	—	—	
	660	fragment	schist	590.0	86.9	75.8	
	661	fragment	schist	—	—	—	
	662	fragment	schist	—	—	—	
	663	fragment	schist	—	—	—	
	664	fragment	schist	550.0	74.0	87.4	
	665	fragment	schist	—	—	—	
	666	proximal	schist	—	—	—	
337	1136	fragment	granite	93.7	74.1	62.6	2
379	2093	complete	granite	262.0	63.0	61.0	3
409	1272	midsection	siltstone	84.3	80.0	66.9	2
444	1274	complete	siltstone	160.0	76.6	68.2	3
509	1719	fragment	siltstone	125.4	63.3	24.0	5
	1718	fragment	siltstone	124.5	63.8	29.1	5
521	1725	fragment	igneous	210.0	71.9	65.1	unknown
587	1007	medial	siltstone	146.0	97.3	77.2	5
	1003	medial	siltstone	176.0	83.8	82.8	2
	1002	medial	siltstone	152.0	99.8	96.9	1
	1052	distal	siltstone	185.0	76.1	71.2	1
	1856	complete	undetermined	151.4	65.3	49.5	1
	1857	proximal	conglomerate	100.8	69.2	61.1	1
	1858	end	diorite	113.9	66.8	55.6	2
	1047	medial	granite	192.0	70.9	70.9	2
	1004	distal	granite	342.0	80.1	73.9	3
	999	distal	granite	260.0	63.7	64.4	5
	1001	proximal	igneous	113.0	50.9	51.9	5
	1048	complete	igneous	155.0	59.4	59.4	
	951	complete	metasedimentary	192.0	71.1	43.9	5
	1068	distal	metasedimentary	170.0	65.6	49.2	1
	1057	distal	metasedimentary	97.0	56.4	51.0	1

Feature No.	Catalog No.	Portion	Material	Length (mm)	Width (mm)	Thickness (mm)	Stage of Use
	1008	medial	sandstone	133.8	53.8	53.9	5
	1006	medial	sandstone	245.0	81.1	87.0	3
	996	medial	sandstone	80.4	54.5	51.7	5
	1005	distal	sandstone	173.0	83.9	83.1	3
	1000	distal	sandstone	127.3	78.5	81.5	2
594	1728	complete	igneous	206.0	61.7	63.2	5
	1727	complete	granite	183.0	65.6	63.3	5
601	1734	fragment	granite	59.8	92.7	73.9	1

Table 8.16. Frequency and Percentage of Lithic Material Types by Debitage Size Class for LAN-64

Material	Size (in.)						Total
	0.0625–0.125	0.125–0.25	0.25–0.5	0.5–1	1–2	> 2	
Chert	75 (51.4)	42 (28.8)	18 (12.3)	11 (7.5)	—	—	146
Chalcedony	42 (68.9)	9 (14.8)	7 (11.5)	3 (4.9)	—	—	61
Quartzite	5 (25.0)	4 (20.0)	5 (25.0)	1 (5.0)	3 (15.0)	2 (10.0)	20
Metasediment	5 (29.4)	3 (17.6)	4 (23.5)	2 (11.8)	3 (17.6)		17
Nonspecific igneous	1 (11.1)	1 (11.1)	2 (22.2)	2 (22.2)	1 (11.1)	2 (22.2)	9
Quartz	2 (100)	—	—	—	—	—	2
Rhyolite	—	—	2 (100)	—	—	—	2

Table 8.17. Core Data for LAN-64

Catalog No.	Provenience	Type	Material	Length (mm)	Width (mm)	Thickness (mm)
347	U 13	undetermined	quartzite	36.8	25.3	33.0
348	U 14	unidirectional	quartzite	34.6	38.0	29.6
351	U 13	multidirectional	quartzite	19.1	26.0	17.5
247	Feature 76	multidirectional	chert	44.4	61.6	53.8
229	Feature 76	multidirectional	metasediment	86.5	64.5	60.1
261	Feature 76	multidirectional	metasediment	52.3	59.5	41.1
286	Feature 32	unidirectional	chert	26.7	17.7	13.3
20	Feature 56	unidirectional	quartzite	58.4	51.4	25.6

Table 8.18. Mano Data for LAN-64

Feature No.	Catalog No.	Portion	Material	Length (mm)	Width (mm)	Thickness (mm)	Number of Faces	Stage
12	49	complete	granite	120.0	111.6	45.2	2	3
12	50	fragment	granite	82.1	49.1	66.1	1	3
17	57	fragment	conglomerate	76.5	48.8	43.8	2	5
17	58	fragment	granite	92.6	53.2	50.4	1	1
23	283	fragment	conglomerate	71.8	60.1	34.8	1	1
33	72	nearly complete	sandstone	121.0	90.2	31.8	1	2
66	46	fragment	conglomerate	106.0	85.3	45.6	2	2
66	47	fragment	granite	66.3	95.1	58.9	2	1
76	228	fragment	conglomerate	72.4	102.8	43.6	1	5
76	259	fragment	conglomerate	91.2	48.6	47.2	1	5

Table 8.19. Obsidian Studies Results for LAN-63

Catalog No.	Provenience	Source	Type	Sample location	Hydration (μ)	Estimated Years B.P.
1574	PP	West Sugarloaf	debitage	—	5.3	1496
1575	F 587, U 207, L 5	West Sugarloaf	debitage	—	6.2	2152
1576	F 587, U 207, L 5	West Sugarloaf	debitage	—	5.9	1918
1623	F 587, U 222, L 2	West Sugarloaf	debitage	—	4.8	1189
1624	PP	West Sugarloaf	debitage	—	6.5	2402
1625	U 3, L 5	West Sugarloaf	debitage	—	6.7	2577
1626	PP	West Sugarloaf	debitage	—	6.6	2488
1684	PP	West Sugarloaf	biface	blade	4.2	872
				break, reworking	4.2	872
1685	PP	Mono Glass Mountain	biface	blade	4.0	
				break, reworking	4.0	
1686	PP	West Sugarloaf	biface	base	4.9	1247
				relict worked surface	5.0	1307
1687	PP	West Sugarloaf	biface	blade	2.6	287
				relict worked surface	3.8	691
1688	PP	Casa Diablo	biface	blade	4.1	
				relict worked surface	4.7	

Key: F = Feature; PP = point provenienced; F = Feature; L = Level, U = Unit

Table 8.20. Summary of Feature Constituents at LAN-63

Artifact Class	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	318	337	340	409	444	446	462	468	475	480	492	509	521	587	594	600	601	Total
Bifaces	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	3
Borers	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
Burins	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Scrapers	—	2	—	7	—	—	—	—	1	—	1	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	3	—	—	—	17
Edge-modified pieces	—	2	2	—	2	1	—	1	1	4	—	—	—	—	1	2	2	—	—	—	—	1	1	—	2	2	3	1	—	1	—	—	—	3	—	—	1	33
Choppers	1	1	1	8	1	—	—	—	1	1	—	1	2	1	1	1	—	—	—	—	—	1	—	—	1	—	1	—	—	1	—	1	—	—	—	—	—	25
Cores	3	6	—	19	—	—	1	—	—	3	—	1	1	—	1	—	—	—	—	—	1	2	—	2	2	—	—	1	—	5	—	1	—	1	—	—	1	51
Debitage	12	9	2	66	49	91	9	11	30	69	33	12	31	5	2	6	6	—	—	21	35	—	—	2	16	9	40	35	10	105	160	9	3	87	1	11	12	999
Manos	3	1	—	1	1	4	1	1	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	2	2	2	4	—	1	—	—	1	1	—	—	—	27
Metates	2	—	—	—	1	1	—	—	1	—	—	—	2	—	—	—	—	—	—	2	1	—	—	—	—	—	1	—	—	—	—	—	—	7	—	—	1	19
Pestles	—	—	—	—	—	—	1	—	2	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	20	2	—	1	36
Mortars/Bowls	—	1	5	—	—	—	5	—	1	7	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	1	—	26	—	—	—	48
Anvils	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	2
Hammer stones	—	—	—	—	1	3	—	—	2	—	—	—	—	—	—	2	1	—	—	—	3	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	14
Shaft straighteners	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	2
Unclassifiable ground stone	5	2	2	1	—	2	2	—	5	—	1	—	—	—	1	1	1	—	—	4	—	—	—	—	—	—	2	—	—	—	—	1	—	17	—	—	2	49
Steatite debris	—	—	—	—	3	—	—	—	—	701	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	—	—	—	716
Unclassifiable	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Unknown	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	2
Possible Ornaments																																						
Effigies	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Beads	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	3	—	—	—	4
Perforated “Disks”	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	5
Pendants	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Manuports	9	7	2	2	—	2	2	1	14	1	2	15	7	1	5	—	—	1	1	4	25	8	5	8	33	1	31	1	—	—	—	5	1	15	2	—	22	233
Tarring Pebbles	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	26	1	—	—	1	—	—	—	—	—	—	1	32
Fire-affected Artifacts																																						
Choppers	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	3
Hammer stones	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Cores	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	1	—	—	4
Manos	2	1	—	—	1	—	—	—	2	—	—	—	2	—	—	1	—	—	—	—	4	3	—	—	3	1	—	1	—	—	—	1	—	—	—	—	4	26
Metates	1	—	—	—	—	—	—	—	1	—	—	1	1	—	—	—	—	—	—	1	1	5	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	13
Pestles	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	1	1	—	—	—	—	4
Mortars and bowls	—	1	1	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	1	5	—	5	—	—	—	—	—	—	—	—	3	4	—	—	—	23
Anvils	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	2	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	5
Unclassifiable ground stone	3	—	2	—	—	3	—	—	3	5	—	—	2	—	—	—	1	2	1	3	2	7	—	1	—	—	1	1	—	—	—	2	2	3	—	—	2	46
Manuports	2	1	3	1	1	1	—	—	5	1	—	1	6	—	1	1	—	1	—	1	44	79	21	11	18	—	18	5	—	1	—	4	6	9	1	—	75	318
Fire-affected rock	3	1	1	—	—	—	—	—	—	—	—	12	1	—	—	—	—	3	—	—	8	1	—	—	1	—	—	—	—	3	—	1	—	5	—	—	—	40
Total	48	38	22	105	60	109	21	14	69	806	37	44	56	7	13	14	12	8	3	37	129	117	28	31	83	41	103	53	12	120	160	32	17	219	7	11	122	2,808

Table 8.21. Summary of Feature Constituents at LAN-64

Artifact Class	12	17	23	32	33	36	43	49	52	56	61	62	64	65	66	76
Burins	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Scrapers	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2
Edge-modified pieces	1	2	—	—	—	1	—	—	1	—	—	—	—	1	—	—
Choppers	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	3
Cores	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	3
Debitage	1	6	—	2	—	—	86	2	22	35	3	3	62	17	10	2
Manos	2	—	1	—	1	—	—	—	—	—	—	—	—	—	2	1
Metates	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Mortars/Bowls	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	6
Hammer stones	—	1	1	—	—	2	—	—	—	—	—	—	—	—	—	1
Unclassifiable ground stone	1	—	—	—	1	—	—	—	—	4	—	1	—	—	—	3
Steatite debris	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ornaments and other																
Beads	—	—	—	—	—	—	—	—	8	—	—	1	4	5	7	—
Perforated "disks"	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—
Pendants	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—
Manuports	—	2	1	—	1	2	—	—	4	1	—	—	—	—	—	3
Tarring pebbles	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fire-affected artifacts																
Manos	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Metates	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
Mortars or bowls	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Unclassifiable ground stone	—	1	—	—	1	—	—	—	1	—	—	—	1	—	1	3
Manuports	1	1	—	—	—	1	—	—	—	—	—	—	—	—	1	6
Fire-affected rock	—	—	—	—	—	—	—	—	3	—	—	—	—	—	2	—
Total	7	17	3	3	7	7	86	2	40	43	3	6	69	25	23	38

Table 8.22. Summary of Feature Constituents at LAN-206A

Artifact Class	100	105	106	107
Bifaces	—	—	—	1
Edge-modified pieces	—	1	—	2
Choppers	—	—	—	1
Debitage	9	—	2	—
Manos	—	2	—	1
Metates	—	1	1	7
Hammer stones	—	—	1	2
Unclassifiable ground stone	—	—	—	6
Manuports	1	1	1	3
Tarring pebbles	—	—	—	2
Fire-affected artifacts				
Metates	—	—	1	—
Unclassifiable ground stone	—	—	—	6
Manuports	—	—	1	—
Total	10	5	7	31

Ornaments and Other Artifacts

Sarah J. Van Galder and Kathleen L. Hull

A variety of ornaments and worked bone and shell artifacts made up a small but important part of the West Bluffs artifact collection. In this chapter, shell and stone beads and ornaments, and a variety of worked bone and shell artifacts are documented and discussed. Only a few of these artifacts were identified during the 2000 and 2003 excavations by SRI, compared to the quantities recovered by Van Horn in the 1980s. The majority of the artifacts discussed in this chapter were found at LAN-63. As part of our treatment of these artifacts, we discuss why this may be the case.

Shell Beads and Ornaments

Sarah J. Van Galder

Prehistoric Californians have used shell for ornaments and tools for more than 10,000 years. Shell beads, in particular *Olivella* spp. beads, are one of the most temporally diagnostic artifacts produced by native Californians (Bennyhoff and Hughes 1987). Archaeologists use beads to date cultural deposits and trace trade and exchange relationships. No worked shell was recovered from LAN-64 or LAN-206A during the 2000 and 2003 excavations. Excavations at LAN-63 during 2000 and 2003 yielded a total of 29 worked shell artifacts, including 18 shell beads, 7 shell bead fragments, and 4 pendants. All shell beads and shell bead fragments were made from *Olivella* shell. During the 1980s excavations at the site, Van Horn recovered only six shell beads, five made from *Olivella* shell and one *Oliva spicata* shell. No other worked shell was noted during previous excavations at LAN-63 (Van Horn 1987).

Methods

All worked shell from LAN-63 (26 artifacts) collected during the 2000 and 2003 excavations was examined using an x10 monocular lens. Shell bead classification followed the typology devised by Bennyhoff and Hughes (1987), with amendments for southern California contexts by King (1990) and Gibson (1992). Shell taxa were identified using a type collection and standard field guides (Keen and Coan 1974; McLean 1978; Morris et al. 1980; Rehder 1996). Once identification was complete, the data were entered into a site database. Tables were produced to aid in analysis and data presentation; all worked shell artifacts were photographed for recording and reporting purposes.

Shell Beads

As stated above, all *Olivella* shell beads and shell bead fragments were recovered from two feature contexts at LAN-63: Feature 587, a mortuary feature, and Feature 475, a burial feature. All of the shell bead fragments and 16 of the 18 beads were found in the mortuary feature (Table I.1). The other two beads were found in the burial feature.

Olivella shells were the most commonly used material for beads in prehistoric California, and *Olivella* beads have been recovered in large numbers from archaeological deposits throughout the state (Bennyhoff and Hughes 1987). Several archaeologists have recognized shell beads, particularly *Olivella* beads, as some of the most time-sensitive artifacts available to California archaeologists (Gibson et al. 2003; King 1990; Lillard et al. 1939). As such, these beads are useful in dating cultural deposits.

For both the Gabrielino and the Chumash, shell bead ornaments denoted wealth and status and were conspicuously displayed during ritual and social gatherings. Beads were used as offerings and adorned the dancers during festivals and special rituals, such as the Harvest Ceremony (Librado 1981:48, 85–86) and the Mourning Ceremony (McCawley 1996; Merriam 1955:80–83; Walker 1951). Beads also served as a medium of exchange and as a validation of social and political authority (King 1974:91).

Gamble and Zepeda (2002) suggested in their recent research on the trade network of shell beads across California that the Gabrielino may have acted as go-betweens in shell-bead trade between the Chumash and inland groups such as the Cahuilla and Kumeyaay (see also Gibson et al. 2003). Barker (2002: 20) noted, however, that *Olivella* beads, which dominated the LAN-63 collection, were not used for currency but rather to ornament ceremonial items and baskets.

Olivella Whole-Shell Beads

Whole-shell *Olivella* beads were made from a nearly complete *Olivella* shell by removing the spire or apex and sometimes the basal end as well, which produced a hole perpendicular to the body axis. The apex or spire was removed by grinding or careful chipping, or both. This bead type has been produced and distributed throughout most of California and the Great Basin over a span of at least 7,000 years (Bennyhoff and Hughes 1987; King 1981). Beads made from the smaller shells (less than 6.5 mm in diameter) were most popular during the late part of the Early period, early phases of the Middle period, and again in the early part of the Late period. A large sample is required, however, to make any firm conclusions concerning the preferred shell size and the time period in which the bead was manufactured.

Four whole *Olivella* beads in two bead types were recovered from LAN-63 (Figure 9.1; see Table 9.1). Two of the beads were small spire-removed beads, and two were end-ground beads. Bead dimensions, time periods in which they are most common, and their locations in LAN-63 are listed in Tables 9.1 and I.1. All four of these beads were found in Feature 587. Class A is the simplest kind of bead, made by careful removal of the apex or spire. As stated earlier, these beads have been found in southern California in varying quantities throughout the last 7,000 years. The small bead type present at LAN-63 (Type A1a), however, was most common during the Intermediate period, around 2000 B.P.

Olivella bead Type B2, End-Ground, is similar to the regular spire-removed bead but also has basal grinding (or, rarely, chipping) that removed all of the canal notch and part or all of the folds. The spire end is usually ground perpendicular to the long axis of the shell but sometimes has a slightly oblique ground spire (Gibson 1992). This type is most common in the Early period but also was used throughout the Middle period and Phase 1 of the Late Period (Bennyhoff and Hughes 1987: 121).

Olivella Wall Beads

Wall beads are made from the wall of the *Olivella* shell and are circular to oval in outline with well-ground edges. Two classes of wall beads were present at LAN-63, Saucers (Class G) and Wall Disks (Class J). Bennyhoff and Hughes identified several types of saucers including Ring, Oval, and Irregular Saucers (1987:133). Table 9.1 shows the shell bead types recovered from LAN-63 and their associated time periods; detailed location and metric information is provided in Table I.1. Excavators recovered 14 wall beads from LAN-63, including 5 Normal Saucers, 4 Tiny Saucers, 2 Oval Saucers, and 1 Wall Disk (Figures 9.3–9.4).

Tiny Saucers (Type G1) range in diameter from 2.0 to 5.0 mm, with a perforation diameter between 0.8 and 2.0 mm. This bead type can be found in any time period. King (1990) distinguished two size classes in the Tiny Saucer type: medium wall beads with diameters larger than 3.5 mm and small wall beads less than 3.5 mm in overall diameter. These two sizes of Tiny Saucer can also be found in any time period. Gibson et al. (2003) also noted that perforation diameter is critical to distinguishing the Tiny Saucers made during the Intermediate from those produced during later periods. The Tiny Saucers from LAN-63 had smaller perforation diameters, between 1.1 and 1.5 mm, suggesting that these were produced during the Intermediate period.

Normal Saucer (Type G2) diameter dimensions range between 5.0 and 10.0 mm, with perforation diameters between 1.4 and 2.7 mm (Bennyhoff and Hughes 1987). This saucer-bead type is a marker for the Middle period in southern California and is found most frequently with cultural deposits dating to the early part of the Intermediate period from 2,600 to 1,300 B.P. (Gibson 1992).

Oval Saucers (Type G5) are similar to Normal Saucer beads in size and have an oval shape. Oval Saucer beads have a length and width difference of more than 0.3 mm and often have an off-center perforation (Bennyhoff and Hughes 1987). This bead type is also a marker for the Middle period.

Wall Disk (Type J) beads from southern California are typically smaller than those from the San Joaquin Valley. Bead diameters range in size from 5.0 to 6.0 mm, with perforation diameters between 1.0 and 1.5 mm. The Wall Disk perforation diameters are generally smaller than those of the Tiny or Normal Saucer beads. Wall Disk bead production started during the late Intermediate period or early Late period, and these beads were common between 1,300 and 168 B.P. (Bennyhoff and Hughes 1987; Gibson 1992).

Ethnographic data from the Chumash indicate that *Olivella* wall beads were strung and used as bracelets or necklaces (Gibson 1992). Both saucer and disk beads were high-status items used by elite members of society (Gibson 1992:32; King 1974:91). It is therefore not surprising that all of the shell beads recovered from LAN-63 were found in one of two ceremonial features.

Other Shell Ornaments

Four shell pendants were also recovered at LAN-63 (Figure 9.5; Table 9.2). Three of the pendants were made from scallop or Venus clam shell. Three of these artifacts were found in Feature 587; the *Argopecten* pendant was recovered from Unit 58 (see Figure 6.1)

Discussion

Most of the worked shell was recovered from two features. Only one artifact, a pendant, was recovered outside these features. Gibson (1992) and King (1976) reported that saucer and disk beads, which dominated SRI's sample, are associated with wealth and status among the Chumash and that these beads been recovered from high-status site areas throughout California. Although the Gabrielino inhabited areas south of the Chumash and did not have a complex chiefdom as did the Chumash, the Gabrielino too associated status with beads (McCawley 1996). For this reason, it was not surprising that most of the beads at West Bluffs were found in ceremonial or mortuary features, which typically reflect the status and wealth of the deceased.

SRI recovered 19 of the 22 worked shell artifacts, including 16 of the 18 beads, from Feature 587, a dense concentration of artifacts and shell, including FAR, flaked and ground stone, large mammal bone, isolated pieces of burnt human bone, and possibly unburnt, human bone. Most of the worked shell was recovered in the most concentrated part of the feature in Units 207, 209, 210, and 211. Feature 587 was likely a mortuary feature containing the remains of the Mourning Ceremony. Excavations at the Chatsworth Cairn site, Malaga Cove site, Big Tujunga Wash, and a site on San Clemente Island revealed mortuary features with very similar characteristics as Feature 587 (Eisentraut 1990; Meighan 1983; Walker 1951:102–116). The eight-day Mourning Ceremony was performed every one to four years, usually in August or October, to mourn those who had died since the last such ritual (McCawley 1996; Merriam 1955:77–85). During the ceremony, mourners offered gifts to show their devotion to the memory of the dead and often including food, clothing, baskets, and beads. Additionally, the baskets and poles used for the ceremony were also decorated with beads and crow feathers (McCawley 1996; Merriam 1955:77–85). Given this description, it is not surprising that many shell ornaments, particularly beads, were recovered from this feature.

Feature 475 was a partially disarticulated burial of a 4–5-year-old child that dated to the late Intermediate period. A steatite object and two beads (one saucer and one disk bead) were recovered from this feature. This feature produced slightly later dates than other site areas. The Gabrielino often sent off the dead with their own belongings or gifts showing wealth and status.

One pendant made from a calico scallop was found in Unit 58. Fire-affected rock and ground stone fragments were also recovered from this unit. There was no evidence that this area was used for ceremonial or mortuary purposes, however, as was the case with both the mortuary and burial features.

As stated earlier in this chapter, Van Horn (1987) recovered only six shell beads during excavations in the 1980s, surprisingly few given the extensive excavations conducted. This low number may be due to the lack of burial or ceremonial site areas discovered or excavated at that time. Van Horn reported 15 features, most of which were rock concentrations with a few associated artifacts, and none held shell beads or ornaments. The units in which the shell beads were recovered were not reported.

Radiocarbon dates from the two features in which most of the beads were found corresponded well with the dates of the bead types. Based on radiocarbon results, Feature 587 (a mortuary feature) dated between 1670 and 1290 B.P., Feature 475 (a child burial) dated between 1410 and 1060 B.P., and most of the *Olivella* beads in the features dated to the Intermediate period.

In summary, then, all of the beads from LAN-63 were made from Olivella shell and were either whole-shell or wall bead types. Overall, the bead-based chronology agrees with the radiocarbon dates from the site. Most of the types were produced at some time during the Intermediate period. All worked shell, except one scallop pendant, was recovered from two features. Both were ceremonial—a burial and a large mortuary feature—rather than utilitarian, such as hearths or refuse pits. Based on radiocarbon dates and the shell types in these features, the mortuary feature was slightly older than the child-burial feature. The burial contained one wall disk, a type which was not likely produced until the late Intermediate period or the Late period.

Worked Bone

Sarah Van Galder

Very little worked bone was recovered from the West Bluffs sites during the 2000 and 2003 excavations. Twenty-two worked-bone fragments were recovered from LAN-63, two from LAN-64, and none from LAN-206. During excavations in the 1980s, however, archaeologists recovered 294 worked-bone tools or tool fragments from LAN-63, including 261 pointed bone tools, 3 gorges, 5 compound fishing hooks, 1 atlatl spur, 13 drilled or decorated bone artifacts, and 11 unidentifiable worked-bone fragments. A total of 16 worked-bone artifacts were recovered from LAN-64, including 14 pointed bone tools, 1 compound hook barb, and 1 drilled bone item (Van Horn 1987). No bone artifacts were reported in Van Horn and White's 1997 report on LAN-206.

Methods

All worked bone from SRI's 2000 and 2003 data recovery excavations were examined for this analysis. Each artifact was measured, the bone was identified to the species level (if possible), patterns of modification and tooling were described, and the artifacts were described. Drawing on analogs from other artifact studies, form and possible function were assigned to those artifacts with sufficient components or characteristics to make a complete or nearly complete article. Once identification was complete, the data was entered into a site database. Tables were produced to aid in analysis and data presentation and photographed all worked bone artifacts for recording and reporting purposes.

Results

LAN-63

This site contained 19 worked bone fragments: 14 pointed tool fragments, 1 wedge tool fragment, 1 drilled pendant fragment, 2 bones covered with asphaltum, and 4 bone artifacts that showed cutmarks, polishing or grinding (Table 9.3).

Eight of the worked bone fragments were recovered from Feature 587, a large mortuary feature, and included a drilled pendant fragment (Figure 9.6), a large-mammal rib covered with asphaltum, and six large-mammal bone pointed tools (Figure 9.7). The function of the asphaltum-covered rib was unclear. Asphaltum was used ethnographically as a glue, as waterproofing, and to make small handles for awls (Blackburn 1963). The small pendant fragment was partially blackened and retained half of a drilled perforation, 3.2 mm in diameter. Likely, this pendant was worn as a decoration.

In California, as elsewhere, pointed bone tools have been used in a variety of activities, including basketry (as awls), sewing (as needles), fishing (hooks and gorgets), hunting (bone points or darts), and stone tool production (pressure flaking tools) (Blackburn 1963). Because pointed bone tools can be used in so many ways, it can be impossible to identify the particular task or tasks for which a tool was used, especially if only fragments were recovered and no use-wear was preserved. The pointed bone tool fragments found in Feature 587 were larger than tools typically used for basketry or sewing. All six were made from large-mammal bone, showed burn damage, and had blunt ends. Three were completely calcined, one was completely blackened, and one was partially calcined. The blunt ends might have indicated that these tools were used for pressure flaking. Because of weathering and the lack of use-wear on these tools, however, it was not clear if the very tips of these tools were broken off and discarded or if these tools had been used with blunt ends. Large-mammal bone pointed tools were recovered only in Feature 587; large-mammal-bone tools were not found elsewhere on the site, and none of the smaller pointed tools were recovered from this feature.

The remaining 14 worked-bone fragments were from a variety of site contexts, including features and units, and lacked a pattern in their distribution across the site. Nine of the 14 were pointed bone tools (Figure 9.8). One possible fish gorget fragment was recovered from an excavation unit (catalog no. 10035). This tool had one pointed end and a bowed shaft; the other end, likely another pointed end, was missing. This tool also showed possible evidence of fine-cordage indentation around the middle of the artifact. Four small cylindrical bone points were probably used as awls or needles. Two of these were from feature contexts and two from different excavation units. One showed the twisting use-wear marks typical of basket-making tools (Shelley, personal communication 2005). Of the three small fragments of medium-sized split-bone pointed tools, two were badly weathered, and none showed use-wear; consequently, their functions were unknown.

One wedge-shaped bone tool fragment was recovered from a burial feature (Feature 475) (Figure 9.9). This tool had use-wear striations both parallel to the length of the tool and diagonally. A midsection of an awl or pointed bone tool was recovered from (Unit 55) and was partially calcined with evidence of polish. Two worked-bone fragments showed evidence of cut marks or grinding. One showed very small cut marks that appeared decorative, rather than the result of butchering or use-wear. The other fragment had marks that might also have been decorative, but were a little wider and looked ground rather than cut.

LAN-64

Only two worked-bone fragments were recovered from LAN-64 during the 2000 and 2003 excavations (see Table 9.3). These included one calcined pointed tool, probably an awl, made from a metapodial of a large-mammal, and a completely calcined ground and polished rib of a medium-size mammal. Neither of these items was recovered from a feature context.

Discussion

Worked-bone tools provide little time-relevant information. Many of the basic bone-tool types were used throughout prehistory in many different regions.

It is interesting that there was such a large discrepancy between the quantities of worked bone found during excavations in the 1980s compared to those found during SRI's 2000 and 2003 excavations at both LAN-63 and LAN-64. This discrepancy may be at least partly due to different excavation and research strategies. The research results from the 1980s excavations reflected mostly nonfeature contexts. Archaeological Associates conducted extensive hand excavations, including 49 (1-by-1-m) hand-excavated units, and found 15 features in a variety of contexts at LAN-63. In addition to these areas, Archaeological Associates excavated 8 trenches, including 9 "wedges," and 163 1-by-1-m units. All excavated sediments from these areas were screened. None of the 15 features contained any bone tools. Those bone artifacts with reported locations were found in excavation units (DiGregorio 1987). DiGregorio (1987) noted that 80 percent of the bone tools were recovered from the top 50 cmbs.

A few hand-excavation units, related to the mortuary feature, were excavated during SRI's 2003 excavations, and 56 hand units were excavated at both LAN-63 and LAN-64 during the 2000 excavations. The number of nonfeature contexts excavated in the 1980s far exceeded that of the 2000 and 2003 field seasons combined. Excavations during the 2003 season, particularly, focused on features and isolated finds easily visible to archaeological monitors who followed the graders that stripped sediments across the site 10 cm at a time. Twelve of the bone artifacts were recovered from feature contexts and nine from nonfeature contexts.

It may be that bone tools were not typically disposed of in feature contexts, particularly the rock concentrations and hearth features that dominate the feature types at LAN-63. The reason fewer numbers of tools were recovered during the 2000 and 2003 field seasons might have been due to the focus on recovering features, particularly during 2003. The feature that contained the most worked bone from these excavations was a mortuary feature, a ceremonial feature where we would expect to find more tools and decorative items that might have been used or sacrificed during the ceremony. Even allowing for these differences in research strategies, however, we expected more than seven worked-bone artifacts from the 56 units excavated during the 2000 field season.

Lithic Ornaments

Kathleen L. Hull

Methods

All lithic ornaments from SRI's 2000 and 2003 data recovery excavations were analyzed. Each artifact was measured and described, the material type was identified, and patterns of modification and tooling were examined. Form and possible function was assigned to artifacts, based on analogies from other artifact studies. Once identification was complete, the data was entered into a site database. Tables were produced to aid in analysis and data presentation, and all worked shell artifacts were photographed for recording and reporting purposes.

Results

LAN-63

Stone Beads

The 13 stone beads recovered from LAN-63 consist of 1 cylindrical bead, 11 round disk beads, and 1 disk that was heptagonal in plan view (Figure 9.10; Table I.2). Recovered from Feature 587, the heptagonal disk (Figure 9.11) had undulating, rather than flat, faces and a biconical central perforation 2.5–4 mm in diameter. The cylindrical bead from this same feature (Figure 9.12) also had a biconical central perforation approximately 5 mm in diameter. The remaining 11 round disk beads were conically drilled from a single surface, with hole diameters from 1.6 to 2.2 mm. The diameter and perforation size of 10 of these beads were consistent with Type IA1c defined by Rigby (1987:10); the eleventh bead was Type IA1b (Rigby 1987:9). Regional chronologies suggest that both of these types dated to ca. 2750–2150 B.P. (Rigby 1987).

Most of the beads at LAN-63 were rectangular in cross section with flat faces, although one piece was roughly triangular, as the faces converged on one side of the bead circumference. Twelve of the beads were slate, with colors ranging from black opaque to translucent ivory. These specimens ranged from approximately 4 to 7 mm in diameter and 1 to 2 mm thick. The cylindrical bead, however, was of undetermined stone, with some red residue visible on the surface. This bead was also somewhat larger.

Stone Effigies

A siltstone phallic effigy (catalog no. 772; Figure 9.13) was recovered from Feature 18. This piece was 84 mm long, 56 mm wide, and 50 mm thick, with striations from shaping visible on the surface. In addition, there were several deeper gouges on the piece that might have related to use or postdepositional damage.

Stone Pendants

Five items were identified as pendants, and one additional artifact might have been a pendant fragment. Only one of these objects was recovered from a feature; the others were point-provenienced artifacts. The specimen from Feature 20 (catalog no. 937) was an oblong pendant of steatite 98 mm long, 49 mm wide, and 17 mm thick. It had a 7–8-mm-diameter biconically drilled hole near one long edge. Two other steatite pendants were also oblong ornaments with a single perforation near one long edge. The proximal fragment (catalog no. 1841) had a biconical hole 1–2 mm in diameter, whereas the nearly complete specimen (catalog no. 1851) had a conical perforation 10–17 mm in diameter. The latter ornament was approximately 121 mm long, 63 mm wide, and 13 mm thick. The remaining pendants include one triangular piece (catalog no. 1849) and a rectangular specimen (catalog no. 1842), both of which were of slate. Both had a single biconical perforation, with the former ranging from 1.5 to 6 mm in diameter and the latter ranging from 3 to 5 mm in diameter. The latter piece (Figure 9.14) also had incised, diamond cross hatching, whereas the former piece, made from a waterworn cobble spall, lacks decoration. The possible distal pendant fragment (catalog no. 1846; Figure 9.15) was a steatite piece with a longitudinal zig-zag pattern on the faces and two parallel incisions perpendicular to long axis at the distal end of the piece. This artifact was 59 mm long, 58 mm wide, and 13 mm thick. Red residue, perhaps blood, was present on both faces, and by the discoloration of the core, the artifact also appeared to have been exposed to high heat. This assemblage was consistent in terms of material, size, shape, technology, and decoration with pendants previously recovered from LAN-63 (DiGregorio 1987) and other nearby sites (see DiGregorio 1987:180).

LAN-64

Stone Beads

Thirty-three stone beads were recovered from LAN-64, including eight from Feature 52, one from Feature 62, four from Feature 64, five from Feature 65, seven from Feature 66, five from Test Pit 1009, and three point-provenienced artifacts (Table I.3). Nearly all were slate. All but one of these ornaments were disk beads (Figure 9.16), ranging from just 3.5 to 5 mm in diameter (mean = 4.05) and 1 to 2 mm thick (mean = 1.18). Twenty-one had a conically drilled perforation 1–2 mm in diameter. The remaining disk beads were biconically drilled, with perforations of roughly similar range of diameters. Most beads were round in plan view and rectangular in cross section, but a few were triangular in cross section, with convergent faces. The small size of all these beads was consistent with Rigby's (1987) small class, and the variation in the minimum size of the perforation indicated that 1 Type IA1a, 26 Type IA1b, and 5 Type IA1c beads were represented. The beads of stone other than slate include the Type IA1a and two Type IA1b beads. As noted by Rigby (1987), all of these types evidently dated to ca. 2750–2150 B.P.

The remaining bead (catalog no. 273; Figure 9.17) was a roughly tubular ornament of granitic rock. This piece had rounded ends, an irregular cross section, a biconical perforation, and was much larger than other tubular stone ornaments recognized by Rigby (1987) in the previous collection from this site.

Stone Palette

A nearly complete steatite palette (catalog no. 353; Figure 9.18), 150 by 90 mm and 17 mm thick, was recovered as a point-provenienced artifact not associated with any feature. This piece was incised with straight lines on both faces, with predominant diamond cross-hatching in the area along the longitudinal axis. Square cross-hatching was present in more-peripheral areas of the piece, and other parallel lines appear throughout the specimen.

Stone Pendants

Two items were pendants, with one complete oblong pendant of steatite from a nonfeature context (catalog no. 22) and a fragmentary pendant of metasedimentary stone (catalog no. 31) (Figure 9.19) from Feature 65. The latter was 29 mm long, 16 mm wide, and 8 mm thick, with a biconical perforation at one end that was 3–5 mm in diameter. There were multidirectional striations on one face and reddish streaks in the interior of the stone. The other pendant was 18 by 6 mm and 3 mm thick, with shallow, parallel, diagonal, decorative incisions on one face.

Discussion

Overall, the distribution of lithic ornaments were from specific contexts. For example, stone beads from both LAN-63 and LAN-64 were primarily from mortuary contexts, either burials (in the case of LAN-64) or a large mortuary feature (Feature 587, LAN-63). None of these stone beads were identified in the field as being part of strands, but, rather, were found in feature fill. It was possible, especially in the case of the small stone beads from LAN-64 (from burial Features 52, 62, and 64–66), that these beads were disturbed from their original context by rodent burrowing. Given the clustering of burials with beads from LAN-64 (all the burials in this area save Feature 32 contained small slate beads), it was possible that all of these burials were somehow related, given the similar grave goods. The typology suggested that the beads (Types IA1a and IA1b) were all contemporaneous, ca. 2750–2150 B.P., in the Intermediate period, which roughly corresponds with radiocarbon assays from specific contexts across both sites. This pattern of stone ornaments found mostly in mortuary or burial contexts was recognized for worked shell and bone also. It is clear that grave goods in the Intermediate period were as varied and carefully designed as those described for the ethnographic Gabrielino thousands of years later.

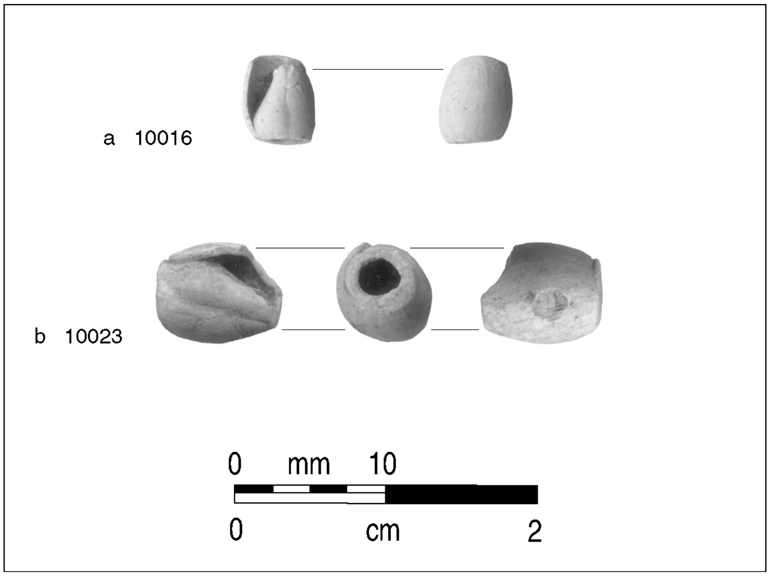


Figure 9.1. Whole Olivella beads: Classes A1a and B2 from LAN-63.

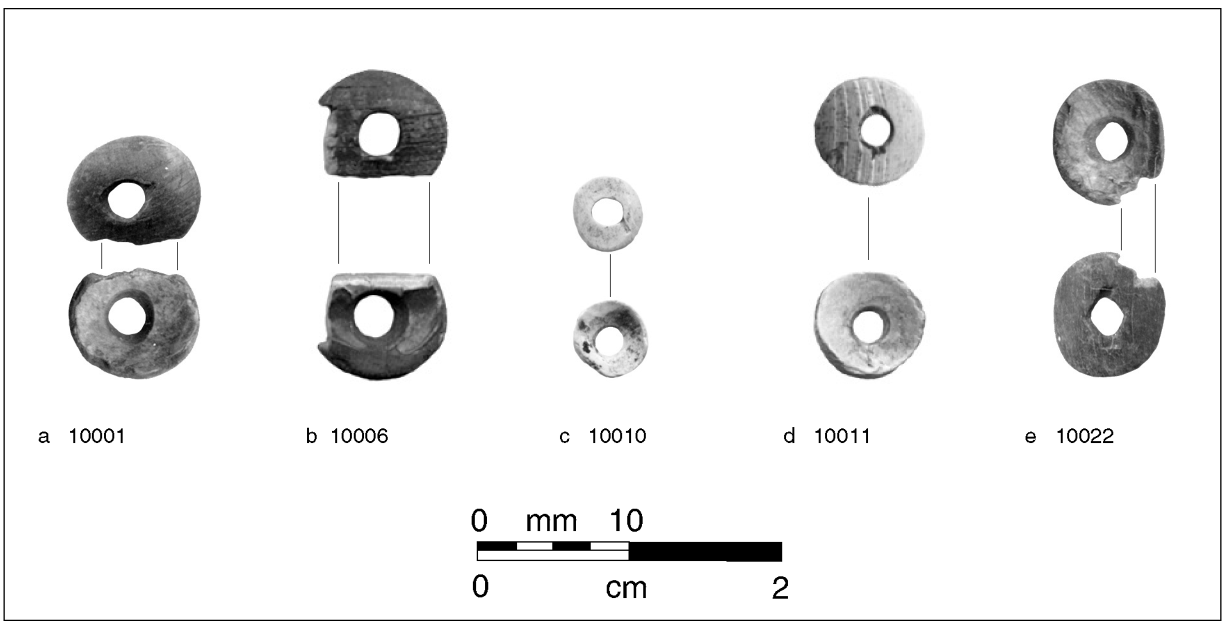


Figure 9.2. *Olivella* wall beads from LAN-63.

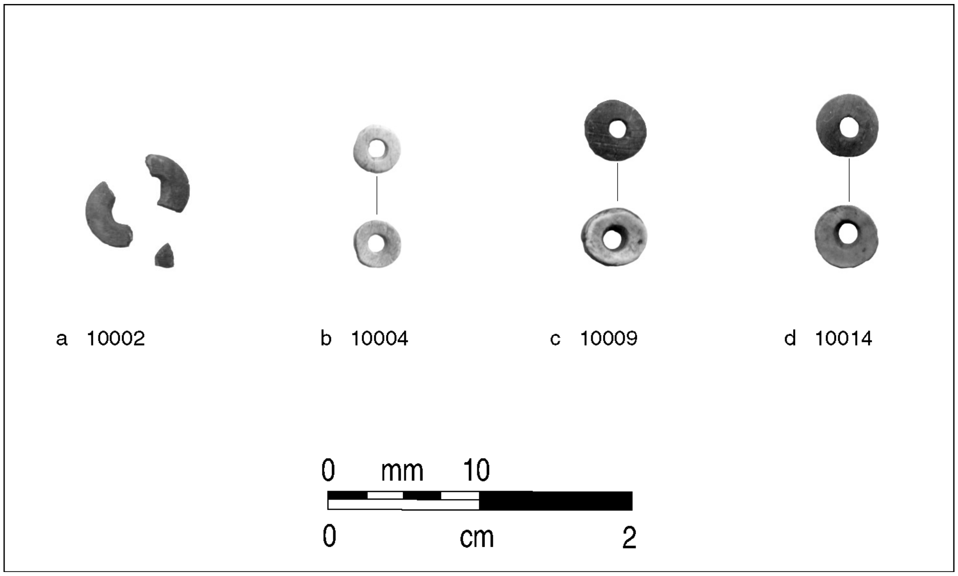


Figure 9.3. *Olivella* wall beads from LAN-63.

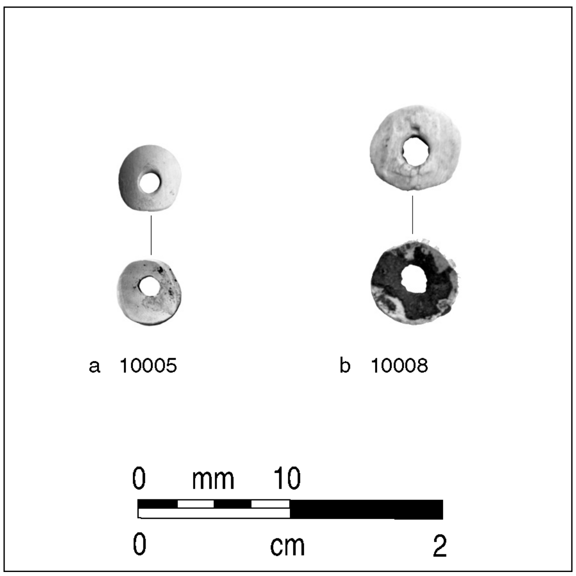


Figure 9.4. *Olivella* wall beads from LAN-63.

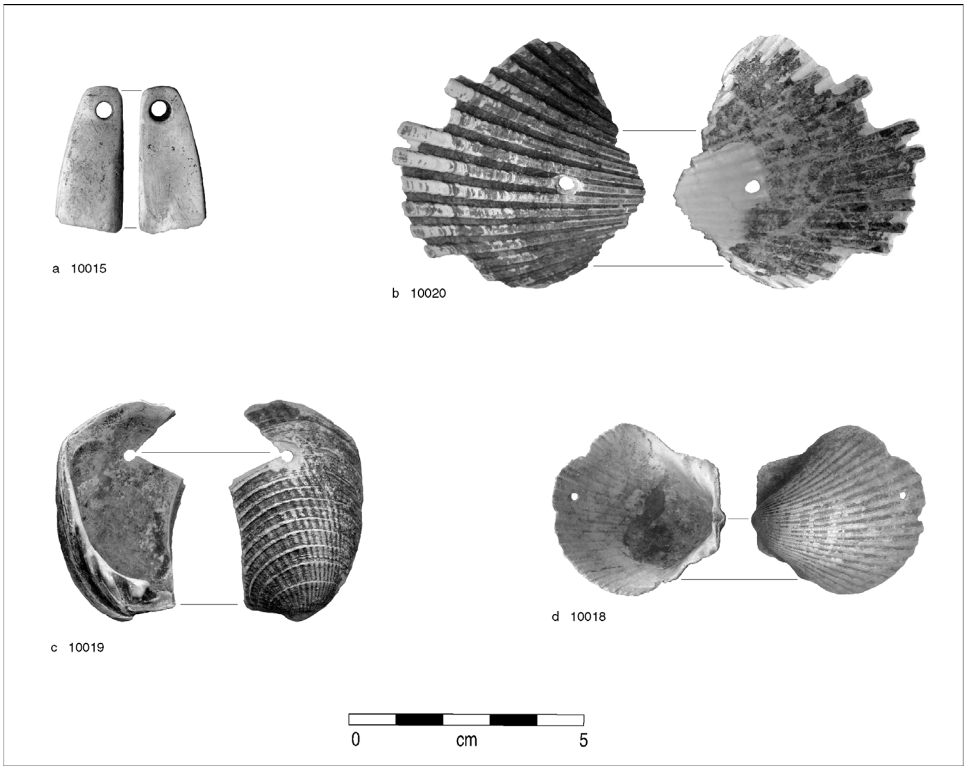


Figure 9.5. Shell pendants from LAN-63.

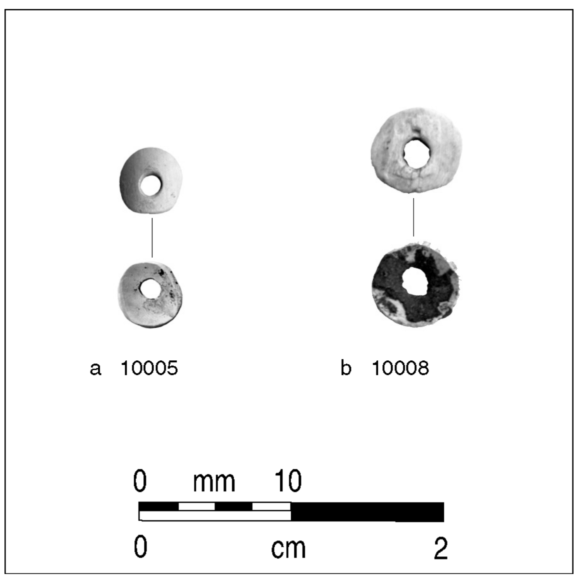


Figure 9.6. Drilled pendant fragment from Feature 587, LAN-63.

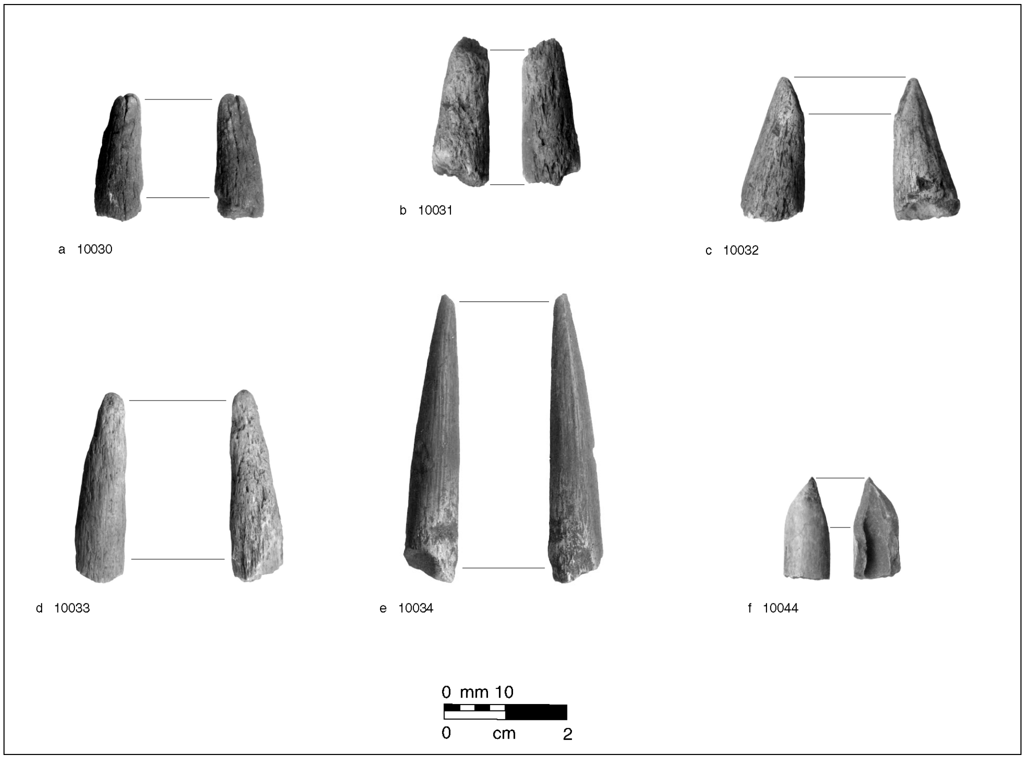


Figure 9.7. Pointed bone tools from Feature 587, LAN-63.

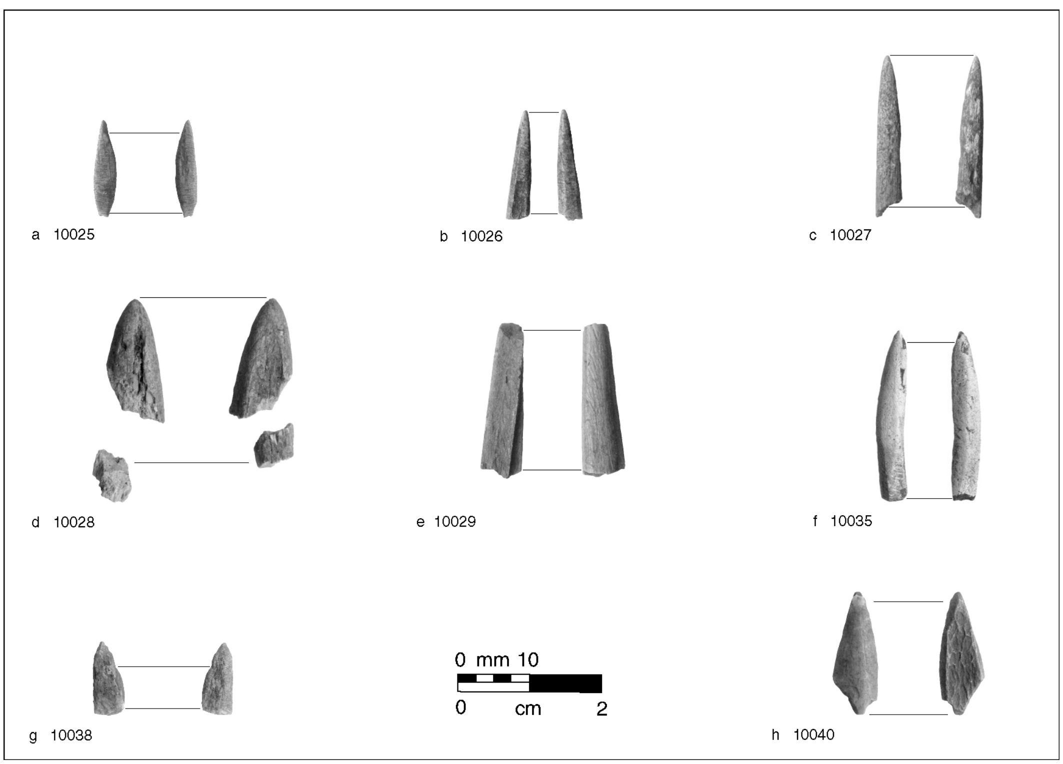


Figure 9.8. Pointed bone tools from a variety of site contexts at LAN-63.

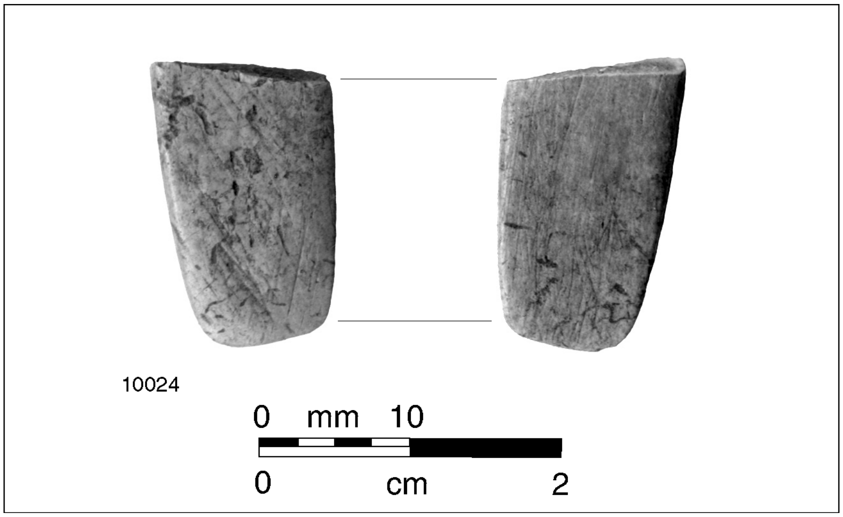


Figure 9.9. Wedge-shaped bone tool from Feature 475, LAN-63.

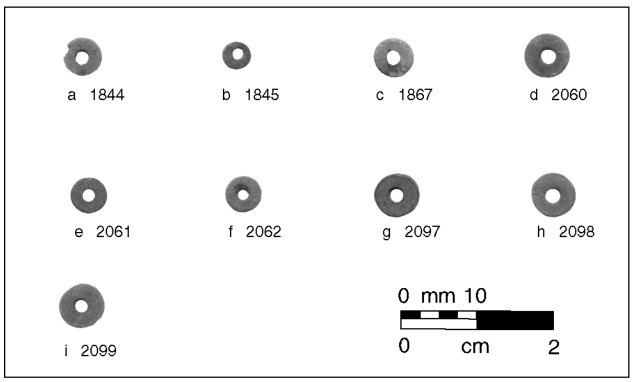


Figure 9.10. Stone disk beads from LAN-63.

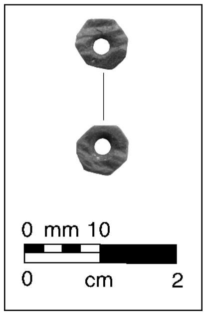


Figure 9.11. Heptagonal stone bead (catalog no. 1850) from LAN-63.

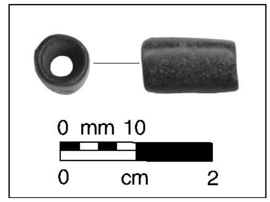


Figure 9.12. Cylindrical bead (catalog no. 1066) from LAN-63.

Figure 9.13. Phallic effigy (catalog no. 772).

Figure 9.14. Pendant (catalog no. 1842).

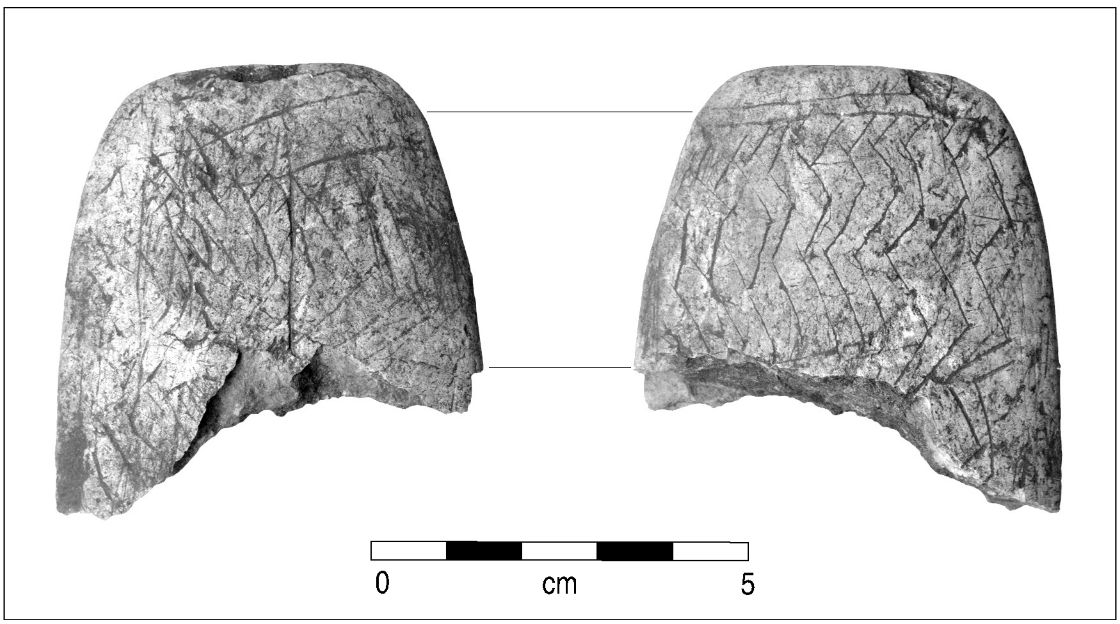


Figure 9.15. Pendant (catalog no. 1846).

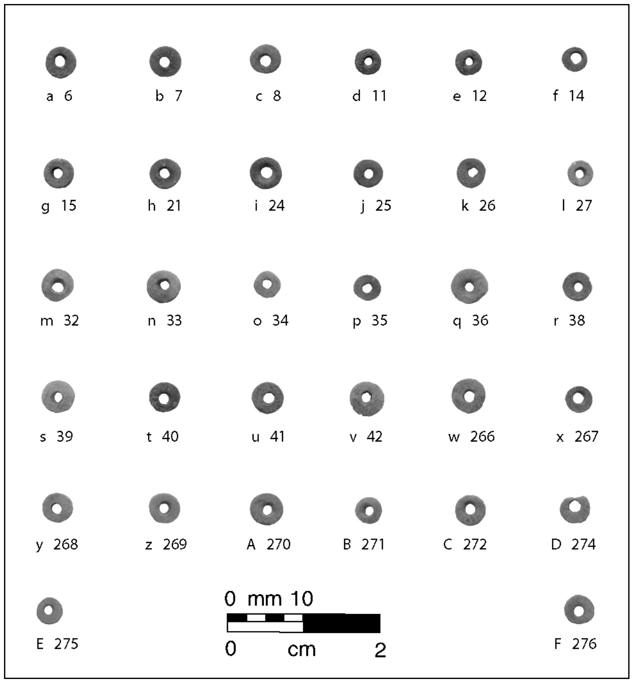


Figure 9.16. Stone disk beads from LAN-64.

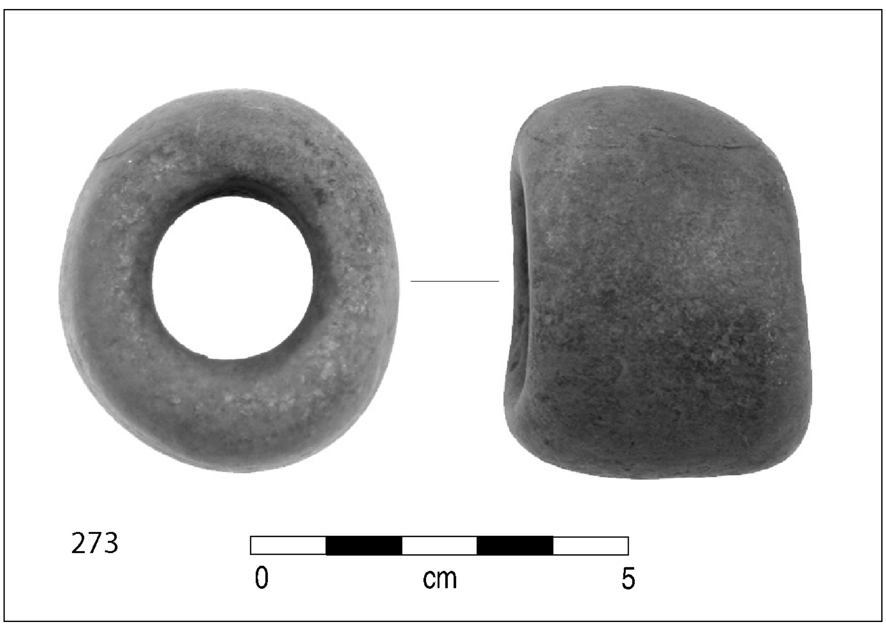


Figure 9.17. Large tubular ornament (catalog no. 273).

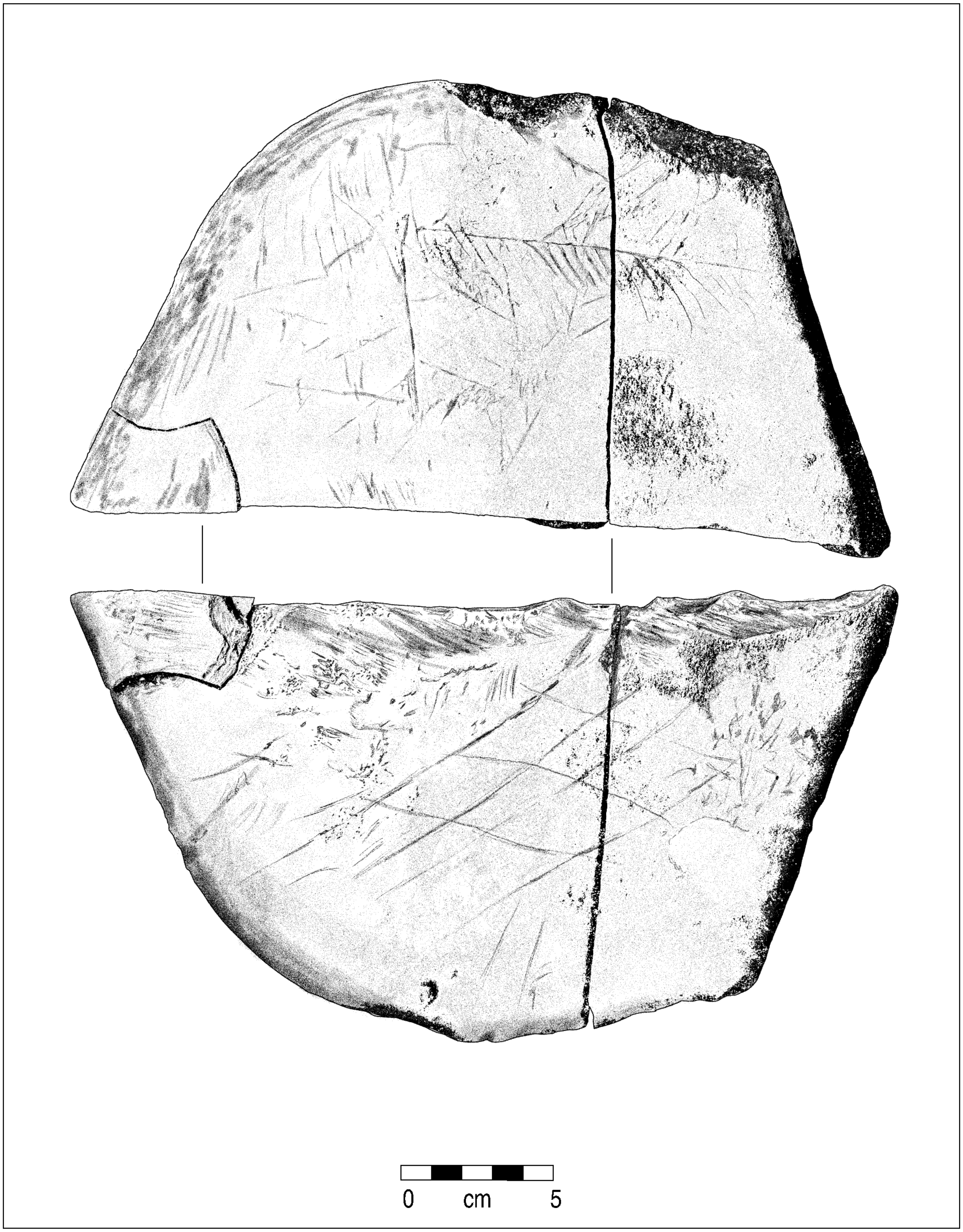


Figure 9.18. Stone palette (catalog no. 353).

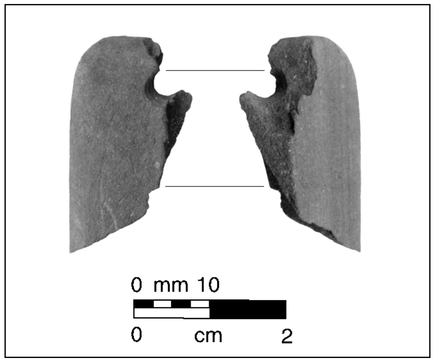


Figure 9.19. Pendant (catalog no. 31).

Table 9.1. Summary Data for Typed Olivella Beads from SRI's Fieldwork at LAN-63

Bead Type	n	Diameter (mm)	Thickness (mm)	Perforation (mm)	Date Range (Time Period)
Spire-removed Small (A1a)	2	4.5–6.4	—	1.0	All time periods
End-ground (B2)	2	4.9	—	2.0	Most common in Early period and Phase 1 of Late period, but used throughout the Middle period also
Tiny Saucer (G1)	4	3.1–4.3	0.9–1.2	1.1–1.5	All time periods; most common A.D. 700–1782 (M4–L2)
Saucer (G2)	5	5.2–8.8	0.8–1.5	1.9–2.5	Throughout Middle period, most common 600 B.C.–A.D. 700 (M1–M3)
Oval Saucer (G5)	2	5.5–8.2	0.8–0.9	2.0–2.5	Middle period
Wall Disk (J)	1	5.0	0.8	1.0	A.D. 700–1782 (M4–L2)

Note: All measurements in millimeters. Types from Bennyhoff and Hughes (1987); date ranges from Bennyhoff and Hughes (1987) and Gibson (1992).

Table 9.2. Pendants Recovered from LAN-63

Catalog No.	Provenience	Taxa	Length	Width	Thickness	Comments
10015	F 587	Veneridae	31.0	15.0	3.5	Conical perforation, distal portion broken off
10018	F 587, U 210, L 3	*Pecten* sp.	36.0	36.0	0.9	Punched perforation
10019	F 587, U 209	*Chione californiensis*	57.0	34.0	2.9	Punched perforation
10020	U 58, L 2	*Argopecten circularis*	56.0	55.0	1.0	Punched perforation

Note: all measurements in millimeters.

Table 9.3. Worked Bone

Worked Bone Type	Catalog No.	Provenience	Length (mm)	Width (mm)	Thickness (mm)	Comments
LAN-63						
Wedge	10024	F 475	18.5	11.2	0.2	
Point tip	10025	U 32 L 5	13.9	3	3	
Point tip	10026	F 449	15.5	3	2	
Point tip	10027	U 35 L 6	22.3	3.8	3.2	
Point tip	10028	Survey	17	8	4.5	
Point	10029	F 412	19	4.5	3.5	
Point tip	10030	F 587, U 208, L 2	19.1	7	7	calcined
Point	10031	F 587 U 216 L 2	24	9.8	9.5	calcined
Point tip	10032	F 587 U 214 L 4	23.2	10	9.9	calcined
Point tip	10033	F 587 U 229 L 2	31.1	8.2	8	calcined
Point tip	10034	F 587 U 208	48	8.6	8.2	calcined
Point tip	10035	U 54 L 1	21.4	3.8	3.5	calcined
Pendant	10036	U 205 L 7	12.2	7.6	1.8	partially blackened
Point tip	10038	F 567	10.3	4.4	2.5	
Modified bone	10039	F 587 U 214 L 4	4	8.5	7.5	asphaltum, cut marks
Point tip	10040	U 5 L 4	17.2	6.5	1.2	partially calcined
Modified bone	10041	U 55 L 5	25	8.9	6.2	calcined, polished bone
Modified bone	10042	U 12 L 5	10	3.9	1	cut marks, possibly decorative
Modified bone	10043	F 512	—	—	2.2	5 fragments, cut marks, possibly decorative
Point tip	10044	F 587 U 210 L 7	16.5	7.3	4.5	partially blackened
Point tip	10045	U 36 L 8	15	4.8	3.4	
Modified bone	10046	U 36 L 8	7.2	5.8	0.6	asphaltum
LAN-64						
Point tip	10001	U 1009 L 3	—	—	—	calcined
Modified bone	10002	Point provenience	28	7.9	1.2	calcined, polished bone

Note: F = feature; L = level; U = unit.

Chapter 10

Vertebrate Faunal Remains

Sarah J. Van Galder, Kenneth W. Gobalet, Steven D. Shelley, and David Maxwell

Vertebrate faunal assemblages consist of faunal remains that are present as a result of natural or anthropogenic processes. For the West Bluffs sites, we use recovered faunal materials to address questions pertaining to prehistoric subsistence practices in the Ballona region, including what animals occupants used as food sources, how these animals were prepared and processed, the seasonality of site use, formation processes affecting the site collection, and the past environments of the region. We address these topics for the faunal collections recovered from LAN-63, LAN-64, and LAN-206A during the 2000 and 2003 excavations.

This chapter is organized into two parts. The first part analyzes vertebrate faunal remains from LAN-63, LAN-64, and LAN-206A. We begin with a discussion of the descriptive and analytical methods used to study the vertebrate remains, followed by descriptions of remains from each site. Within these descriptions, we offer intrasite comparisons, which focus on different site contexts, in order to investigate different use areas. The second part of this chapter compares the results from the investigations at the West Bluffs sites to other sites in the Ballona. We review the patterns at other sites within the Ballona region and discuss LAN-63 and LAN-64 within the context of the Ballona in terms of both their spatial and chronological position. Our analysis of the materials from LAN-63 is also compared with the analysis of materials recovered by Van Horn in the 1980s from this same site.

Analytical Methods

Both fish and nonfish vertebrate remains were selected for analysis from a sample of features and units that contained high densities of faunal material. Varying percentages of the nonfish vertebrate faunal remains were analyzed from ⅛-inch-mesh and larger screens. Fish bones were analyzed from all screen sizes from features and units with a high density of faunal material. At LAN-63, 25 percent of the faunal materials from sampled contexts that contained more than 20 bones or bone fragments were analyzed; all of the faunal materials from sampled contexts that contained fewer than 20 bones were analyzed. At LAN-64, 50 percent of the faunal remains from the sampled contexts that contained more than 20 bones were analyzed; all bones were analyzed in contexts with fewer than 20 bones. All of the faunal remains from LAN-206A were analyzed because the sample size was so small. The counts in the tables of this chapter were adjusted to compensate for the percentage of sample bone. For example, the bone count for a feature in which only 25 percent of the bone was analyzed was multiplied by four to get a more accurate idea of how many bones are expected to have been recovered from the feature.

Faunal analysis has been previously conducted at several sites in this region as part of SRI's ongoing research in other parts of the Ballona (Maxwell 1998a, 1999a, 1999b, 1999c, 2000, 2003a). To maintain comparability and consistency, we applied the same methods of identification, description, and analysis. These are discussed in detail below.

Identification and Taxonomic Abundance

Analysts identified each specimen to as specific a taxonomic level as possible. Whenever possible, specimens were identified to genus and species. In addition, skeletal elements were identified to the specific portion of the element present and the side of the body from which the element came. Unidentifiable specimens included fragments lacking recognizable features such as muscle attachments or articular surfaces. Identification proceeded by referencing comparative collections housed in Simon Fraser University in Burnaby, British Columbia, and SRI in Redlands, California, and published identification guides including Cohen and Serjeantson (1996), Olsen (1979b, 1979c), Gilbert et al. (1996), Brown and Gustafson (1979) for mammals and birds; Gilbert (1990), Hildebrandt (1955), Lawrence (1951), Olsen (1968, 1973, 1979a), Schmid (1972) for reptiles and amphibians; and Hillson (1986) and Zweifel (1994) for teeth.

Fish identifications were made by Jereme Gaeta, Eric Schaad, and Ken Gobalet using the comparative collection in the Department of Biology at California State University, Bakersfield. The rationale for many of these identifications is provided in Gobalet and Jones (1995), Gobalet (2000) and Gobalet et al. (2004). Illustrations in Eschmeyer et al. (1983) assisted in the identification of elasmobranch teeth. Other reference guides included McGinnis (1984) and Moyle (2002) for freshwater fish; and Skinner (1962), Miller and Lea (1972), Fitch and Lavenberg (1968, 1971, 1973), Gotshall (1977), Eschmeyer et al. (1983), Dewees (1984), Goodson (1988), Love (1996), Leet et al. (1992, 2001), Love et al. (2002), and Ebert (2003) for marine species.

Quantification was limited to the number of identifiable specimens (NISP), owing to the problems associated with calculating minimum numbers of individuals (MNI) for vertebrate remains (Abe et al. 2002; Grayson 1981, 1984; Pilgram and Marshall 1995; Ringrose 1993, 1995).

Size Classes

Each mammal bone or bone fragment was assigned to one of four body-size classes. The size classes used for this study are (1) large, indicating body size similar to a deer or larger; (2) medium, ranging from jackrabbit to coyote; (3) small, encompassing larger rodents through cottontails and skunks; and (4) very small, including smaller rodents and other microfauna such as insectivores. These estimates are nonmetric in nature and based on “eyeballing” the specimen for robusticity (i.e., thickness, density) and dimensions. Unidentifiable materials allow for overlap; so, specimens may be described as “medium-sized to large” and so forth.

Taphonomy and Formation Processes

Formation processes (Schiffer 1976, 1983, 1987), including taphonomic factors, are well known for transforming archaeological assemblages. In this study, we considered weathering, burning, fragmentation, mineral staining, butchery marks, gnawing, root etching, and caliche coating. Taphonomic data was recorded for all terrestrial fauna analyzed but only for a portion of the fish remains due to the use of analysts unfamiliar with recording these data.

Weathering

The degree of weathering reflects differences and similarities in the depositional histories of different specimens and assemblages, particularly with regard to the duration of surface exposure prior to burial.

We used the weathering stages outlined by Behrensmeyer (1978), which provided a well-known comparative standard, even though they were developed to describe patterns of diagenesis noted for large-bodied African animals rather than the patterns of weathering affecting small animals from coastal southern California. Therefore, these stages were used on a descriptive basis only, and we did not assume they can be used to estimate the duration of exposure prior to burial (see Lyman and Fox 1989; Potts 1988). Further, there are no published descriptions of weathering stages for any nonmammalian species; thus, even though weathering was frequently noted on the bones of birds and reptiles, there are no criteria for describing these patterns. In this study, birds and reptiles were classified in the same descriptive stages as mammals. This allowed for the assessment of weathering damage to the entire collection, rather than just the mammalian portion.

Burning

Like weathering, the burning of bone has received considerable attention (Lyman 1994; McCutcheon 1992; Nicholson 1993; Stiner et al. 1995). Burning, however, is perhaps even less well understood than bone weathering, and its interpretation can be problematic. Szuter (1991) argued that patterns of burnt bone at Hohokam sites in southern Arizona—with burning present primarily on the extremities of long bones—reflect the roasting of whole rodents. Bone can also be burnt naturally when archaeological deposits are exposed to wildfires (Maxwell and Shelley 2003).

For the present study, bone was classified as either unburnt or burnt. Burnt bones are further classified into the following categories:

> **Blackened:** The entire specimen has been exposed to heat sufficient to turn it black, similar to charcoal. This is suggestive of exposure to low heat (240–440°C).
>
> **Calcined:** The specimen has been exposed to heat sufficient to turn at least part of it white or gray, and the bone frequently takes on a chalky consistency. Calcination requires exposure to heat higher than 500°C for at least five minutes.
>
> **Partial:** Part of the bone is blackened but other parts remain unburnt. Partial blackening may result from partial exposure of the specimen, possibly during roasting or similar activities.

Bone Completeness and the Fragmentation Index

In mainland southern California, rodent burrowing and historical-period agricultural practices frequently disturb the upper levels of archaeological sites, and bone collections are typically highly fragmentary. The fragmentation index (FI) has been developed as a means of assessing the degree of bone breakage present in a collection (Maxwell 1998b, 1999c, 2003a). Fragmentary bone is described as a percentage of the originally whole specimen: a complete specimen is given the value of 1.0, whereas a minute fragment is classified as 0.1; all other specimens fall within this continuum. FI is calculated as follows:

$$FI = (\Sigma c/f)100$$

where c is the numeric degree of completeness (e.g., 0.3 or 30 percent), which varies between 0.1 and 1.0, and f is the number of fragments.

The degree of completeness (c) of each specimen was estimated during initial examination, the c values were totaled, and the sum was divided by the number of specimens. For example, hypothetical

Unit A contains eight bone fragments whose *c* values are 0.2 (n = 1), 0.3 (n = 3), 0.4 (n = 2), and 0.5 (n = 2). The sum of these *c* values is 2.9. This sum is then divided by 8 and multiplied by 100, producing an FI of 36. The higher the FI value, the lower the degree of fragmentation in the assemblage. A value of 100 indicates none of the bone is broken, whereas a value of 10 demonstrates the assemblage is highly fragmentary. Hypothetical Unit A has a low FI value, indicating most of the bones have been broken.

Low FI values are useful as indicators of postdepositional disturbance and cultural processing of animal remains. Beyond this, the FI is a valuable tool for recognizing intrusive specimens. Recently intruded bones should be less fragmentary than bones of long-buried specimens. Food bones are more likely to show a high degree of fragmentation as a result of common food preparation practices; for example, the Gabrielino reportedly crushed small animals, bones and all, before adding them to soup or mush (McCawley 1996:117). Rodent activity, such as scavenging, tunneling, and nest-building, can also be responsible for fragmentation of bones buried in archaeological deposits. Thus, taxa with a high FI value (meaning the bones are relatively whole) are more likely to be intrusive than taxa with a low FI value. This assumption has been supported in several previous studies (Maxwell 1998b, 1998c, 1999c).

Mineral Staining

Bones stained by minerals in groundwater are commonly found in both archaeological and paleontological assemblages. Unfortunately, the processes producing mineral staining have received very little attention (Shahack-Gross et al. 1997). In this study, we recorded only the presence or absence of mineral staining. Staining is distinguished from burning on the basis of color, with stained specimens appearing dark brown and burned specimens being blackened or calcined. We recorded staining to note the presence of recently intruded specimens because we assumed that recent bone would less likely be stained than bone that had been in the assemblage for a longer period of time. Differences in mineral staining may indicate the mixing of remains from different depositional contexts.

Other Formation Processes

A number of other taphonomic indicators have been recorded for this collection, if infrequently. Bones displaying cutmarks were very rare at all three sites. Cutmarks are sharp, usually short, straight incisions into the bone, frequently running perpendicular to the long axis of the bone (Behrensmeyer et al. 1986; Gifford-Gonzalez 1989; Potts 1988; Potts and Shipman 1981; White 1992). Traces of other types of formation processes—including gnawing by rodents or carnivores, the presence of caliche (calcium carbonate) coating the bones, evidence for root etching and water rolling—were all recorded when present. However, most of these types of alterations were absent or recorded in extremely low frequencies in the LAN-63, LAN-64, and LAN-206A collection.

Vertebrate Faunal Remains from LAN-63

LAN-63 contained the largest number of vertebrate faunal remains of the three sites discussed in this report. A total of 9,954 bones was analyzed. As some of these were recovered from subsampled contexts, we estimated that a total of 18,292 bones was recovered from our sampled site contexts, including Features 1, 5, 6–15, 17, 21, 318, 340, 409, 444, 446, 462, 468, 475, 509, 521, 587, 594, and 601, Units 36 and 53, and Column Samples 1, 2, and 3. As described in the methods, above, estimated counts are provided here to give a more accurate picture of the number of bones expected to have been recovered in each subsampled provenience. Table 10.1 shows that mammal remains dominate the vertebrate faunal collection. Bony fish represented 25 percent (n = 4,376) of the LAN-63 collection. Of the nonfish vertebrate faunal remains, 94 percent (n = 12,713) were identifiable to class, but only 3 percent (n = 381) were identifiable to order, and even fewer were identifiable to family, genus, and species.

Taxonomic Analysis

Cartilaginous Fish

Cartilaginous fish (Chondrichthyes) constituted only 2 percent (n = 263) of the vertebrate collection from LAN-63; the majority of these were unidentifiable beyond the class level. Shovelnose guitarfish *(Rhinobatos productus)*, Pacific angel shark *(Squatina californica)*, and bat ray (*Myliobatis californica*) were the only taxa recovered in any frequency, although none is represented by as many as 20 specimens. All of these fish can be procured in shallow waters relatively close to shore or in bays, estuaries, or lagoons (Table 10.2).

Bony Fish

Bony fish (Osteichthyes) constituted 25 percent (n = 4,376) of the vertebrate collection; the majority were unidentifiable. Of the identifiable remains, however, 69 percent (n = 1,486) were clupeids (Pacific sardine) and atherinopsids (jacksmelt, topsmelt, and California grunion). Embiotocids (surfperches), engraulids (anchovies), scombrids (chub mackerel), and pleuronectiforms (righteye and lefteye flounders) constituted 26 percent (n = 553) of the remainder. Collectively, these six groups constituted 94 percent (n = 2,039) of the total identifiable sample. The remaining 122 elements were divided among 8 families and 13 genera, none of which exceeded 31 in number. Generally, most of these fish were small and schooling (clupeids, atherinopsids, and engraulids). The presence of arroyo chubs and threespine sticklebacks suggests people exploited freshwater marshy habitats and marine habitats. The majority of identified fish can be procured from shallow water along shores or in bays, estuaries, or lagoons.

Reptiles

The remains of reptiles constituted less than 1 percent (n = 69) of the collection, and most were unidentifiable. Kingsnake (*Lampropeltis getulus*) and Pacific pond turtle (*Actinemys marmorata*) were the only identifiable species recovered at LAN-63. Both species are native to southern California. The pond turtle prefers areas where water persists throughout the year, usually on islands of vegetation within the water. The kingsnake lives in a variety of environments throughout southern California.

Birds

Bird bones also constituted less than 1 percent (n = 28) of the collection, with virtually all unidentifiable beyond the class level. Two great blue heron and two common flicker bones were recognized. Both of these bird species are native to southern California. As a shore bird, the great blue heron (*Ardea herodias*) is common in the Ballona area throughout the year; the common flicker (*Colaptes auratus*), however, is a less frequent visitor to the Ballona region.

Mammals

Overall, mammal remains accounted for 73 percent (n = 12,616) of the vertebrate faunal collection, the overwhelming majority of which were unidentifiable. Only 73 mammal bones were identifiable to genus, although six families and seven genera were present (see Table 10.1). Of the identifiable mammals, cottontail rabbits (*Sylvilagus* sp.) and pocket gophers (*Thomomys* sp.) were the most abundant; artiodactyls constituted the majority of those specimens identifiable to only the family level. All of the represented species are native to southern California and are common in the Ballona region.

Formation Processes

Formation processes were recorded for all nonfish bone from the three West Bluffs sites and for a sample of the fish bone from LAN-63. The nonfish bones from LAN-63 showed a high degree of burn damage. However, they lacked signs of other obvious taphonomic formation processes such as weathering, staining, and root etching.

Weathering

Almost 95 percent (n = 12,888) of the 13,594 nonfish bones fell into Behrensmeyer's (1978) weathering Stage 1; these exhibited little damage beyond the basic degreasing expected of bone buried under typical soil conditions. This suggests that most of the materials recovered from LAN-63 were buried rapidly. Only 5 percent (n = 706) of the bones fell into advanced ranges (Stages 1.5, 2, 2.5, and 3). All site areas showed similar effects of weathering.

Burning

Thirty percent (n = 4,077) of the nonfish bone collection showed some degree of burn damage (Table 10.3). This is typical of many Ballona sites where at least 25 percent or more of the bones are burnt (Maxwell 2003a). The majority of the burnt bone from our sample was blackened rather than calcined, suggesting bones were burned at a low temperature (between 240° and 500°C) without much oxygen (Buikstra and Sweigle 1989; David 1990). The degree of burn damage at LAN-63 varied by animal size and site contexts (Tables 10.4 and 10.5). The medium-sized to large mammal bones most frequently showed burn damage, whereas the small to medium-sized mammal bones showed the least. Interestingly, the very small to small mammals also showed a high degree of burn damage. We would expect that most of the very small to small mammal bones would be intrusive and therefore not show cultural damage such as fragmentation or burning. The burn damage to these very small to small mammal bones likely indicates that not all of these smaller mammal bones were intrusive; instead, people purposely roasted some of these animals for consumption. Twenty percent of the bird and reptile remains also showed burn damage. Those that were burned included 1 Pacific pond turtle bone, 1 kingsnake bone, 10 unidentifiable reptile bones, and 6 unidentifiable bird bones.

Fragmentation

The mammal remains from LAN-63 were mostly unidentifiable and highly fragmented (FI = 12). Less than 1 percent (n = 107) of this collection was identifiable to even the family level and even fewer to genus and species. The degree of fragmentation varied by animal size, but varied very little between different site contexts (see Table 10.5). Very small to small mammals were the least fragmented (FI = 22–23), whereas medium-sized to large mammals and mammals of indeterminate size class were the most fragmented (FI = 10–12).

Intrasite Comparisons

Vertebrate faunal remains from LAN-63 were analyzed from 33 different excavated contexts, including 3 column samples, 3 1-by-1-m units, and 27 features. Site contexts, which included 2 units and 11 features, containing over 150 bones were used for intrasite comparisons. Table 10.5 shows the feature type, the NISP for both fish and nonfish vertebrate remains, the burn damage of nonfish remains, and the degree of fragmentation for medium-sized and larger mammals.

Unit 36

Unit 36 was a 1-by-1-m unit located within the shell midden (see Figure 6.1). Nine 10-cm levels were excavated from this unit. Bones from all nine levels were analyzed. An estimated total of 231 fish bones and 2,670 nonfish bones was recovered from this unit. Most of the nonfish bones were unidentifiable mammal remains, most of which (n = 1,034) were small to medium-sized mammals. Unidentifiable cartilaginous fish (n = 52) and bony fish (n = 50) dominated the fish assemblage. A large number of embioticids (n = 48) were also recovered from Unit 36.

Unit 53

Unit 53 was a 1-by-1-m unit located just north of the shell midden (see Figure 6.1). Bones were analyzed from the two 10-cm levels excavated within this unit. An estimated total of 64 fish bones and 529 nonfish bones was recovered from this unit. All of the nonfish bone, except for two reptile bones, were unidentifiable mammal bone, of which the majority are small to medium-sized mammals (n = 272). Unidentifiable bony fish represented 25 percent (n = 16) of the fish bone, and unidentifiable cartilaginous fish accounted for 17 percent (n = 11). Embioticids accounted for 19 percent (n = 12) of the fish bone.

Feature 1

Feature 1 was a rock concentration consisting of fire-affected rock (FAR), ground stone fragments, flaked stone, shell, and faunal bone in the central part of LAN-63 (see Figure 7.1). This feature contained 143 fish bones and 39 other vertebrate faunal bones (see Table 10.5). All of the nonfish vertebrate remains from this feature were unidentifiable mammal remains from all size classes. Twenty-one percent (n = 8) of these bones from this feature displayed burn damage, most of which were blackened. Atherinopsids, clupeids, and unidentifiable bony fish dominated the fish collection from this feature.

Feature 8

Feature 8 consisted of a tight cluster of FAR, ground stone fragments, flaked stone, and vertebrate faunal bone. The feature was in the central part of LAN-63 (see Figure 7.1). This feature contained 142 fish bones and 82 nonfish bones (see Table 10.5). Nineteen percent (n = 16) of the bones showed burn damage, most of which were blackened. Most of the remains were unidentifiable mammal remains that were also unidentifiable to size class. Analysts also identified one bird bone and two pocket gopher bones from this feature. The pocket gopher bones were likely intrusive. They were unburnt and showed no other signs of cultural damage. The majority of the fish bones were unidentifiable bony fish.

Feature 9

Feature 9 was a rock concentration that consisted of FAR, ground stone fragments, flaked stone, steatite fragments, shell, and faunal bone. This feature was located in the central part of the site (see Figure 7.1). Forty-five nonfish faunal bones and 117 fish bones were recovered from this feature. Fifteen percent (n = 7) of the nonfish bone displayed burn damage; unlike other site areas, these bones were mostly calcined. Three pocket gopher bones were recovered from this feature. These remains were probably intrusive as they displayed no cultural damage. Again, unidentifiable bony fish dominated the collection from this feature. Atherinopsids and clupeids were also represented.

Feature 10

Feature 10 was a rock concentration containing fire-cracked rock, ground stone fragments, and vertebrate faunal remains. The feature was located in the central part of the site (see Figure 7.1). Excavators recovered 79 nonfish bones and 232 fish bones from this feature. No medium-sized to large mammal remains were recovered. Unidentifiable mammal bones of indeterminate size class dominated the bone collection from this feature. One bird bone was recovered from this feature. Bones from clupeids and atherinopsids dominated the fish bones. Less than 3 percent (n = 2) of the nonfish bones displayed burn damage, the lowest percentage within our sampled site area (see Table 10.5).

This area may have been used for grease rendering. Bones typically found from a grease-rendered assemblage are greatly fragmented and show a low degree of burn damage (Leechman 1951; Outram 2001; Vehik 1977). This area could also have been a hearth or processing area used repeatedly and cleaned frequently. In this case, we would expect to find mostly smaller bones, which would not be easily picked up during cleaning (Hayden and Cannon 1983; O'Connell et al.1991).

Feature 11

Feature 11 was a dense artifact concentration consisting of FAR, ground stone, steatite, flaked stone, shell, and faunal bone. Steatite debris comprised 87 percent (n = 701) of the lithic remains from the feature (see Chapter 8). Excavators noted that the large unidentifiable mammals' remains were recovered from the northeastern portion of the feature. A total of 1,399 fish bone and 708 nonfish bone was recovered from this feature. Again, the bone collection from this context was highly fragmented (FI = 11). The majority (79 percent, n = 570) of the assemblage was unidentifiable to size class. This feature contained the second highest percentage of burnt bones, 34 percent (n = 245), most of which were blackened (see Table 10.5). Unidentifiable bony fish made up the majority of the fish remains. The atherinopsids and clupeids constituted the majority of the identifiable fish bone.

Feature 444

Feature 444 was a rock concentration from the western part of the site (see Figure 7.1). Excavators recovered FAR, ground stone, flaked stone, shell, and faunal bone from this feature. Analysts counted 137 fish bones and 49 nonfish bones. All of the nonfish bones were unidentifiable mammal bones from all size classes. Again, unidentifiable bony fish, the atherinopsids and clupeids constituted the majority of the fish collection. Only 15 percent (n = 26) of these bones in this feature displayed burn damage; the majority were blackened rather than calcined. All but two of the bones displaying burn damage were very small to medium-sized mammal bones. This damage pattern suggests the smaller mammals were roasted in this area.

Feature 462

Feature 462 consisted of a dense concentration of FAR, flaked stone, ground stone, and faunal bone. Twenty-five fish bones and 235 nonfish bones were recovered from this feature. Most of the nonfish remains were small to medium-sized mammal bones and bones unidentifiable to size class. Sixteen percent (n = 38) of the nonfish bones displayed burn damage, a fairly low percentage compared to other site contexts. The medium-sized mammal bones showed the most burn damage. The bones were highly fragmented. Clupeids (n = 7) and unidentifiable cartilaginous fish (n = 6) dominated the fish bone assemblage.

Feature 468

Feature 468 was a rock concentration, composed of FAR, ground stone, flaked stone, shell, and faunal bone. Thirty-four fish bones and 78 nonfish bones were recovered. Fifteen percent (n = 38) of the bones from this feature showed burn damage. Bones from this feature were highly fragmented. One artiodactyl bone and two gopher bones were the only identifiable remains from this feature. All other nonfish bones were unidentifiable mammal bones from all size classes, but the most came from the small to medium-sized class. The great majority of the fish collection consisted of unidentifiable bony fish, atherinopsids, and clupeids.

Feature 475

Feature 475 was a human burial that contained an incomplete skeleton of a child, flaked stone, a lithic bead, a shaft straightener, and faunal bone. This burial was located within the shell midden (see Figure 7.1). Analysts counted 38 fish bones and 488 nonfish bones within this burial feature. Twenty-six percent (n = 134) of the nonfish bone from this feature showed evidence of burn damage, over 90 percent (n = 124) of which was blackened. The faunal assemblage was fairly fragmented (see Table 10.5). Analysts identified five artiodactyl bones, one lagomorph bone, one leporid bone, one *Peromyscus* sp. (deer mouse) bone and four *Sylvilagus* sp. bones. The *Peromyscus* sp. bone was likely intrusive; the bone showed no cultural damage. The rest of the nonfish bone was unidentifiable mammal bone from all size classes. Forty-one percent (n = 198) of these cannot be assigned to a size class. The medium-sized, large, and indeterminate-sized mammal bones showed the most burn damage. Most of the fish collection consisted of embiotocids and unidentifiable bony fish. It is unclear whether the bones from this feature were left as grave goods or deposited earlier within the shell midden.

Feature 587

Feature 587 was a large mourning feature located in the southwest part of LAN-63 within the shell midden (see Figure 7.1). This feature was distinctive because of its large and dense artifact concentration and the large number of broken ground stone fragments. The feature also contained FAR, flaked stone, worked bone, shell, and ground stone, faunal bone, and small fragments of human bone. Analysts identified 485 fish bones and 7,046 nonfish bones from 2 of the 16 units analyzed in this feature. Three percent of the collection from this feature was identified to at least the family level, the highest percentage from any sampled context at this site. The identifiable bone came from several species including kingsnake, pacific pond turtle, great blue heron, cottontail rabbit, mouse, pocket gopher, dog/coyote, and deer. The fish collections was dominated by atherinopsids, clupeids, and embiotocids. Forty-two percent (n = 2,942) of the nonfish bone showed burn damage, the highest percentage of burnt bone from our sampled site areas. Of the burnt specimens, 68 percent (n = 2,001) were blackened and 32 percent (n = 941) were calcined. This is similar to the burn damage shown on the human bone fragments recovered from Feature 587 (see Chapter 13). Forty-seven percent (n = 111) of the very small to small mammals, which we would expect to be intrusive, were blackened, and 2 percent (n = 12) were calcined. This could result from the incidental exposure of intrusive rodent remains to the cremation fire.

Feature 601

Feature 601 was a rock concentration located in the eastern part of the site (see Figure 7.1). Excavators recovered FAR, flaked stone, ground stone, and faunal remains. Six fish bones and 236 nonfish bones were identified from this feature. All nonfish bone was unidentifiable mammal bone from all size classes. Only 13 percent (n = 30) of these bones displayed burn damage, the second lowest percentage from any sampled context at this site. Almost 40 percent (n = 13) of the medium-sized to large mammal bones displayed burn damage, whereas less than 12 percent (n = 17) of the small to medium-sized mammal bones displayed burn damage. The fish assemblage consisted of three unidentifiable bony fish and three unidentifiable cartilaginous fish.

LAN-63 Summary

The LAN-63 vertebrate faunal collection consisted of an estimated 18,292 bones from fish, reptiles, birds, and mammals. The remains indicate that a variety of animals, including land and sea animals, were important in the site's function and economy. The mammal remains, which represent 70 percent (n = 12,616) of the total vertebrate faunal collection and 93 percent of the nonfish collection, were unidentifiable and highly fragmented. About 30 percent of the mammal remains showed some degree of burn damage (see Table 10.5). All the bones from this collection were very fragmented, with a little variation between size classes (see Table 10.4). This degree of fragmentation suggests that prehistoric inhabitants of LAN-63 heavily processed animals at this site or that bones were deposited in locations subject to trampling, or both. Another possibility is that the bones were subject to postdepositional processes which caused the bone fragmentation. The site area was plowed regularly from in the modern era, which could fragment bones in tilled deposits. However, excavation revealed the plow zone only extended 30 cm deep. There is also very little evidence for carnivore or rodent gnawing, which may also cause bone fragmentation. The bones we analyzed were from feature contexts and units containing a high density of faunal remains. We would not expect the bones to experience much trampling within feature contexts, particularly rock features. Many of the faunal collections from the features were just as fragmented, if not more fragmented, than the unit collections. Feature contexts may also have been cleaned, with the larger bones removed and the smaller bones left behind. In this case, we would expect to find site areas containing the large bone refuse, but we found no contexts containing large bone fragments.

A total of 4,376 of the fish elements from LAN-63 came from bony fish. Ninety-four percent (n = 2,039) of the identifiable bony fish are clupeids, atherinopsids, embiotocids, engraulids, scombrids, and pleuronectiforms. These fish are all found nearshore either along sandy beaches or in bays, lagoons, or estuaries—environments that could be easily exploited from LAN-63. Generally, most of these are small and schooling fish (clupeids, atherinopsids, embiotocids, and engraulids) that are most easily caught with seines, gill nets, weirs, or cast nets.

Bones from all sampled site features and units were highly fragmented with FIs ranging from 10 to 14. Features 11, 475, and 587 contained the highest percentage of burnt bone than any other sampled site context (see Table 10.5). These features also contained more bone than any other sampled feature. It is interesting that these three features were the only features that were not categorized as rock concentrations or hearths. Features 475 and 587, located within the shell midden, were ceremonial features: a burial and a mourning feature, respectively. Feature 11, located just 10 m to the northwest of the shell midden, was noted as an artifact concentration composed mostly of steatite fragments and contained the most fish of all the sampled contexts. The large quantity of fish bones in this feature may indicate that the feature was used for processing or disposing of fish. Feature 11, however, was not a hearth feature where one might expect fish processing to occur: it was an artifact concentration that was dominated by more typically ceremonial artifacts. Unit 36, located within the shell midden, also contained a large quantity of bone, although only 14 percent showed burn damage. It may be that the features' and units' location within the shell midden, a place where refuse was likely disposed, is the reason for the high density of bones in these features. The bones from the ceremonial features may show a high frequency of burn damage because they were part of the soil matrix, which was burned along with other feature items. However, if this were the case, we would expect faunal bone density to be high throughout the shell midden area, instead of in just a few of the feature and unit contexts within the midden.

Features 1, 8, 9, and 10 were all rock concentrations that contained more fish bone than nonfish bone, which differs from other sampled contexts where the opposite is true. Whereas all of the nonfish bone from these features displayed lower burn damage than the site average, bones from Feature 10 showed almost no burn damage (3 percent, n = 2). Features 444, 462, 468, and 601 are also rock concentrations; however, the nonfish bones make up more than 50 percent of these collections. The percentage of the burn damage was lower than the site average but similar to that of the other nonceremonial features. The majority of burnt bones from Features 9 and 462 showed a high percentage of calcination (see Table 10.5) suggesting that bones from these areas were burned at a very high temperature.

Vertebrate Faunal Remains from LAN-64

LAN-64 contains fewer vertebrate faunal bones than LAN-63. A total of 727 bones was analyzed. As some of these were recovered from subsampled contexts, we estimate that a total of 1,190 bones was recovered from our sampled site contexts including Features 17, 32, 49, 50, 52, 56, 60, 66, and 76 and Units 11–14 and 1009. As described in the methods, above, estimated counts are provided here to give a more accurate picture of the number of bones expected to have been recovered in each subsampled provenience. Table 10.6 shows that mammal remains dominated the vertebrate faunal collection. Bird-bone fragments represented 3 percent of the collection; whereas bony and cartilaginous fish together constituted less than 2 percent of the faunal collection. Of the nonfish vertebrate faunal remains, 95 percent were identifiable to the class level, but only 1 percent were identifiable to order; even fewer were identifiable to family, genus, and species.

Taxonomic Analysis

Cartilaginous Fish

Seven cartilaginous-fish bones were recovered from LAN-64 (see Table 10.6). Of these, only two bones were identifiable—an angel shark and a shovelnose guitarfish. Both of these species are found in shallow waters relatively close to shore (see Table 10.2).

Bony Fish

Eleven bones from bony fish were recovered from the site (see Table 10.6). Six of these were identifiable to at least the family level. All of these fish can be found in the surf or shallow waters relatively close to shore (see Table 10.2). The Pacific staghorn sculpin *(Leptocottus armatus)* and the longjaw mudsucker *(Gillichthys mirabilis)* prefer bays and estuaries on sand or mud bottoms and were likely caught in the nearby Ballona lagoon.

Bird Remains

All of the bird bone remains were recovered from one provenience, Feature 50. All 40 bones were unidentifiable long bone fragments from a medium-sized bird. Even if some were from different bones in the bird's body, likely all were from the same bird. None of these bones showed burn damage or displayed cutmarks or any other cultural damage.

Mammal Remains

Mammal remains dominated the faunal collection from LAN-64. Ninety-nine percent of these mammal remains were unidentifiable to class, family, genus, or species. The identifiable mammals included rodents and artiodactyls. Likely, the rodent bones were intrusive, none displayed burn damage or other cultural damage. The majority (60 percent, n = 679) of the recovered mammal bones were from large mammals. The intermediate sizes, small to medium and medium to large, make up another 26 percent (n = 293) of the collection.

Formation Processes

Weathering

Almost all (n = 1,333) of the 1,339 nonfish bones fall into Behrensmeyer's (1978) Stage 1; these showed little damage beyond the basic degreasing expected of bone buried under typical soil conditions. This suggests that most of the materials recovered from LAN-64 were buried rapidly. Very few bones (less than one percent, n = 6) fell into Stage 1.5. No bones displayed weathering beyond Stage 1.5.

Burning

Overall, 50 percent of the faunal collection displayed burn damage. The majority of burnt bones from most site contexts were calcined rather than blackened (Table 10.7), suggesting most bones were burnt in a hot fire (over 500°C) with plenty of oxygen (Buikstra and Sweigle 1989; David 1990). The degree of burn damage varied between animal type and site context (Tables 10.8; see Table 10.7). Only two, less than 5 percent, of the very small to small mammal bones showed burn damage. Likely, many of these elements were intrusive. The medium-sized to large mammal bones displayed the most burn damage, the majority of which were calcined rather than blackened. Almost 60 percent of the mammal bone of indeterminate size displayed burn damage. Of these, 60 percent were partially blackened. This is interesting because the majority of bone from all other size classes was calcined.

Fragmentation

As with LAN-63, most mammal remains from LAN-64 were unidentifiable and highly fragmented. The percentage of unidentifiable bone alone suggests a greatly fragmented bone collection. Forty-four percent of the fish remains were only identifiable to the family level. None of the nonfish remains were identifiable to family, genus, or species. The degree of fragmentation varied by animal size and site context. The very small to small mammal bones, although highly fragmented, showed the least fragmentation of all the mammal sizes. Other mammal sizes were fairly consistent in their degree of fragmentation (see Table 10.8).

Intrasite Comparisons

Vertebrate faunal remains from LAN-64 were analyzed from 16 different contexts throughout the site, including 5 1-by-1-m units and 11 features. Because fewer bones were recovered from LAN-64, intrasite comparisons include site contexts that contained more than 50 bones, rather than 150 bones as was done for LAN-63. Table 10.7 shows the feature type, the NISP of both fish and nonfish vertebrate remains, burn damage of nonfish remains, and the degree of fragmentation for medium-sized and larger mammals.

Units 11, 13, and 14

Three 1-by-1-m units contained about 70 faunal bones each (see Table 10.7). These units were near each other in the center of the site (see Figure 6.2). All three units contained mammal bone from most size classes. The bones from all three units were highly fragmented. Only about 8 percent (n = 6) of the bone from Units 13 and 14 showed burn damage, whereas 51 percent (n = 37) of the bone from Unit 11 displayed burn damage, most of which was partial blackening. This unit contained 61 percent of the unidentifiable mammal bone whose size class was indeterminate. Unit 11 also contained 5 fish bones, 29 percent of which was found on-site. Units 13 and 14 were dominated by small to medium-sized mammal bones whereas Unit 11 was dominated by unidentifiable mammal bone that was also of an unidentified class.

Unit 1009

Unit 1009, which is associated with Feature 52 (discussed below), was located about 3 m south of burial Feature 32 (also discussed below) (see Figure 6.4). Like Feature 52, this unit consisted primarily of medium-sized to large mammal bones. Ninety-six percent (n = 154) of the bones showed calcined burn damage.

Feature 32

Feature 32 was a burial feature containing a human cranium, other small fragments of human bones, and unidentifiable large mammal bone (see Figure 7.36). All of the 124 faunal bones from this feature were large mammal bones. These were fairly fragmented compared to the overall bone fragmentation from the sampled site areas. Only 15 percent (n = 19) of the bones showed burn damage, a low percentage compared to most of the other sampled site contexts. Of the burnt bone, 95 percent (n = 18) were calcined. None of the bones recovered from this feature displayed cutmarks or any discernable cultural modifications other than burn damage.

Feature 50

Feature 50 was a small refuse deposit containing mostly scallop shell with small amounts of Venus clam and oyster (see Figure 7.36). This feature dated to the early Millingstone period, as did three other shell deposits within LAN-64. The feature contained 1 fish bone and 56 other vertebrate faunal bones, 40 of which were unburnt bird long bone fragments, possibly from the same long bone, and likely from the same bird. Only 5 of the 16 mammal bones displayed burn damage. All of the mammal bone recovered from this feature was very fragmented and from very small to medium-sized mammals. The shell from this feature, however, showed very little fragmentation compared to other site contexts (see Chapter 11). Although the faunal collection from this context was small, the fragmentation differences between bone and shell suggests the bones were fragmented from processing rather than postdepositional processes, otherwise we would expect the shell to be fragmented as well.

Feature 52

Feature 52 was a burial feature of an older male in a flexed position. Ninety-six percent (n = 276) of the faunal bone from this feature consisted of medium-sized to large mammal bones, including the one identified artiodactyl element. Ninety-one percent (n = 262) of this bone showed evidence of burn damage; the great majority of these bones (98 percent, n = 257) were calcined. This feature was located about 3 m north of Unit 1009, discussed earlier in this chapter. These two contexts had similar characteristics, including a high percentage of medium-sized to large mammal bone and a high percentage of burnt bone, which was mostly calcined. The faunal bone was likely burnt along with the human bone, which was also primarily calcined (see Chapter 13).

Feature 76

Feature 76 was a rock concentration containing FAR, ground stone, flaked stone, faunal bone, shell, and charcoal. Excavators recovered 199 bones from this feature. All were medium-sized to large mammal bones. Eighty-eight percent (n = 175) of the bones were burnt, most of these were calcined. This feature was probably a hearth where medium-sized to large mammals were roasted or cooked at high temperatures. If this is the case, larger bone fragments may have been removed from the feature during cleaning, which may explain the degree of fragmentation.

LAN-64 Summary

The 1,190 bones recovered from LAN-64 were from fish, birds, and mammals. The bird bones were all long bone fragments from the same context and likely belonged to one bird. Only 8 elements of the 18 fish bones or teeth identified from LAN-64 were identifiable to an analytically useful taxon: Pacific angel shark, shovelnose guitarfish, Clupeidae, Atherinopsidae, Pacific staghorn sculpin, Embiotocidae, and longjaw mudsucker. All of these fish were also represented at LAN-63, which is not surprising since people from both sites had access to similar fisheries. The fish remains from LAN-63 and LAN-64 were consistent with those previously recorded from coastal Los Angeles, Orange, and Ventura Counties (Fitch 1967, 1969; Salls 1988). The mammal remains constitute 95 percent of the assemblage. Twelve of these bones, 11 rodent bones and 1 artiodactyl bone, were identifiable to order only.

Whereas most of the bones across the site were highly fragmented, not all showed the same degree of burn damage. Bones from Units 13 and 14, Feature 50, a shell midden, and other site contexts not included in the intrasite comparisons, showed very little burn damage. This may indicate that bones were not burned while processing but later when thrown into fires as refuse. Bones from Feature 52, a burial, and Feature 76, a hearth, showed the highest degree of burn damage. Bones from Units 11 and 1009, which is associated with Burial Feature 52, also showed a high degree of burn damage. The faunal bone from the burial was probably burned along with the human remains. Bones from the hearth feature were likely burned during cooking or thrown on a hot fire as refuse.

Overall, the majority (59 percent, n = 671) of these bones displayed burn damage. Of these burnt bones, almost 60 percent (n = 383) were calcined rather than blackened, indicating they were subjected to very hot fires. The few very small to small mammal remains were likely intrusive; they were generally unburned and showed no other cultural damage. The high numbers of burnt bone, the degree of fragmentation, and the unidentifiableness of the faunal collection suggests that prehistoric inhabitants of this site targeted primarily medium-sized to large mammals; processed them for food, which caused a high degree of fragmentation; and cooked them or disposed of them in high-temperature fires.

Vertebrate Faunal Remains from LAN-206A

Excavators recovered only 20 mammal bones from LAN-206A (Table 10.9). All of the bone was collected from point-provenienced surface locations, none of which were associated with a particular feature or unit. Eighteen of the bones were unidentifiable large mammal bones, and one is unidentifiable mammal of indeterminate size class. The one identifiable bone is a horse phalange. None of the bone displayed burn damage. The horse phalange showed rodent gnawing.

Previous Work at West Bluffs

Van Horn (1987) initially excavated LAN-63 and LAN-64 in the mid-1980s. Susan Colby (1987a, 1987b) analyzed the nonfish vertebrate faunal remains from those two excavations, and Roy Salls (1987) analyzed the fish remains. Very few fish bones (n = 18) were recovered from LAN-64 during the 2000 and 2003 excavations; therefore, there is no discussion here to compare the collections from the different excavations.

LAN-63

Nonfish Vertebrate Faunal Remains

Colby (1987a, 1987b) analyzed an estimated 14,000 bones from LAN-63. She reported only the identifiable bone and explained that only 10–30 percent of the collection were identifiable depending on the site context. Colby did not record the amount of unidentifiable bone that was excavated. In order to compare our unidentified bone with Colby's, we needed to reconstruct the size of Colby's bone collection that was unidentifiable. We were able to calculate an estimated total based on Colby's total number of identifiable bones and her stated percentage of identifiable bones. We estimated conservatively; it is likely that she looked at more than 14,000 bones. Table 10.10 shows bone counts and percentages for each order from both Colby's and SRI's faunal collections.

Colby (1987a, 1987b) analyzed a sample of the faunal remains from all 4 trenches and 9 of the 48 hand-excavated units from all areas of LAN-63. She noted a highly fragmented assemblage, particularly the large mammal bone. She reported that the majority of the identifiable collection consisted of rodents, but they were likely intrusive. The majority of the identifiable collection used by humans consisted of large mammals, canids, and sea mammals. Table 10.10 shows that birds were also an important resource.

Our collection was similar to Colby's (1987a, 1987b). We noted most of the same animal types she did but in lower proportions. This discrepancy may have been due to differences in sampling strategies. Colby concentrated on bone from all site areas rather than high density or feature areas. We, however, analyzed bones from features and units in high density areas where we would expect more traffic, which would cause bone fragmentation. We also concentrated on features, most of which were rock concentrations or possible hearths that may have been repeatedly used and cleaned. If cleaned, we would expect the larger bone refuse to be removed with smaller fragments left behind. Although Colby noted that her collection was highly fragmented, our collection may simply be *more* fragmented.

The difference in collection counts may also be due to differing analysts. We had high counts of very small to small mammals, many of which were likely rodents, and high counts of medium-sized to large bone, many of which may have been canids. If one assumes that this is the case, the two collections start to look very similar.

Colby (1987a, 1987b) listed substantially more bird bone than we recovered. She reported many birds which are common only in the winter months, including the pintail, green-winged teal, cinnamon teal, American widgeon, and northern shoveler. These species suggest that people occupied LAN-63 during the winter months. We identified four bones from two species of birds, including the great blue heron and the common flicker, neither of which provide seasonality information.

Fish

For this project, Gobalet analyzed a total of 4,698 fish bones recovered from LAN-63 during the 2000 and 2003 excavations. Salls (1987) analyzed 6,108 fish recovered during the 1986 excavations. There are several discrepancies between the two data sets, the most obvious of which being the difference in counts of cartilaginous fish (Table 10.11). Gobalet reported that less than 6 percent of the total fish were cartilaginous, whereas Salls reported that almost half of the bones (47 percent) from his fish collection were cartilaginous. Gobalet identified 22 species of cartilaginous fish whereas Salls identified 64 species.

The majority of Gobalet's fish collection consisted of bony fish, which accounted for 94 percent of the fish bones. Forty-seven percent of the fish were unidentifiable ray-finned fish. Another 35 percent of Gobalet's assemblage consisted of and atherinopsids, clupeids, and engraulids. Bony fish made up only 53 percent of Salls collection, a difference of more than 40 percent. Even though Salls reported no unidentifiable ray-finned fish, he did report a number of clupeids similar to that reported by Gobalet—17 percent. Salls, however, reported fewer numbers of engraulid and atherinopsid bones and many more embiotocid, Pacific chub mackerel, and diamond turbot bones.

These discrepancies may have been due to the analysts or the site contexts from which the two collections were recovered. Salls (1987) analyzed fish from the same contexts, the four trenches and nine units, as Colby (1987a, 1987b), whereas our collection came primarily from features and areas with a high density of bone and other cultural materials. Salls found that cartilaginous fish bones dominated in site contexts in the east camp and the northern part of the site along the rim of the bluff. Bony fish dominated within Trench B, in the higher elevations of the eastern part of the site, and an unit located within the shell midden in the western part of the site. Gobalet analyzed all of the fish bone from the feature, midden, and other contexts described in the methods section. Bony fish made up the majority of the fish bone in every site context. Unit 36, located within the shell midden, and Unit 53, located just north of the shell midden in the western part of the site, contained the highest percentage of cartilaginous fish (24 percent, n = 56 and 23 percent, n = 15, respectively).

LAN-64

Colby (1987a, 1987b) analyzed about 1,400 bones from LAN-64. Again, she reported only the identifiable bone and explained that only 10 percent of the assemblage was identifiable. Colby did not record the amount of unidentifiable bone that was excavated. In order to compare our unidentified bone with Colby's, we needed to reconstruct the size of Colby's bone collection that was unidentifiable. We were able to calculate an estimated total based on Colby's total of identifiable bone and her stated percentage of identifiable bone. We estimated conservatively; it is likely that she looked at more than 1,400 bones. Table 10.12 shows bone counts and percentages for each order from both Colby's and SRI's faunal collections.

Colby (1987a, 1987b) reported that 73 percent of the unidentifiable collection was dominated by medium-sized to large mammals. Whereas the larger mammals dominated the assemblage, they were the least identifiable, suggesting they were also the most fragmented. A similar percentage, 77 percent (n = 871), of our collection was made up of medium-sized to large mammal bones which were the most fragmented. Again, Colby was able to identify more elements to the species level, but 90 percent of her collection was unidentifiable.

Colby (1987a, 1987b) analyzed bone from every fifth unit of the four trenches and 11 units, whereas our analysis focused on features and areas with a high density of bone and other artifactual material. Colby noted that 61 percent of the large mammal bones and 55 percent of the small mammal bones displayed bone damage.

Regional Comparisons

Over the past 20 years, archaeologists have conducted sufficient faunal analysis in the Ballona region to discuss local patterns. David Maxwell (2003a) has discussed Ballona sites from several time periods—LAN-211/H, LAN-193, and LAN-2769—in detail. This section reviews Maxwell's findings and discusses LAN-63, LAN-64, and LAN-206A in relation to other Ballona sites.

Bluff-Top Sites

Many of the Ballona bluff-top reports do not include detailed information on unidentifiable reptile, bird, and mammal remains, and simply stated the percentage of recovered bone that was identifiable (Colby 1984, 1987a, 1987b). For this reason, previous SRI reports synthesizing regional patterns did not consider the unidentifiable mammal, bird, or reptile bone for the bluff-top sites, although this unidentifiable data was considered for the lowland sites. However, we were able to conservatively estimate the number of unidentifiable mammal, bird, and reptile bones for previous Ballona excavations based on the reported percentage of identifiable bone. Once we estimated this number, we found that the bluff-top sites did not follow the pattern we previously believed, and, in fact, these sites follow a pattern similar to the lowland sites in the Ballona. All of the bluff-top contexts considered here date to the Intermediate period. LAN-64 also has a Millingstone period component; however, we analyzed bone from only one feature from this component.

Mammal remains dominated the faunal assemblages from all of the bluff-top sites except LAN-59 (Figure 10.1). Of the mammal remains, rodent bones constituted the bulk of the mammalian specimens at all sites except LAN-61A. Many of these rodent bones were fragmented and showed burn damage. Colby (1987a, 1987b) reported that the collections (all species) from LAN-61A and LAN-61B were highly fragmented and that only about eight percent of these collections were identifiable. LAN-61A was the only site in the Ballona region where bird bones were the most frequent animal type, making up 36 percent of the collection. Lagomorph specimens were also abundant at LAN-61A and showed the highest degree of burn damage, almost 60 percent. Some of the rodent bones, particularly those of California ground squirrels, showed considerable burn damage as well (33 percent). The faunal collection from LAN-61B consisted of mostly rodent bones, but lagomorph and pinniped specimens were abundant as well. Again, 44 percent of the California ground squirrel bones showed burn damage. The carnivore bones (canids, *Taxidae*) showed the most burn damage (about 60 percent), but lagomorph elements were also burnt but in smaller quantities (45 percent).

The inhabitants of LAN-63 collected a variety of animals including mammals of all sizes, birds, and reptiles. Unidentifiable mammal remains made up the majority of the collection; rodents made up the majority of identifiable specimens. In general, the bone collection from LAN-63 was highly fragmented with an average FI of 13. Thirty percent of the bones displayed burn damage, 66 percent of which were partially or completely blackened, and 24 percent were calcined. Very small to small mammal bones, which mostly came from rodents, showed a high degree of burn damage as well; between 20 and 30 percent (see Table 10.4) displayed carbonization and/or calcination.

The LAN-64 faunal collection contained extremely burnt (70 percent) and fragmented medium-sized to large mammal bone, with very little fish. Most of these burnt bones were calcined rather than blackened, indicating that they were exposed to very high temperatures (over 440°C). The overall FI for the site was 11, though very small to small mammal remains were slightly less fragmented (FI = 22–23) than bones from other mammal size classes and showed almost no burn damage (see Table 10.8).

The remains of cartilaginous fish outnumbered bony fish at LAN-59, LAN-61A, and LAN-61B. While our studies at West Bluffs indicated that bony fish were the dominant fish type, previous studies at

West Bluffs sites excavated during the 1980s suggested that cartilaginous fish specimens predominated (Salls 1987). Several analysts studied the fish collections from the lowland sites, while one analyst conducted the early studies from the bluff-top sites. While prehistoric inhabitants of the bluff-top sites may have preferred processing cartilaginous fish at some of the bluff-top sites, we must note that this discrepancy may have resulted from differing excavation and analytical approaches.

Lowland Sites

Sites from the lowlands dated to the Intermediate, Late, and protohistoric periods. As with the bluff-top sites, mammal remains dominated all of the excavated collections (Figure 10.2). Again, rodent elements were the most common identifiable specimens, particularly pocket gophers. The collections from lowland sites of all time periods were highly fragmented and fairly burnt.

Intermediate Period Sites

Small mammals, both rodent- and rabbit-sized, dominated the LAN-60 collection (Cairns 1994). Only 12 percent of the collection displayed burn damage. Most of the burnt elements belong to rodents, which made up the bulk of the identifiable specimens. Cairns (1994) reported that larger mammal bones were highly fragmented but showed little evidence of burning. Cairns (1994) believed that much of this damage resulted from processing bones for marrow and grease. This pattern of highly fragmented larger mammal bones with little burn damage is what we would expect from a marrow- or grease-rendered assemblage (Leechman 1951; Outram 2001, Vehik 1977). The high degree of burn damage to rodent bones suggests people were possibly roasting these animals.

Mammal remains made up the majority of the bone collection from LAN-2768. Very little fish bone was recovered. Again, most identifiable specimens came from rodents. The bone collection was extremely fragmented, and less than 20 percent of the bones showed burn damage. The rodent elements were fairly fragmented with an average FI of 45. Artiodactyl specimens showed the highest degree of fragmentation (FI = 28) (Maxwell 1999d). Again, the high degree of fragmentation and low levels of burn damage may reflect grease-rendering activities.

At LAN-2676, fish specimens were more abundant than at other Intermediate period, lowland sites. The nonfish bones from LAN-2676 were highly fragmented and suffered greater burn damage (33 percent) than collections from other Intermediate period, lowland sites (Maxwell 1998a). Almost 80 percent of these were partially or completely blackened, suggesting a higher frequency of roasting or discarding bone refuse in lower temperature fires. There were spatial differences in burnt bone distribution at the site. Some areas contained only calcined bone that was produced in very hot fires, probably refuse thrown into the fire during cooking. Again, the mammal collection was dominated by small mammals, mostly rodents and lagomorphs. Pocket gopher bones were the most abundant of the identifiable rodents. While rodent bones were less fragmented than other mammals, they were still fairly fragmented for intrusive elements (FI = 56). Maxwell (1998a) did not report which mammal bones were burned.

The LAN-2769 bone collection was dominated by mammal bone, particularly pocket gopher and unidentifiable rodent elements. There were only seven fish bones recovered, a very small number compared to the other lowland Ballona sites and most of the bluff-top sites. The bones from this site showed the least amount of burn damage compared to any other Ballona site (less than 2 percent). The rodent elements were the least fragmented and unburnt, suggesting they were likely intrusive. Artiodactyl remains were the most fragmented (FI = 30).

Late Period Sites

Two sites from the Ballona, LAN-47 and LAN-62, dated to the Late period. Mammal bones were the most abundant element at both sites, and again rodent remains dominated the identifiable specimens. Late period occupants of LAN-62 relied more heavily on fish, particularly bony fish, than did those at LAN-47. Twenty-eight percent of the bones from LAN-62 showed burn damage. Most of these (77 percent) were partially or completely blackened. The bone collection was highly fragmented (FI = 26). Again, rodent bones were fairly fragmented (FI = 50), though less fragmented than larger mammal bones. Twenty-two percent of the bone from LAN-47 showed burn damage. Less than 20 percent of the vertebrate faunal collection from LAN-47 was identifiable, indicating a highly fragmented assemblage (Sandefur and Colby 1992).

Protohistoric Period Sites

LAN-211/H and LAN-1932/H dated to the protohistoric period. Occupants of both sites, particularly LAN-211/H, exploited a variety of animal resources (see Figure 10.3). Mammal bones made up about 50 percent or less of the faunal collections—the lowest percentage of all the bluff-top Ballona sites except LAN-59. Bones from LAN-211/H were fairly fragmented; however, they were less so than other Ballona sites. Of the mammal remains, the pinniped elements were the least fragmented (FI = 90), whereas artiodactyl elements showed the greatest fragmentation (FI = 48). Only 15 percent of the bones showed burn damage (Maxwell 2003a). Maxwell (2003a) reported that the change in subsistence strategy from more focused to more generalized may be due to European contact, resulting in population movements, decimation by disease, and probably a breakdown in the traditional hunting-and-gathering lifeway. He also suggested that the Ballona inhabitants may have shifted their subsistence economy in order to trade for various resources. Of particular interest are the bird remains, as these were dominated by wing and shoulder elements, which suggests that aboriginal people were targeting specific species in order to trade their feathers (Maxwell 2003a).

Discussion

Prehistoric people in the Ballona region exploited a variety of nearby environments, including both marine and freshwater habitats near the lagoon. Mammal remains were the most abundant at most of the sites. Most of these were unidentifiable beyond the class level. Rodents represented up to 60 percent of the identifiable bone collection at many of these sites. The data from the protohistoric period suggest that people diversified their diet in the Ballona during later periods to exploit a larger variety of fish, reptiles, and birds, as well as small and large mammals. Less common species recovered from archaeological sites in the Ballona region included the remains of a great white shark (*Carcharodon carcharias*), swan and geese, and pronghorn antelope (*Antilocapra americana*). Although swans and geese both frequent wetland environments, neither is common in the area today (Dunn and Dickinson 1999). Pronghorn are also not present in the Ballona area today. McCawley (1996) reported, however, that they were eaten by the Gabrielino, and their remains were found at several of the Ballona sites including LAN-60, LAN-194, and LAN-211/H.

Although the bone collections from Ballona archaeological sites showed varying degrees of burn damage, all of the assemblages were highly fragmented and contained numerous rodent elements. Some authors suggested that most of the rodents were intrusive and have caused much of the fragmentation at these sites (Cairns 1994; Maxwell 2003a:164). However, it is unlikely that rodents could have caused the degree of fragmentation found at these sites, particularly to medium-sized and large animal bones. There was little evidence of gnawing or other rodent-caused damage. It also seems unlikely that the recovered rodent remains were entirely intrusive; many showed significant burn damage and breakage. Ethnographic accounts establish that the Gabrielino and Luiseño caught, roasted, and ate ground squirrels and gophers year-round. Rodents not eaten immediately were dried and their bones were crushed to make soup (Koerper 1981).

It is difficult to determine the full range of species exploited by the West Bluffs inhabitants. It is also impossible to assess how many animals were represented, if particular body portions were brought back after a hunting expedition, or if whole animals were represented at the sites. The faunal bone was very fragmented and highly unidentifiable. We do know that West Bluffs inhabitants exploited fish, reptiles, birds, and marine and land mammals of all sizes. Whereas rodent bones dominated the identifiable collections at both sites, large unidentifiable mammals actually dominated the whole collection at LAN-64. Rabbit-sized and larger mammals far outnumbered the rodent-sized (very small to small) mammals at LAN-63. So, even if many of the small rodents were targeted for food, they probably contributed very little to the diet compared to larger mammals such as lagomorphs and artiodactyls.

As stated earlier, 30 percent of the bones from LAN-63 showed burn damage. Overall, almost 70 percent of the burnt bones were completely or partially blackened rather than calcined. There was some variability by feature type indicating different uses in different contexts. The majority of bones from two features, Features 9 and 468, showed calcination rather than blackening. Blackening often occurs on bones that still have flesh during roasting in low or high temperature fires, with cultural or natural causes, once flesh has been burned off the bones. In contrast, 50 percent of the bones from LAN-64 displayed burn damage, almost 90 percent of which were calcined rather than blackened. This suggests that much of the animal refuse at LAN-64 was disposed of in high temperature fires. Meat on an animal roasted to this degree would be completely charred and not edible.

Archaeological assemblages typically contain a high percentage of unidentifiable bone fragments compared to identifiable elements, reflecting the combined effects of human modification and continuing postdepositional processes such as compaction. In her survey of archaeological, ethnographic, and carnivore-ravaged bone collections, Gifford-Gonzales (1989:Figure 6, Table 6) found that archaeological assemblages contained unidentifiable bone fragments at a rate of 66–96 percent, ethnographic assemblages at 28–88 percent, and carnivore-ravaged assemblages at 21–78 percent.

It does not seem likely that bones from the West Bluffs sites were fragmented to this degree by natural postdepositional processes. In fact, we found highly fragmented bones in deposits where other material that we would expect to reflect postdepositional fragmentation (i.e., shell) showed no such damage. For example, the shell in Feature 50 from LAN-64 was one of the least fragmented shell collections on site. However, the bone from this feature was highly fragmented (FI = 11). In addition, the bones from Feature 587 within LAN-63 were very fragmented (FI = 13), but complete abalone shells were recovered from this feature. Shell is typically more fragile than bone, particularly large mammal bone, and should fragment more easily than shell. Even if bone was in a matrix that covered up a feature (including abalone shell), it should not be more fragmented than the shell that was finally deposited in the same place. These bones had to be fragmented before they were deposited. Whether the fragmentation is due to cultural postdepositional processes or processes related to food preparation is unclear.

It is interesting to note that the bone from within features at both LAN-63 and LAN-64 was just as fragmented as bone recovered from outside of the feature contexts, such as the shell midden area within LAN-63. It is unlikely that bones within features, particularly rock features, would be subject to much trampling compared to nonfeature contexts, even after the feature was out of use. Much of the fragmentation was likely due to cultural activities such as cooking or preparation processes.

Ethnographic sources reported that the Gabrielino extracted marrow from the long bones of large mammals and rendered the grease from the bone fragments to use as food, for tanning hides, and for hair oil (Koerper 1981). Harrington (1942) and Martin (1972) reported that the Gabrielino would pound small animals in a mortar prior to cooking or eating them. The small mammals were usually consumed as mush or soup (Harrington 1942). Kroeber (1925) also reported that the Gabrielino pulverized meat, including bone in the case of rabbits, then dried and stored the meat. There is also archaeological evidence that prehistoric Californians used ground stone for pulverizing small mammals. Yohe et al. (1991) reported that immunological residues on ground stone from two southern California sites showed that these tools were used for processing small mammals. Many of these techniques could explain the fragmented bone collection at West Bluffs.

Conclusions

Vertebrate faunal collections from LAN-63 and LAN-64 contained typical species found at Ballona archaeological sites. Archeofauna recovered from the site included snakes, turtles, rodents, rabbits, hares, canids, artiodactyls, bony and cartilaginous fish, and birds. These remains indicate that prehistoric West Bluffs inhabitants used a number of resources from local marine, freshwater, and terrestrial environments, reflecting broad-based subsistence strategies. Mammal remains made up the majority of the bone collection at all three of the West Bluffs sites, suggesting that people relied most heavily on mammals over other animals. The large number of burnt, fragmented, and unidentifiable bones reflects anthropogenic processes, most likely food processing and disposing of animal refuse in fires.

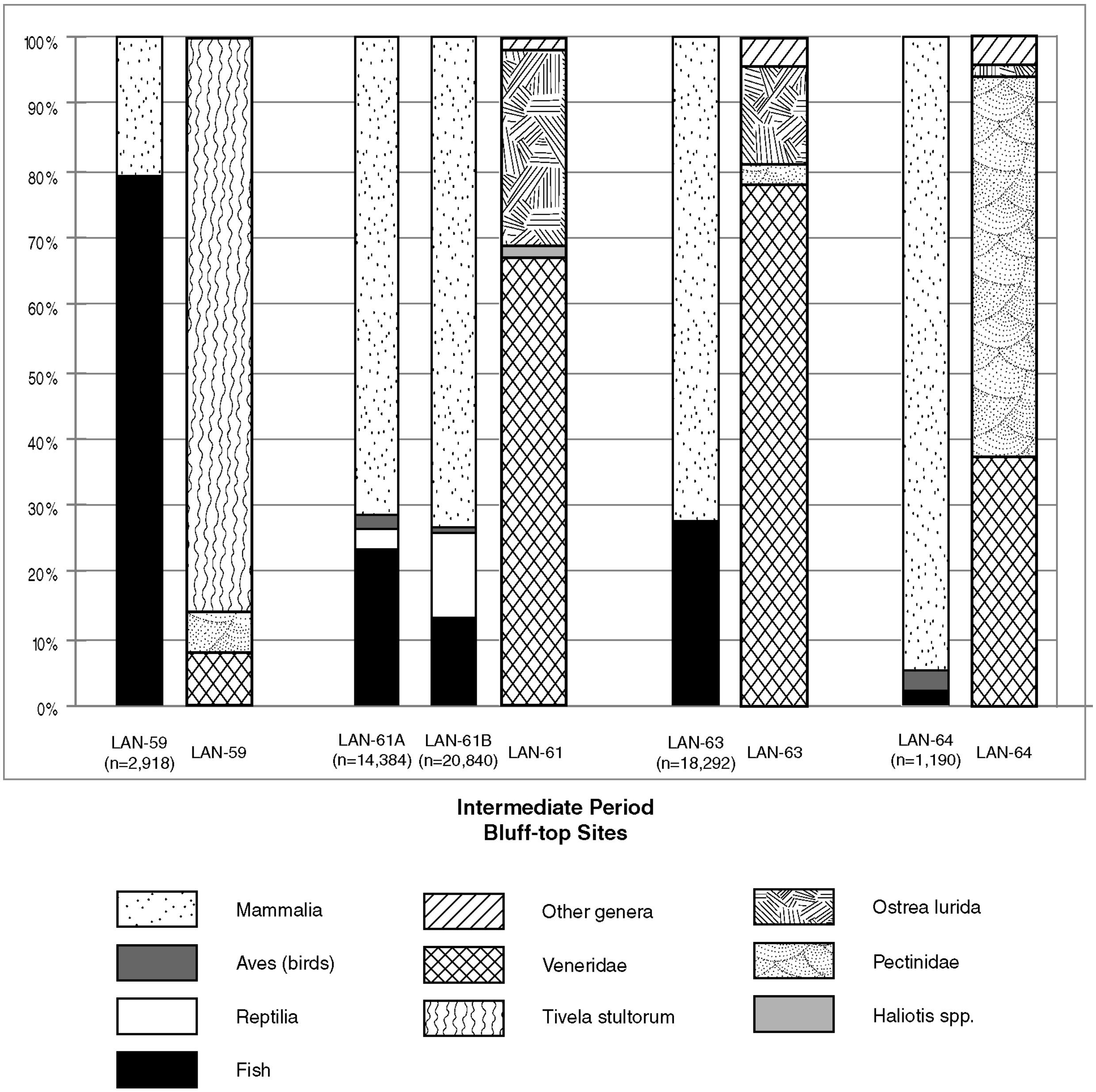


Figure 10.1. Faunal remains from Intermediate period, bluff-top sites in the Ballona region.

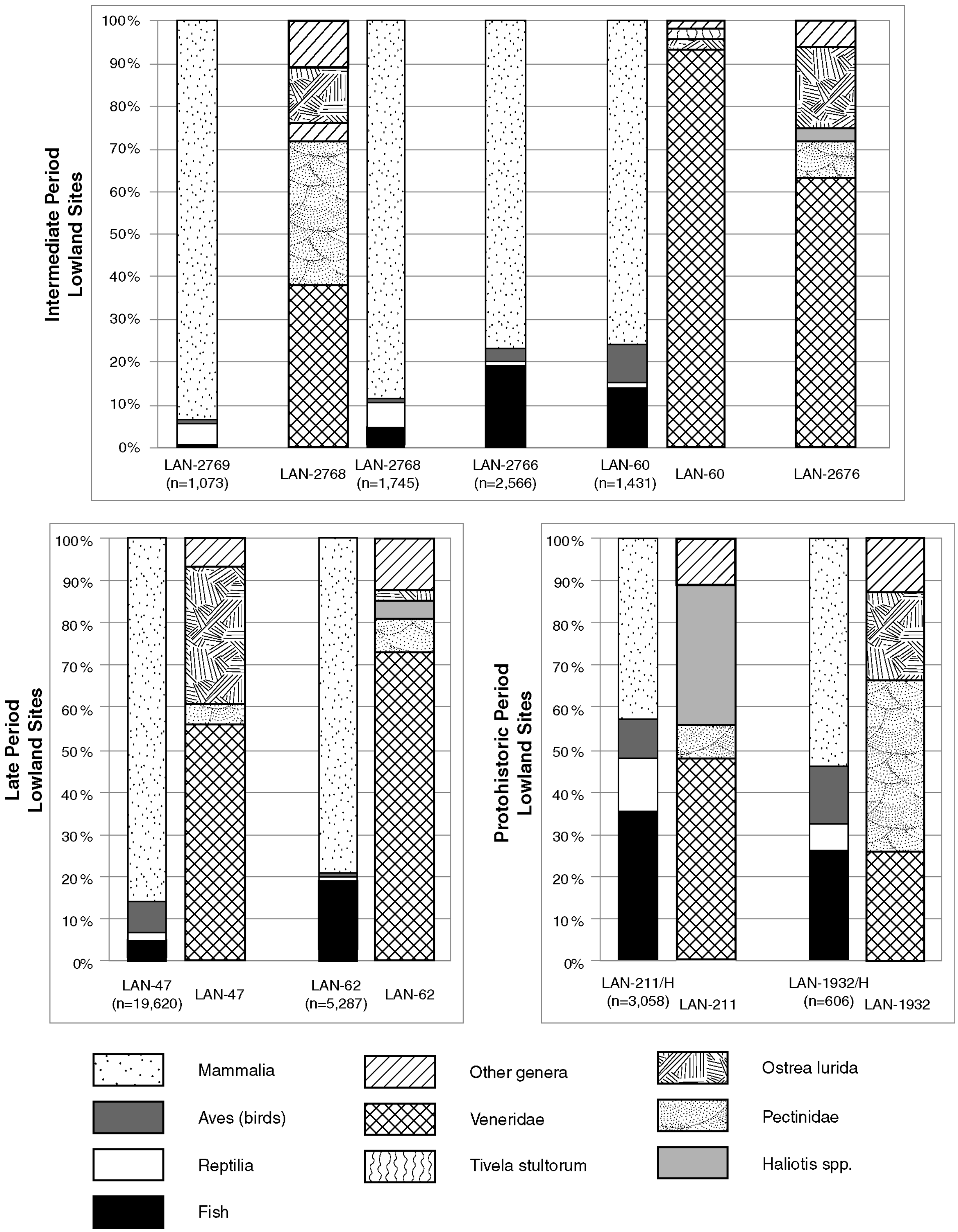


Figure 10.2. Faunal remains from lowland sites in the Ballona region.

Table 10.1. Vertebrate Faunal Remains from LAN-63

Taxon	Common Name	Actual Count	Estimated Count
Chondrichthyes	cartilaginous fish		
Elasmobranchii	sharks, skates, rays	206	206
Squatiniformes			
Squatinidae			
Squatina californica	angel shark	10	10
Carcharhiniformes			
Carcharhinidae			
Unidentifiable	requiem shark	1	1
Triakidae			
Galeorhinus galeus	tope shark	3	3
Triakis semifasciata	leopard shark	1	1
Unidentifiable	smoothhounds	6	6
Rajiformes			
Platyrhinidae			
Platyrhinoidis triseriata	thornback ray	1	1
Rhinobatidae			
Rhinobatus productus	shovelnose guitarfish	16	16
Rhinobatus sp.	guitarfish	1	1
Unidentifiable	skates	8	8
Myliobatiformes			
Myliobatidae			
Myliobatis californica	bat ray	9	9
Myliobatis sp.	ray	1	1
Subtotal, Chondrichthyes		263	263
Osteichthyes	bony fish		
Actinopterygii			
Unidentifiable	ray-finned fish	2,215	2,215
Clupeiformes			
Engraulidae			
Unidentifiable	anchovies	175	175
Clupeidae			
Sardinops sagax	Pacific sardine	45	45
Unidentifiable	herrings, shads, sardines	752	752
Atheriniformes			
Atherinopsidae			

Taxon	Common Name	Actual Count	Estimated Count
Leuresthes sardina	gulf grunion	1	1
Unidentifiable	flying fish, needlefish	688	688
Scorpaeniformes			
Scorpaenidae			
Sebastes spp.	rockfish	5	5
Cottidae			
Leptocottus armatus	Pacific staghorn sculpin	6	6
Unidentifiable	sculpins	4	4
Perciformes			
Carangidae			
Seriola lalandi	yellowtail	1	1
Haemulidae			
Xenistius californiensis	salema	1	1
Sciaenidae			
Genyonemus lineatus	white croaker	9	9
Seriphus politus	queenfish	9	9
Umbrina roncador	yellowfin croaker	1	1
Unidentifiable	drums, croakers	31	31
Embiotocidae			
Rhacochilus vacca	pile perch	2	2
Unidentifiable	surfperch	218	218
Labridae			
Chromis punctipinnis	blacksmith	1	1
Oxyjulis californica	senorita	17	17
Semicossyphus pulcher	California sheephead	1	1
Gobiidae			
Gillicthys mirabilis	longjaw mudsucker	25	25
Scombridae			
Scomber japonicus	Pacific chub mackerel	86	86
Pleuronectiformes			
Unidentifiable	flat fishes	72	72
Freshwater Fish			
Cypriniformes			
Cyprinidae			
Gila orcutti	arroyo chub	3	3
Unidentifiable	carps	5	5

Taxon	Common Name	Actual Count	Estimated Count
Gasterosteiformes			
Gasterosteidae			
Gasterosteus aculeatus	threespine stickleback	3	3
Subtotal, Osteichthyes		4,376	4,376
Unidentifiable fish		59	59
Subtotal, fish		4,698	4,698
Reptilia			
Squamata			
Unidentifiable	reptile	13	52
Squamata (Serpentes)			
Colubridae			
Lampropeltis getulus	kingsnake	1	2
Unidentifiable	poisonous snake	4	6
Chelonia			
Emydidae			
Actinemys marmorata	Pacific pond turtle	2	5
Testudinae			
Unidentifiable	tortoises/turtles	4	4
Subtotal, Reptilia		24	69
Aves			
Ciconiiformes			
Ardeidae			
Ardea herodias	great blue heron	1	2
Piciformes			
Picidae			
Colaptes auratus	northern flicker	1	2
Passeriformes			
Unidentifiable	passerines	1	2
Unidentifiable	bird	13	22
Subtotal, Aves		16	28
Mammalia			
Lagomorpha			

Taxon	Common Name	Actual Count	Estimated Count
Leporidae			
Sylvilagus sp.	cottontail rabbit	14	37
Unidentifiable	hares/rabbits	2	6
Unidentifiable		7	25
Rodentia			
Cricetidae			
Microtus californicus	California vole	1	2
Peromyscus sp.	mouse	2	4
Geomyidae			
Thomomys sp.	pocket gopher	16	23
Heteromyidae			
Perognathus californicus	California pocket mouse	1	4
Unidentifiable	pocket mouse	2	5
Unidentifiable	rodents	41	104
Cetacea			
Unidentifiable	whales	10	10
Carnivora			
Canidae			
Canis sp.	coyote/dog	1	2
Artiodactyla			
Cervidae			
Odocoileus sp.	deer	1	1
Unidentifiable	even-toed mammal	30	83
Unidentifiable	mammal	4,635	12,310
Subtotal, Mammalia		4,763	12,616
Unidentifiable		453	881
Total		9,954	18,292

Table 10.2. Habitats of Fish Recovered from LAN-63 and LAN-64

Taxon	Common Name	Habitat
Chondrichthyes	cartilaginous fish	
Elasmobranchii	sharks, skates, rays	
Squatiniformes		
Squatinidae		
Squatina californica	angel shark	shallow water outside surf line, on sand, or mud bottoms
Charcharhiniformes		
Charcharinidae		
Prionace glauca	blue shark	Tropical; subtropical; warm, temperate seas; deep water
Triakidae		
Triakis semifasciata	leopard shark	shallow areas with sandy bottom, in bays and lagoons, also shallow rocky areas
Rajiformes		
Platyrhinidae		
Platyrhinoidis triseriata	thornback ray	sandy areas just outside surfline—aggregate on tidal flats, bays, or lagoons
Rhinobatidae		
Rhinobatus productus	shovelnose guitarfish	shallow water; common in surf, shallow bays, sloughs, and estuaries
Unidentifiable		benthic dwellers of warm and temperate seas
Myliobatiformes		
Myliobatidae		
Myliobatis californica	bat ray	shallow bays and estuaries along sandy coastlines
Osteichthyes	bony fish	
Actinopterygii	ray-finned fish	
Clupeiformes		
Clupeidae		
Sardinops sagax	Pacific sardine	near shore, outer edge of kelp beds
Unidentifiable	anchovies	near shore and in shallow bays
Engraulidae		
Unidentifiable		coastal, usually near shore, found to depth of 220 m
Atheriniformes		

Taxon	Common Name	Habitat
Atherinopsidae		
Unidentifiable		tropical salt and freshwater environments
Leuresthes sardina	gulf grunion	sandy coasts
Scorpaeniformes		
Scorpaenidae		
Sebastes spp.	Rockfish	rocky areas with low reefs, open coasts with sandy beaches, near soft bottoms, tide pools
Cottidae		
Leptocottus armatus	Pacific staghorn sculpin	commonly found near shore, especially in bays and estuaries, most frequently on sandy bottoms
Unidentifiable		tide pools
Perciformes		
Carangidae		
Seriola lalandi	yellowtail	offshore islands, deep reefs, and outer kelp beds; near surface in summer and then fall to a depth of 69 m
Haemulidae		
Xenistius californiensis	salema	deep water
Sciaenidae		
Genyonemus lineatus	white croaker	inshore, waters shallower than 30 m sometimes in deeper water to 183 m
Seriphus politus	queenfish	inshore, common in bays, tidal sloughs, and around piers on sandy bottoms
Umbrina roncador	yellowfin croaker	shallow sand areas, bays, estuaries, and sloughs
Unidentifiable	drums, croakers	sandy bottoms or in estuaries
Embiotocidae		
Rhacochilus vacca	pile perch	inshore species near underwater obstructions such as pilings, jetties, piers, rocks, or kelp
Unidentifiable	surfperch	generally in the surf along sandy beaches
Labridae		
Chromis punctipinnis	blacksmith	near bottom, over or near rocks, especially over steep banks, and also in kelp beds
Oxyjulis californica	senorita	usually at depths shallower than 23 m, lives near kelp, seaweed, or over rocks

Taxon	Common Name	Habitat
Semicossyphus pulcher	California sheephead	rocky areas, in and around heavy kelp stands, 3–55 m
Gobiidae		
Gillicthys mirabilis	longjaw mudsucker	tidal flats, bays, and coastal sloughs, mud bottoms
Scombridae		
Scomber japonicus	Pacific chub mackerel	deep water, inshore schooling fish
Pleuronectiformes		
Unidentifiable	flatfishes	
Cypriniformes		
Cyprinidae		
Gila orcutti	arroyo chub	freshwater
Unidentifiable	carps	freshwater
Gasterosteiformes		
Gasterosteidae		
Gasterosteus aculeatus	threespine stickleback	freshwater

Note: Habitat information from Salls (1987) and Love (1996).

Table 10.3. Counts of Unidentifiable Mammal Bone, Burn Damage, and Fragmentation Index at LAN-63

Mammal Size Class	Burnt Bone		Type of Burn Damage			Total		FI
	n	%	Calcined (%)	Blackened (%)	Partially Blackened (%)	n	%	
Very small	24	19.5	33.3	50.0	16.7	123	1.0	22
Very small to small	129	29.5	3.1	79.8	17.1	437	3.5	23
Small	141	24.9	30.5	36.9	32.6	566	4.5	23
Small to medium sized	578	18.0	25.1	59.9	15.1	3,208	25.6	17
Medium sized	319	44.2	29.8	50.2	20.1	722	5.8	17
Medium sized to large	836	30.5	52.9	42.7	4.4	2,740	21.8	10
Large	308	47.4	27.9	67.5	4.5	650	5.2	12
Unidentifiable	1,469	35.9	31.7	63.4	5.0	4,095	32.7	10
Total	3,804	30.3	33.9	57.0	9.1	12,541	100.0	13

Note: Unidentifiable to family, genus, and species levels; calcined, blackened, and partially blackened category percentages are percentages of burned bone totals.

Key: FI = fragmentation index

Table 10.4. Bone Counts, Burn Damage, and Fragmentation, by Contexts at LAN-63 with More than 150 Bones

Provenience	Fish Count (n)	Nonfish Count (n)	Burnt Bone		Type of Burn Damage			FI
			n	%	Calcined (%)	Blackened (%)	Partially Blackened (%)	
U 36	231	2,670	380	14.2	32.1	44.5	23.4	12
U 53	64	529	74	14.0	32.4	62.2	5.4	13
Feature 1								
Rock concentration	143	39	8	20.5	50.0	50.0	0.0	10
Feature 8								
Rock concentration	142	82	16	19.5	25.0	75.0	0.0	11
Feature 9								
Rock concentration	117	45	7	15.6	71.4	28.6	0.0	14
Feature 10								
Rock concentration	232	79	2	2.5	50.0	50.0	0.0	10
Feature 11								
Artifact concentration	1,399	708	245	34.6	11.0	72.2	16.3	11
Feature 444								
Hearth	137	169	26	15.4	38.5	15.4	46.2	11
Feature 462								
Hearth	25	235	38	16.2	86.6	13.2	0.0	13
Feature 468								
Hearth	34	251	38	15.1	23.7	10.5	65.8	12
Feature 475								

Provenience	Fish Count (n)	Nonfish Count (n)	Burnt Bone		Type of Burn Damage			FI
			n	%	Calcined (%)	Blackened (%)	Partially Blackened (%)	
Burial	38	488	134	27.5	7.5	91.0	1.5	13
Feature 587								
Mourning	485	7,046	2,942	41.8	34.0	60.6	5.4	13
Feature 601								
Hearth	6	236	30	12.7	43.3	0.0	56.7	12
Rest of Site								
Mixed contexts	1,645	1,017	137	13.5	54.0	31.4	14.6	11
Total	4,698	13,594	4,077	30.0	32.8	58.2	9.0	12

Note: Counts presented in this table are for medium-sized and larger mammal bones. Only nonfish vertebrate remains were analyzed for burning. Total FI represents the overall FI average for the nonfish bone.
Key: FI = fragmentation index, U = unit

Table 10.5. Vertebrate Faunal Remains from LAN-64

Taxon	Common Name	Actual Count	Estimated Count
Chondricthyes	cartilaginous fish		
Elasmobranchii			
Unidentifiable	sharks, skates, rays	5	5
Squatiniformes			
Squatinidae			
Squatina californica	angel shark	1	1
Rajiformes			
Rhinobatidae			
Rhinobatus productus	shovelnose guitarfish	1	1
Subtotal, Chondricthyes		7	7
Osteichthyes	bony fish		
Actinopterygii			
Unidentifiable	ray-finned fish	5	5
Clupeiformes			
Clupeidae	herrings, shads, sardines	2	2
Atherinopsiformes			
Atherinopsidae			
Unidentifiable	flying fish, needlefish	1	1
Gobiidae			
Gillicthys mirabilis	longjaw mudsucker	1	1
Scorpaeniformes			
Cottidae			
Leptocottus armatus	Pacific staghorn sculpin	1	1
Perciformes			
Embiotocidae			
Unidentifiable	surfperch	1	1
Subtotal, Osteichthyes		11	11
Subtotal, fish		18	18

Taxon	Common Name	Actual Count	Estimated Count
Aves	birds		
Unidentifiable		40	40
Mammalia			
Rodentia	rodents		
Unidentifiable		6	11
Artiodactyla	even-toed mammals		
Unidentifiable		1	1
Unidentifiable	mammals	657	1,115
Subtotal, Mammalia		664	1,127
Unidentifiable		5	5
Total		727	1,190

Table 10.6. Bone Counts, Burn Damage, and Fragmentation, by Contexts at LAN-64 with More than 50 Bones

Provenience	Fish Count (n)	Nonfish Count (n)	Burnt Bone		Type of Burn Damage			FI
			n	%	Calcined (%)	Blackened (%)	Partially Blackened (%)	
U 11	—	73	37	50.7	8.1	—	91.9	10
U 13	—	72	6	8.3	100.0	—	—	10
U 14	—	69	6	8.7	100.0	—	—	12
U 1009	—	238	154	64.7	95.5	4.5	—	10
Feature 32	—	124	19	15.3	94.7	5.3	—	10
Faunal concentration								
Feature 50	1	56	5	8.9	40.0	—	60.0	11
Shell midden								
Feature 52	—	288	262	91.0	98.1	1.5	0.4	11
Burial								
Feature 76	—	199	175	87.9	90.9	6.9	2.3	10
Hearth								
Rest of Site	17	53	7	13.2	57.1	42.9	—	15
Mixed contexts								
Total	18	1,172	671	57.3	89.7	4.0	6.3	11

Note: Percentage of burnt bone is a percentage of the nonfish bones in the collection.
Key: FI = fragmentation unit, U = excavation unit

Table 10.7. Counts of Unidentifiable Mammal Bone, Burn Damage, and Fragmentation Index at LAN-64

Mammal Size Class	Burnt Bone		Type of Burn Damage			Total		FI
	n	%	Calcined (%)	Blackened (%)	Partially Blackened (%)	n	%	
Very small	1	25.0	100.0	—	—	4	0.4	20
Very small to small	—	—	—	—	—	9	0.8	28
Small	1	3.4	100.0	—	—	29	2.6	20
Small to medium sized	20	14.4	85.0	—	15.0	139	12.3	11
Medium sized	43	64.2	76.7	4.7	18.6	67	5.9	10
Medium sized to large	107	69.5	98.1	1.9	—	154	13.7	10
Large	453	69.7	94.0	4.9	1.1	650	57.7	10
Unidentifiable	44	58.7	40.9	—	59.1	75	6.7	10
Total	669	59.4	89.8	3.9	6.3	1127	100.0	11

Note: Unidentifiable to the family, genus and species level.
Key: FI = fragmentation index

Table 10.8. Vertebrate Faunal Remains from LAN-206A

Taxon	Common Name	Count
Mammalia		
Perissodactyls		
Equidae		
Equus caballus	horse	1
Unidentifiable		19
Total		20

Table 10.9. Comparison of Colby's and SRI's Vertebrate Faunal Remains (Nonfish) from LAN-63

Taxon	SRI		Colby	
	n	%	n	%
Reptilia				
Chelonia	9	0.1	6	—
Squamata (Serpentes)	60	0.4	68	0.5
Aves				
Anserimformes	—	—	—	--
Ciconiiformes	2	—	—	--
Falconiformes	—	—	—	--
Gaviiformes	—	—	—	--
Passeriformes	2	—	—	—
Piciformes	2	—	—	—
Unidentifiable	22	0.2	249	1.8
Mammalia				
Artiodactyla	84	0.6	80	0.6
Carnivora	2	—	115	0.8
Insectivora	—	—	2	—
Lagomorpha	68	0.5	610	4.4
Marsupialia	—	—	1	—
Pinnipedia	—	—	1	—
Rodentia	142	1.0	1,771	12.7
Sea mammals	10	0.1	75	0.5
Unidentifiable	13,191	97.0	11,022[a]	78.7
Total	13,594	100.0	14,000	100.0

Note: Species present, but no exact counts given. Unless noted, the numbers in the Colby columns come from Colby's (1987a, 1987b) research. The percentage columns represent a percentage of the total collection.

[a] This number represents SRI's estimate of the amount of unidentifiable bones in Colby's (1987a, 1987b) collection. Estimated total count based on Colby's stated percentage of identifiable weight.

Table 10.10. Comparison of Colby's and SRI's Fish Species from LAN-63

Taxon	Common Name	SRI		Salls	
		n	%	n	%
Chondrichthyes	cartilaginous fish				
Elasmobranchii	sharks, skates, rays	206	4.4	—	—
Squaliformes				1	—
Squalidae					
Squalus acanthias	spiny dogfish	—	—		
Squatiniformes	angel shark	10	0.2	65	1.1
Squatinidae					
Squatina californica					
Heterodontiformes				43	0.7
Heterodontidae					
Heterodontus francisci	horn shark	—	—		
Lamniformes				14	0.2
Lamnidae					
Carcharodon carcharias	white shark	—	—		
Isurus oxyrinchus	shortfin mako	—	—	8	0.1
Triakidae				—	—
Galeorhinus galeus	tope	3	0.1		
Mustelus californicus	gray smoothhound	—	—	35	0.6
Mustelus henlei	brown smoothhound	—	—	5	0.1
Triakis semifasciata	leopard shark	1	—	48	0.8
Unidentifiable	smoothhound	6	0.1	43	0.7
Carcharhiniformes				15	0.2
Carcharidae					
Prionace glauca	blue shark	—	—		
Unidentifiable	requiem shark	1	—	—	—
Torpediniformes				12	0.2
Torpedinidae					
Torpedo californica	Pacific electric ray	—	—		
Rajiformes				437	7.2
Platyrhinidae					
Platyrhinoidis triseriata	thornback ray	1	—		
Rhinobatidae				950	15.6
Rhinobatis productus	shovelnose guitarfish	16	0.3	—	—
Rhinobatis sp.	guitarfish	1	—	184	3.0
Unidentifiable	skates	8	0.2		

Taxon	Common Name	SRI		Salls	
		n	%	n	%
Myliobatiformes				409	6.7
Dasyatidae					
Urolophus halleri	round stingray	—	—		
Myliobatidae				583	9.5
Myliobatis californica	bat ray	9	0.2		
Myliobatis sp.	stingray	1	—	—	—
Osteichthyes	bony fish				
Actinopterygii				—	—
Unidentifiable	ray-finned fish	2,215	47.1		
Clupeiformes				4	0.1
Engraulidae					
Anchoa compressa	deepwater anchovy	—	—		
Engraulis mordax	northern anchovy	—	—	19	0.3
Unidentifiable	anchovies	175	3.7	—	—
Clupeidae				1,028	16.8
Sardinops sagax	Pacific sardine	45	1.0		
Unidentifiable	herrings, shads, sardines	752	16.0	22	0.4
Batrachoidiformes				2	—
Batrachoididae					
Porichthus spp.	midshipman	—	—		
Atheriniformes				—	—
Atherinopsidae					
Leuresthes sardina	Gulf grunion	1	—		
Unidentifiable	flying fish, needlefish	688	14.6	299	4.9
Scorpaeniformes				32	0.5
Scorpaenidae					
Sebastes spp.	rock fish	5	0.1		
Cottidae				7	0.1
Leptocottus armatus	Pacific staghorn sculpin	6	0.1		
Scorpaenicthys marmoratus	cabezon	—	—	1	—
Unidentifiable	sculpins	4	0.1	3	—
Serranidae				42	0.7
Palabrax spp.	sea bass	—	—		
Perciformes				1	—
Carangidae					
Seriola lalandi	yellowtail	1	—		

Taxon	Common Name	SRI		Salls	
		n	%	n	%
Trachurus symmetricus	jack mackerel	—	—	118	1.9
Haemulidae				1	—
Anistremus davidsonii	sargo	—	—		
Xenistius californiensis	salema	1	—	—	—
Sciaenidae				10	0.2
Atractoscion nobilis	white seabass	—	—		
Genyonemus lineatus	white croaker	9	0.2	9	0.1
Mentricirrhus undulatus	California corbina	—	—	65	1.1
Roncador streansii	Spotfin Croaker	—	—	15	0.2
Seriphus politus	queenfish	9	0.2	1	—
Umbrina roncador	yellowfin croaker	1	—	24	0.4
Unidentifiable	drums, croakers	31	0.7	55	0.9
Embiotocidae				64	1.0
Amphistichus sp.	surfperches	—	—		
Embiotoca spp.	perches	—	—	107	1.8
Hyssurus caryi	rainbow seaperch	—	—	123	2.0
Phanerodon spp.	seaperches	—	—	96	1.6
Rhaccochilus toxotes	rubberlip surfperch	—	—	8	0.1
Rhaccochilus vacca	pile perch	2	—	145	2.4
Unidentifiable	surfperch	218	4.6	194	3.2
Labridae				—	—
Chromus punctipinnis	blacksmith	1	—		
Haliochoeres semicinctus	rock wrasse	—	—	2	—
Oxyjulis californica	senorita	17	0.4	—	—
Semicossyphus pulcher	California sheephead	1	—	24	0.4
Gobiidae				—	—
Gillicthys mirabis	longjaw mudsucker	25	0.5		
Sphraenidae				20	0.3
Sphyraena argentea	Pacific barracuda	—	—		
Scombridae				4	0.1
Sarda chiiensis	Pacific bonito	—	—	336	5.5
Scomber japonicus	Pacific chub mackerel	86	1.8		
Thunnus albacares	albacore (yellowfin tuna)	—	—	1	—
Thunnus spp.	tuna	—	—	4	0.1
Pleuronectiformes				42	0.7
Unidentifiable	flatfish, flounders, soles	72	1.5		

Taxon	Common Name	SRI		Salls	
		n	%	n	%
Paralichthyidae				1	—
Citharichthys sordidus	Pacific sanddab	—	—		
Paralichthys californicus	California halibut	—	—	89	1.5
Xystreurys liolepis	fantail sole	—	—	2	—
Pleuronectidae				4	0.1
Eopsetta jordani	petrale sole	—	—		
Lopsetta exilis	slender sole	—	—	13	0.2
Microstomus pacificus	dover sole	—	—	5	0.1
Pleuronichthys coenosus	C-O sole	—	—	1	—
Pleuronichthys guttulatus	diamond turbot	—	—	181	3.0
Pleuronicthys ritteri	spotted turbot	—	—	2	—
Freshwater fish					
Cypriniformes				—	—
Cyprinidae					
Gila orcutti	arroyo chub	3	0.1		
Catostomidae				11	0.2
Catostomus santaanae	Santa Ana sucker	—	—		
Unidentifiable	carp	5	0.1	—	—
Salmoniformes				3	—
Salmonidae					
Oncorhynchus mykiss	steelhead	—	—		
Oncorhynchus spp.	salmonids	—	—	16	0.3
Gasterosteiformes				—	—
Gasterosteidae					
Gasterosteus aculeatus	threespine stickleback	3	0.1		
Unidentifiable fish		59	1.3	--	--
Total		4,698	98.7	6,108	100.0

Table 10.11. Comparison of Colby's and SRI's Vertebrate Faunal Remains (Nonfish) from LAN-64

Taxon	SRI		Colby	
	n	%	n	%
Reptilia				
Chelonia	—	—	6	0.4
Squamata (Serpentes)	—	—	5	0.4
Aves				
Unidentifiable	40	3.4	49	3.5
Mammalia				
Artiodactyla	1	0.1	6	0.4
Carnivora	—	—	4	0.3
Cetacea	—	—	2	0.1
Lagomorpha	—	—	22	1.6
Pinnipedia	—	—	2	0.1
Rodentia	11	0.9	44	3.1
Unidentifiable	1,120	95.6	1,260[a]	90.0
Total	1,172	100.0	1,400	100.0

Note: Species present, but no exact counts given. Unless noted, the numbers in the Colby columns come from Colby's (1987a, 1987b) research. The percentage columns represent a percentage of the total collection.

[a] This number represents SRI's estimate of the amount of unidentifiable bones in Colby's (1987a, 1987b) collection. Estimated total count based on Colby's stated percentage of identifiable weight.

Invertebrate Faunal Remains

Sarah J. Van Galder and John G. Douglass

The results of invertebrate faunal studies at West Bluffs provide valuable information about prehistoric human behavior and human environment interaction in the Ballona region. Invertebrate types and abundance in archaeological contexts reflect environmental changes affecting the habitats of different invertebrate species, the timing of human exploitation, and changes in prehistoric subsistence practices affecting foraging choices (Claassen 1998:6). Excavations and analyses of archaeological remains at West Bluffs was conducted to complement and verify previous work done by Van Horn in the 1980s. In this chapter, we report the kinds and abundances of invertebrates recovered during 2000 and 2003 excavations at LAN-63 and LAN-64 to address questions concerning prehistoric human behavior and the chronology of settlement and environmental change in the Ballona wetlands.

Methods

A sample of shell from units and features containing the greatest abundance of shell was selected for analysis at LAN-63 and LAN-64. We analyzed all of the shell from the units and features selected for analysis at LAN-64, but because of the abundance of shell in some contexts at LAN-63, we analyzed shell from a sample of selected proveniences. Twenty-five percent of the shell was analyzed from Units 36 and 210 in Feature 587, and 50 percent from Unit 53. Therefore, only a percentage of the total shell from these areas is described. Consequently, the shell assemblages from these areas, particularly Feature 587, should represent a much higher percentage in both counts and weights than described here. The number of shell analyzed from SRI's LAN-63 collection was much smaller than that analyzed by DiGregorio from the 1986 Archaeological Associates excavations. Because DiGregorio's analysis was so extensive, we felt that analysis of a small sample from a variety of site areas excavated during the 2000 and 2003 field seasons would be effective in verifying previous work and identifying any anomalies between the studies. The number of shell analyzed from LAN-64 for the current study and that by DiGregorio were comparable.

All shell fragments larger than ¼ inch from the sample collection were analyzed and identified completely. Previous work at LAN-62 (Keller and Ford 1998:101) showed no difference in taxa representativeness between the ⅛-inch fraction and larger sizes. Given the considerable effort required to analyze ⅛-inch shell and the tendency for the relative number of identifiable specimens (NISP) to decrease with smaller screen sizes, we decided to analyze only diagnostic shell elements that could be used for calculating the minimum number of individuals (MNI) from the ⅛-inch fraction.

The shell material from each provenience was analyzed separately. Each specimen was identified to the most specific taxonomic level possible with reference to standard identification guides (e.g., Keen and Coan 1974; McLean 1978; Morris et al. 1980; Rehder 1996; Rickets et al. 1985) and to the SRI shell type collection. Where the guides differ, we relied on Rehder's (1996) recent classification.

In addition to taxonomic identification, all shell pieces were weighed and counted. Analysts assigned NISP values to all shell fragments that could be assigned to at least family level. To determine MNI, analysts counted all nonrepetitive elements. For bivalves (class Pelecypoda), this included the number of whole hinges and hinge fragments that were more than 50 percent complete, whereas for gastropods (class Gastropoda), each whole shell, columella, and apex was counted. For bivalves, MNI was calculated by determining the number of left and right valves, and using the larger quantity as the MNI. In cases where right and left valves could not be determined, MNI was calculated by dividing NISP by 2, because in life, each animal has two valves. The technique for counting MNI for gastropods is equivalent to the count of nonrepetitive elements.

The fragmentation index (FI) was calculated for the sampled shell from all analyzed site contexts in LAN-63 and LAN-64. The degree of shell fragmentation provides information on site-formation processes. In order to compare the degree of fragmentation between different contexts, we followed the method outlined by Claassen (1998:114–115), in which the fragmentation ratio is calculated by dividing the total weight from the ½-inch and larger size classes by the total weight of the shell from the ¼-inch size class. The smaller the value, the higher the fragmentation, and, conversely, the larger the number, the less fragmented the shell collection.

NISP, MNI, and shell weight are used to discuss shell remains from LAN-63 and LAN-64. The count of nonrepetitive elements was used for regional comparisons of sites in the Ballona region. Other Ballona sites generally have shell amounts expressed in this form.

Results

A total of 6,391 shell fragments representing 19 species were present at West Bluffs. Table 11.1 shows the families, genera, species, and habitat types represented at both LAN-63 and LAN-64. The great majority of the shell was recovered from LAN-63. No shell was recovered from LAN-206 during the 2003 excavations.

LAN-63

A total of 5,421 shell fragments representing 17 species were analyzed from LAN-63. Fifty-two percent of the shell fragments were identifiable to family level and 45 percent were identifiable to genus level (Tables 11.2 and 11.3). *Chione* spp. (Venus clam), *Ostrea lurida* (native Pacific oyster), *Protothaca staminea* (Pacific littleneck clam), and *Argopecten circularis* (Pacific calico scallop) dominated our collection. Shell from four features (Features 15, 337, 468, and 587) and three excavation units (Units 15, 36, and 53) accounted for more than 95 percent of the shell collection and were used here for further analysis. Unit 36 and Feature 587 were located in the shell midden as defined by Van Horn (1987). Venus and littleneck clam dominated all units and features except Feature 15, which consisted of one *Haliotis* sp. (abalone) shell and one mano (Table 11.4). Native Pacific oyster was also highly represented in Features 337 and 587. The high percentages of Venus clam ranged from 45 percent to 93 percent, depending on the unit or feature. Shell was fairly fragmented throughout the site, averaging a fragmentation index of 2.54 (Table 11.5). Generally, the shell from unit contexts was more fragmented than that of feature contexts. There was no clear pattern between levels and the degree of fragmentation in the units and features.

Feature 587

Feature 587, an extensive mourning feature, contained a high density of cultural material, particularly fragmented ground stone and faunal remains. The feature was located in the eastern part of the primary shell midden as described by Van Horn (1987) and excavated in portions of 16 1-by-1-m units (Figure 11.1). We analyzed shell from all seven levels of Unit 210, which contained the densest concentration of artifacts, bone, and shell in this feature. Of the analyzed site areas, Feature 587 contained the densest amount of shell and the most species (Table 11.6). Levels 4, 5, and 6 contained the most shell. Level 5 contained the highest shell weight, but Level 6 contained the highest number of represented species. Despite the high quantity of shell, the feature contained the lowest relative abundance of Venus clam on site, but relatively high amounts of Pacific littleneck clam and native Pacific oyster (see Table 11.4). The fragmentation index from the feature was relatively low, indicating high fragmentation compared to other site areas (see Table 11.5). The large size of the shell midden and the high fragmentation of shell from these midden contexts suggested that shell was discarded in this area, and the refuse was subject to at least some trampling.

Feature 468

Feature 468 was a small rock hearth (0.06 m^3) containing a dense concentration of FAR and ground stone. This feature, in the northeastern part of the site (see Figure 11.1), contained the highest relative abundance of Venus clam, some littleneck clam, and very little scallop (see Table 11.4). Only these three species were represented, perhaps due to the small size of this feature and the small quantity of shell recovered. The shell fragmentation index from this feature was significantly high, indicating less fragmentation than elsewhere at the site (see Table 11.5). The shellfish might have been processed next to the hearth, and the shell discarded into it; given the hearth context, we would not expect shell to be as fragmented here as in other areas that were usually subjected to more trampling.

Feature 337

Feature 337 was a slightly larger hearth (0.20 m^3) consisting of a dense concentration of FAR, ground and flaked stone, and charcoal in the southwestern part of the site (see Figure 11.1). A relatively high density of shell, representing eight species, was discovered in this feature (see Table 11.5). Venus clam again was the majority of shell in the feature, with significant amounts of littleneck clam, native Pacific oyster, and calico scallop also present (see Table 11.4). The shell from this feature was less fragmented than most of the site except for Feature 468 (see Table 11.5).

Feature 15

Feature 15 was a very small feature consisting only of one abalone shell, fragmented into more than 200 pieces, and one mano. Figure 11.1 shows its location in LAN-63.

Unit 53

This unit was near the center of the site, north of the shell midden; the two levels excavated both contained shell fragments. Although Table 11.6 shows a low quantity of shell in Unit 53, 13 species were represented. As was common at this site, the collection from this unit was dominated by Venus clam and littleneck clam, but the shell was slightly more fragmented compared to shell from the rest of the site (see Table 11.5).

Unit 36

Unit 36 was north of Feature 587, in the northeastern periphery of the shell midden as defined by Van Horn (1987) (see Figure 11.1). Nine levels from this unit were excavated, and all contained shell. Shell density and the number of species represented was high, second only to Feature 587. Levels 5–8 have the highest shell density in this unit (see Table 11.6). Again, Venus clam and Pacific littleneck clam dominated the assemblage in this unit (see Table 11.4). The unit also contained significant numbers of two species not found in other site contexts, *Cerithidea californica* (California horn shell) and *Pectin caurinus* (giant Pacific scallop).

Unit 19

This unit was located in the western part of the site, just west of the shell midden (see Figure 11.1). Shell was recovered from all five levels of Unit 19 in relatively small amounts. Only three species were represented in these levels, with Venus clam constituting more than 90 percent of the shell from this unit, and smaller amounts of littleneck clam and *Tivela stultorum* (Pismo clam) also present (see Tables 11.4 and 11.6). The shell from this unit was the most fragmented on the site (see Table 11.5).

LAN-64

LAN-64 contained much less shell than LAN-63. A total of 970 shell fragments, representing 11 species, were analyzed from four units and six features in LAN-64. Very little shell was found in other site areas. About 80 percent of the analyzed shell were identifiable to family, and slightly more than 70 percent were identifiable to genus (Tables 11.7 and 11.8). More than 90 percent of the shell from LAN-64 was from shell-dump features. Excavators recovered very little shell from the excavation units, in which only Venus clam and unidentifiable shell were found.

Venus clam has the highest MNI; however, scallop has greater total counts and much higher weights than Venus clam (see Table 11.8). No scallop shell was found outside of feature contexts, and all but one piece was found in four features: 45, 49, 50, and 55 (Table 11.9). Venus clam dominated the collections in all of the 1-by-1-m excavation units and one feature (Feature 60). One abalone shell and a few unidentifiable shell fragments were recovered in Feature 76, a rock concentration.

The five shell-dump features showed the densest concentration of shell, the highest number of represented genera and species, and the least fragmentation (Tables 11.10 and 11.11). The four features dominated by scallop were even less fragmented than the other shell dump, the rock feature, and the excavation units. The low fragmentation for units and features dominated by Venus clam shell was unexpected because scallop shell is much lighter than Venus clam shell; all other parameters being equal, one would expect that Venus clam shell, with the highest MNI count, would have far outweighed and been less fragmented than the more fragile shell of the scallop. This was not the case at LAN-64. The preservation of shell in the dump-feature contexts indicated that these were largely undisturbed, primary deposits, whereas other site areas were disturbed and therefore, shell was more fragmented.

Based on current radiocarbon dates, there were three components at LAN-64: an early Millingstone period component, a general Millingstone period component, and an Intermediate period component.

Feature 60, which was dominated by Venus clam, dates to the early Millingstone period. Four of the five shell-dump features dated to the later Millingstone period. During his excavations at LAN-64 during the 1980s, Van Horn did not sample anything that dated earlier than Intermediate period. Likely, archaeological remains from the four excavation units and Feature 76, which were not as deep as the shell dump features, dated to the Intermediate period, as did Van Horn's assemblage. Based on our dates and shell collection, it seems there was a shift in shellfish use through time: an emphasis on Venus clam during the early Millingstone period; on scallop, including *Argopecten circularis* and *Pecten* sp., during the later Millingstone period; and back to Venus clam during the Intermediate period. Only one shell from Feature 60 was dated, however, and no other contexts were this old.

Units 11–14

Units 11 and 12 were in the north-central part of LAN-64, just to the southeast of Feature 49. Units 13 and 14 were in the center of the site, about 30 m southeast of Units 11 and 12 (see Figure 11.2). Units 11 and 12 were excavated to 20 cmbs and Units 13 and 14 down to 40 cmbs. These units contained very little shell, and Venus clam was the only identifiable species (see Tables 11.9 and 11.10). The shell from these units was very fragmented (see Table 11.11), probably due to modern plowing. The few artifacts recovered from these units included shell, flakes, FAR, and a few shards of green and brown glass.

Feature 45

Feature 45 was located in the center of the site, close to both Features 50 and 55 (see Figure 11.2). This feature was one of the five shell-dump features sampled. *Argopecten circularis* and *Pecten* sp. dominated the shell collection. Venus clam and oyster were also present in much smaller percentages. The shell from this feature was the least fragmented of any sampled context on the site (see Table 11.11). This shell-dump feature was one of the four that dated to the Millingstone period.

Feature 49

This feature was located near the center of the site, almost on top of the hill, north of other analyzed features (see Figure 11.2). Again, the two scallop types dominated, with smaller quantities of Venus clam, oyster, and *Strombus maculatus* (Nuttall shell) also present. Some flaked stone was also recovered in this feature, which was dated to the Millingstone period.

Feature 50

Feature 50 was a shell dump containing some faunal bone and was located near Features 45 and 55 in the center of the site (see Figure 11.2). As at most of the shell-dump features sampled, scallop dominated this feature, although Venus clam and native Pacific oyster were also present in smaller amounts. This feature, too, dated to the Millingstone period. Feature 50 contained the most diverse shell collection in the analyzed sample from LAN-64: although only 54 shell fragments were identifiable to genus, 7 taxa were recovered including three *Chione* species.

Feature 55

This feature was another shell dump located in the center of the site (see Figure 11.2). Again, both types of scallop were the most abundant, with lesser amounts of Venus clam, native Pacific oyster and giant Pacific scallop. This collection also dated to the Millingstone period. This feature contained the only giant Pacific scallop fragment found in LAN-64.

Feature 60

Feature 60 was a shell dump dominated almost completely by Venus clam that dates to the early Millingstone period. Flaked stone and one littleneck clam fragment were also recovered from the feature. The feature was located in the southern part of the site (see Figure 11.2).

Feature 76

Feature 76 was the only sampled feature that was not a shell dump; the feature was in the southwestern part of the site (see Figure 11.2). The feature contained FAR, flaked and ground stone, faunal bone, charcoal, one abalone shell fragment, and a few unidentifiable shell fragments. Based on its stratigraphic location at LAN-64, this feature probably dated to the Intermediate period, but nothing in the feature was radiocarbon dated.

Comparison with Previous Work at West Bluffs

LAN-63

Although DiGregorio (1987) analyzed a much greater number of shell, the results of the current study at LAN-63 were similar to those of DiGregorio's analysis in 1987 (Table 11.12). The most abundant shellfish in both excavations included Venus clam, native Pacific oyster, calico scallop, and Pacific littleneck clam. The major difference between the two studies was the sampling strategy. Van Horn analyzed shell from only the site area with the densest shell, six units in the western portion of the primary shell midden. The current study also concentrated on areas with dense shell concentrations, but also included excavation units and feature contexts outside the shell midden.

DiGregorio (1987) analyzed a total of 16,040 diagnostic valves from a volume of 7.4 m^3, averaging 2,168 diagnostic valves per cubic meter. As stated above, the current study focused on shell from 5.4 m^3 from a variety of site areas, only two of which were located in the dense shell midden. Consequently, the diagnostic valves identified from the current study average only 125 diagnostic valves per cubic meter. Feature 587 and Unit 36 were located in the eastern portion of this midden. Even after adjusting counts to reflect 100 percent of the sample from these areas, Feature 587 averaged only 1,154 diagnostic shell fragments per cubic meter and Unit 36 only 751 diagnostic fragments per cubic meter. Feature 587 contained about 50 percent less shell than Van Horn's sample and Unit 36 even less than that.

Although the same four species make up the majority of the collections from both studies, there were some differences in the relative abundance shown by the two studies. DiGregorio's results showed a relative abundance 15 percent higher for Venus clam than the current study. This may be due to the smaller collection from the current study or to the different sampling strategies of the two studies, as mentioned above.

Interestingly, Feature 587, located in the primary shell deposit, contained the lowest relative percentage of Venus clam on the site (except for Feature 15, which consists of single abalone shell). Given its location in the midden, we would have expected the ratio of taxa from Feature 587 to be more similar to those from the Van Horn excavations. Slightly more than 75 percent of the shell from Unit 36, located in the periphery of the shell midden, was Venus clam, almost 10 percent lower than Van Horn's results. Based on our collection, all areas outside the shell midden had a higher percentage of Venus clam than contexts in the shell midden, except for Feature 15, which was outside the midden area and contained no Venus clam.

Results from the current study suggest there was significant variation within the midden. Given its size, the midden was likely the result of many shell-dumping episodes so that the shell density and the relative abundance of particular species from different areas in the midden would not necessarily be identical.

LAN-64

Table 11.13 shows that the relative abundances of particular taxa at LAN-64 were very different between the DiGregorio study (1987) and the current study. Although Venus clam dominated the NISP for both sites, there was almost a 60 percent difference in relative abundance. Also, as stated earlier, Venus clam might have had the highest relative abundance for MNI in SRI's collection, but both *Argopecten circularis* and *Pecten* sp. had higher weights and counts than Venus clam. DiGregorio did not note any scallop during her 1987 work.

DiGregorio (1987) analyzed shell from the site areas with the densest shell, including three 2-by-2-m units, but no feature contexts. Most of the shell (83 percent) was found in the upper 30 cm, and no shell was found deeper than 60 cmbs. DiGregorio also noted the generally poor condition of the valves, likely due to their shallow position in the midden, where modern agricultural activities (discing and fertilization) would have disturbed the upper 20 or 30 cm.

The current study included analysis of shell from several units that were comparable in depth to the previous study, extending only to 40 cmbs, and from several features that were deeper, between 54 and 129 cmbs. These features dated between 6500 and 8500 B.P. All but one feature (Feature 76) was found below the depth to which Van Horn's excavation units extended.

The results of DiGregorio's work, showing the predominance of Venus clam from the top 60 cm of LAN-64, support our data from the excavation units and Feature 76, which were also dominated by Venus clam and likely dated to the Intermediate period. She only excavated Intermediate period strata in which Venus clam was targeted over other species. The deeper and older shell-dump features represent activities of an earlier period, in which scallop was the shellfish of choice, and which were not discovered or analyzed in the previous study.

Discussion

Targeted Species and Habitat Use

Three species dominated DiGregorio's and SRI's shell collections at LAN-63 and LAN-64: Venus clam, scallop, and oyster; littleneck clam was also abundant at LAN-63. Together, these species constituted more than 90 percent of both shell assemblages. All four species thrive in estuarine environments, not surprising given West Bluffs' proximity to the Ballona estuary.

During the Millingstone period at LAN-64, the inhabitants preferred both types of scallop, especially Pacific calico scallop, to Venus clam and other species. Together, these scallops accounted for about 75 percent of the shellfish in the shell-dump features from this period. Although scallop dominated, Venus clam still constituted almost 15 percent of the collection. Later, during the Intermediate period, prehistoric inhabitants targeted the Venus clam at both LAN-63 and LAN-64.

Two common species recovered during excavations at LAN-63 and typically found in protected bays were likely not targeted by prehistoric inhabitants for subsistence or shell decorations: *Crepidula* sp. (slipper shell) and *Cerithidea californica* (California horn shell). The slipper shell frequently attaches itself to other shellfish, such as scallops, and was likely brought in attached to other shellfish. California horn shell is abundant on mud flats in protected bays and often forms dense aggregations under debris and among plants (Morris et al. 1980). It seems possible, if not likely, that these shellfish were unintentionally picked up while collecting such other species as Venus and littleneck clams, which were also found on mud flats in estuarine environments. Neither the horn shell nor the slipper shell provides much meat and likely would not have been targeted as a food source. One California horn shell recovered from LAN-63 was possibly worked, however. Given that only six of these shellfish were found and only one was possibly worked indicated that these shellfish were probably not collected for the purpose of making shell decorations.

The only species at LAN-63 and LAN-64 that were not typically found in quiet bays or estuaries included *Patinopecten caurinus* (giant Pacific scallop), *Tivela stultorum* (Pismo clam), and *Haliotis* sp. (abalone). Pismo clam is found only along wave-swept beaches (Erlandson 2004). Only three Pismo clam fragments, representing one individual, were recovered at LAN-63, suggesting that neither sandy-beach taxa nor collection activities along sandy beaches were of great significance. One highly fragmented abalone was found in Feature 15 at LAN-63 and one abalone fragment was found at LAN-64. Abalone is typically found along rocky shores in intertidal or moderately deep water (Knopf 1981). They are not exclusively rocky-shore species, however, and specimens are regularly found on rocks in the shallow waters of bays and at the mouths of estuaries. Therefore, the abalone fragments recovered from the West Bluffs sites could have been gathered from the Ballona estuary system. The giant Pacific scallop prefers sandy or gravelly habitats in waters 18–91 m deep (Rehder 1981). Although a total of 27 giant Pacific scallop fragments were recovered from LAN-63, only one individual was represented. It does not seem likely that the Pismo clam or giant Pacific scallop were targeted, and neither of the species likely played a significant role in subsistence at LAN-63 or LAN-64.

There were three components represented at LAN-64: an early Millingstone period component, a later Millingstone period component, and an Intermediate period component. Feature 60 was a shell dump that dated to the early Millingstone period. Venus clam constituted more than 98 percent of the shell found in this feature. The other shell-dump features dated to later in the Millingstone period. As stated earlier, scallops were about 75 percent of the shellfish at LAN-64 during this early period. The early predominance of scallop might have been due to human preference for the scallop or an environment slightly different than that during the Intermediate period in which scallop were more predominant. According to optimal-foraging theory, foragers should exploit food sources with high rates of energy return for the energy invested to procure the resource (see Kelly 1995). Table 11.14 shows the meat yields per shell weight of particular species. Scallop contained 2.54 times more meat per shell weight than Venus clam. Although scallop meat constituted 80 percent of all projected shellfish meat at LAN-64, Venus clam predominated in later periods: why?

During the early Millingstone period, the Ballona was an open, unprotected bay. At about 6500 B.P., the open bay started to fill in, extending the salt marsh and mudflats (Shelley et al. 2003). The water became increasingly brackish as the open bay filled in and a barrier formed between the bay and the ocean. Shelley et al. (2003) noted that by 4000 B.P. all oyster and *Siliqua patula* (Pacific razor clam) disappeared from the bay and were replaced by horn snails, which are much more tolerant of fresh water.

Scallops may be better adapted to an open-bay habitat than Venus clam, or, alternatively, Venus clam may be better adapted to estuarine lagoons. Both types of scallop recovered at West Bluffs prefer habitats on sandy or muddy bottoms in fairly shallow waters of bays (as deep as 60 m) or in protected waters (Morris et al. 1980). Venus clams prefer mud or sand flats in bays or estuaries (Knopf 1981) and also tolerate brackish waters better than scallops. Although both species prefer quiet waters and both were present in the Ballona during most of the Holocene, their habitats are different enough that the changing bay environment could have caused a shift in their relative abundance. The archaeological record at LAN-64 suggests that, for some reason, people preferred to collect scallops more than any other shellfish type during the Millingstone period, when the bay was just starting to fill in. Later, during the Intermediate period, when waters were more brackish and the mudflats had increased, the archaeological record shows that Venus clam was targeted over scallop and most other shellfish. It seems likely that these shifts are linked. We propose that the environmental shift created a better habitat for Venus clam during the Intermediate period, making this species more abundant than scallop and more convenient to collect.

Venus clam burrow just under the mud or sand on tidal flats. For this reason, collection strategies for Venus clam are quite simple. They are easily collected by digging at low tide when tidal flats are exposed, or by wading and digging in the shallows. The two species of scallop recovered at LAN-64 have slightly different habitats than Venus clam. Occasionally, scallops will attach themselves to rocks or other shellfish that are on the intertidal beach. Scallops can also be found free swimming in the ocean to depths of 60 m. Typically, however, scallops lie on the bottom of the ocean or bay floor from 1 to 50 or 60 m deep (Morris et al. 1981) and therefore are not as easily collected as Venus clam.

Given their specific habitat, one would expect that scallops would have been more difficult to collect than such other estuary species as Venus clam. When Venus clam were not abundant, however, it would not be economical to spend the time to collect them, particularly as they provide less meat than other species. It might have taken as much or more time to collect as much meat from Venus clam as it would have to collect scallop. In this case, it might have been worth spending the time to procure scallop rather than Venus clam. During the Intermediate period ,when Venus clam habitat increased in the Ballona wetlands, it became more economical to procure the more abundant Venus clam.

Spatial Variation within West Bluffs

LAN-63

All of the dated contexts in LAN-63 dated to the Intermediate period. There seems to be some spatial variation between different contexts in this site. The collection from midden contexts (Feature 587 and Unit 36) showed the highest shell density in the site and generally more fragmentation than that of the hearth features, Features 337 and 468, which also contained high densities of shell. The difference in amounts of breakage was not surprising, as shell in hearth contexts likely would not be subjected to as much trampling as in other site areas. The shell from the two excavation units located outside of the midden area (Units 19 and 53) was even more fragmented than shell from the midden.

There does not seem to be a clear pattern of differing species composition among various contexts at this site as at LAN-64. As stated earlier, Feature 587, the mourning feature in the shell midden, contained the lowest relative abundance of Venus clam and a high number of species compared to other units and features. Unit 36, also in the shell midden, also contained a high number of represented species, and both these contexts contained the only California horn shell from our collection. Unit 36, however, contained a much higher relative percentage of Venus clam than Feature 587. Unit 53, north of the shell midden, and Unit 36 contained the only giant Pacific scallop found in our collection. Feature 468, a hearth in the northeastern part of the site, contained the highest relative percentage of Venus clam and the least number of represented species than any other analyzed context on site except for Feature 15 which consists of one abalone.

LAN-64

Based on the limited number of contexts and the poor preservation of shell recovered at LAN-64, little can be said regarding spatial differences in shellfish use in contemporaneous site areas. Within specific time periods at LAN-64, either only one context existed or too little shell was recovered to make reliable conclusions.

One shell-dump feature, had a date of 8,200 B.P. Although tenuous, this placed the feature in the early Millingstone period. Venus clam was by far the predominant species in this dump, and only one scallop fragment was recovered. Shell from the subsequent Millingstone period deposits at LAN-64 was found only in four shell-dump features. Scallop dominated these four features. Venus clam was present but constituted only 5–10 percent of these shell-dump collections.

As stated earlier, the four excavation units and Feature 76, which were recovered in shallower deposits than the shell-dump features, likely dated to the Intermediate period, as did DiGregorio's (1987) collection. Both DiGregorio's and SRI's collections from Intermediate period strata were dominated by Venus clam. Our Intermediate period collection consisted of only ten Venus clam fragments and a small number of unidentifiable shell fragments. The shell from these contexts were very fragmented in comparison to the rest of the site, probably due to disking and other modern agricultural processes (Van Horn 1987).

Regional Comparisons

Many archaeological excavations have been completed at Ballona sites along the bluff tops (Van Horn 1984, 1987; Van Horn and Murray 1985; Van Horn and White 1997) and in the flatlands along the margins of the lagoon and creeks (Altschul et al. 1992, 1998; Becker 2003; Freeman et al. 1987; Grenda et al. 1994; Keller 1999). Table 11.15 shows the relative abundance of the predominant species at Ballona sites. The table is divided by ecological zone including bluff-tops, lowland areas, and lagoon-edge zones as defined by Altschul and Ciolek-Torrello (1997). As Becker (2003) discussed, making comparisons of the relative abundance of shellfish from the various sites difficult because some researchers used weight to quantify the shell, whereas others used the number of diagnostic elements. As stated in the methods for this study, we calculated the number of diagnostic elements for intersite comparisons.

Becker (2003) categorized Ballona sites based on Winterhalder's (1981, 2003) hunter-gatherer foraging and subsistence strategies classifications, generalized or specialized. Generalized subsistence strategies are those that rely on a broader range or diversity of food types, whereas specialized strategies are focused on fewer but more abundant resources. Becker categorized those sites in which the majority of the shellfish collection was attributable to one taxon as having a focused subsistence strategy (2003); those sites with a more diverse collection were categorized as generalized. In the past, the shellfish assemblages from archaeological sites in the Ballona have been discussed in terms of time period and ecological zones, including bluff-top, lagoon-edge and lowland sites (Becker 2003). Table 11.16 shows the dominant species and the subsistence strategy of Ballona sites excavated by environmental setting and time period.

Most of the archaeological sites in the Ballona contained Venus clam, littleneck clam, calico scallop, and native Pacific oyster in varying abundance, and the results from SRI's studies of LAN-63 and LAN-64 showed that these sites were also dominated by these same estuarine species (see Table 11.15). It is therefore clear that prehistoric inhabitants of the Ballona throughout the Millingstone and into the Late and historical periods relied heavily on estuarine species.

Current research at LAN-64 suggests Ballona inhabitants preferred a diet composed primarily of scallop during the Millingstone period. One date from LAN-206 suggested the site was as old as 6480 B.P. (Van Horn 1997). Although Venus clam dominated the shellfish collection from this site, scallop represents almost 30 percent of the relative abundance of shell, a percentage higher than most other sites in the Ballona except LAN-64 and LAN-2768. Preliminary analysis from excavations during 2003 and 2004 at LAN-62 show a high abundance of scallop (52 percent) in the deepest excavated strata, dating roughly between 4000 and 6500 B.P. (Wegener and Shelley 2004); only one unit from this deep stratum was examined, however.

Venus clam dominated the assemblages in all but four sites dating to the Intermediate period. Those not dominated by Venus clam included LAN-59, LAN-211/H, and LAN-2768. In three of these cases, Venus clam was the second most dominant shellfish type. The majority of the identifiable shell from both LAN-59 and LAN-194 was Pismo clam, a species found along wave-swept beaches (Erlandson 1994), not in quiet bays and estuaries. Van Horn argued that the Pismo clam specimens were collected from "the shore of a bay which was present in what is now the Ballona Creek area northwest of the Hughes site" (Van Horn 1984:44). LAN-2768 was dominated by calico scallop and littleneck clam, which are also abundant in the Ballona wetlands. Abalone, which live along rocky shores in intertidal or moderately deep water, dominated the shell collection at LAN-211/H.

Only two sites dated to the Millingstone period, LAN-64 and LAN-206. As stated earlier, both of these sites' shell collections show a significant abundance of scallop, particularly LAN-64. Both of these were bluff-top sites. Preliminary data from LAN-62 showed a possible Millingstone component containing a majority of scallop (Wegener and Shelley 2004).

Most of the Ballona sites dated to the Intermediate period, roughly between 4400 and 1000 B.P., and represent a focused subsistence strategy. All but two of the sites from this time period had a focused subsistence strategy that was dominated by Venus clam except LAN-59. LAN-2768 and LAN-2676 both had a generalized subsistence strategy. The Late period and protohistoric or historical-period sites showed evidence of a generalized subsistence strategy.

Analyses indicated that there was a shift from the Early and Intermediate period focused-collection strategy that targeted Venus clams, to the generalized strategy of the Late and protohistoric periods, which emphasized a greater proportion of other species, particularly scallop and littleneck clam. Additional data provided by the current study suggests a possible shift in targeted species from a significantly higher amount of scallop during the Millingstone period to increased numbers of Venus clam during the Intermediate period.

Summary

This shell analysis of the West Bluffs sites LAN-63 and LAN-64 has shown that estuarine resources were commonly used by the residents of these site, has identified a change in foraging strategies over time, and suggested that the change in dominant species over time was prompted by a change in the nearby habitat.

Two of three of the West Bluffs sites contained shell assemblages. As at other sites, LAN-63 and LAN-64 contained shellfish assemblages dominated by four key bay and estuary taxa: Venus clam, oyster, littleneck clam, and scallop. Although there were shifts in relative abundance of particular species, these same lagoon and bay species were found at nearly every site excavated in the Ballona, indicating that throughout prehistory, the people of this area focused on the nearby bay or lagoon habitat.

The majority of the shell that SRI recovered at West Bluffs was found at LAN-63. As in most other Ballona sites dating to the Intermediate period, Venus clams—likely collected because of their convenience and abundance in the nearby Ballona wetlands—dominated the collection along with other estuarine species. The abundance of shell found throughout the site in many different contexts suggested that shellfish contributed a major portion of the diet to the inhabitants of LAN-63. It also suggested that the site was occupied repeatedly, if not continuously, throughout the Intermediate period.

LAN-64 provided the first concrete evidence for the habitation of the Ballona during the early Millingstone period. The most interesting point of comparison at LAN-64 was that scallops dominated the shell collection during the Millingstone period, whereas Venus clam clearly dominated most of the archaeological shell assemblages in the Ballona during the Intermediate and Late periods. This may be evidence that humans preferred scallop to Venus clam during this early period or it may be evidence that scallop were more abundant and more economical to collect. It may also indicate that the people at LAN-64 only preferred scallop to Venus clam or that this site, particularly, was used for processing scallop. The shell dumps may indicate individual scallop-procurement events. Venus clam, and shell in general, however, were in low abundance, which may indicate a greater reliance on terrestrial food options or a lower overall population density during this time period. The few and small Millingstone period sites, compared to the abundance of Intermediate period sites in the Ballona, suggest that there was a low population density during the Millingstone period that greatly increased during the Intermediate period.

Table 11.1. Invertebrate Taxa Recovered from LAN-63 and LAN-64

Class and Family	Genus and Species	Habitat
Gastropoda		
Calyptraeidae	*Crepidula* sp. (slipper shell)	Most common on rocks, shells, and pilings in protected bays, but also in sheltered areas on open coast, low intertidal zone, and subtidal waters[a]
Haliotidae	*Haliotis* spp. (abalone)	Most live along rocky shores in intertidal or moderately deep water[a]
Potamididae	*Cerithidea californica* (California horn shell)	Abundant on mud flats and the high intertidal zone in protected bays, often forming dense aggregations under debris and among plants[a]
Pelecypoda		
Cardiidae	*Trachycardium* sp. (cockle)	In sands or sandy mud, in bays and quiet waters[b]
Donacidae	*Donax californicus* (wedge clam)	Common on sandy beaches, low intertidal zone of bays and protected outer coast[a]
Lucinidae	*Lucina nuttalli* (Nuttall's lucine)	In sand, from low-tide line to water 46 m deep[b]
Mactridae	unidentified (surf clam family)	
	Tresus spp. (horse or gaper clam)	Low-tide line to 30 m, buried in sand or sandy mud offshore
Ostreidae	unidentified (oyster family)	
	Crassostrea gigas (giant Pacific oyster)	Commonly cemented to rocks and shells in bays and on mud flats, low intertidal zone[a]
	Ostrea lurida (native Pacific oyster)	Rare to common, attached (cemented by one valve) to rocks, oyster shells, and concrete pilings, low intertidal zone in quiet bays and estuaries[a]
Pectinidae	Unidentified (scallop family)	
	Argopecten circularis (speckled scallop)	On sandy or muddy bottoms of bays, in shallow water to 50 m deep. Normally unattached, but can anchor themselves temporarily to solid substrata. When free, can swim up to a meter at a time.[a]
	Patinopecten caurinus (giant Pacific scallop)	In sand or gravel, in water 18–91 m deep[b]
	Pecten spp. (scallop)	In sand or mud, in protected or calm water 1–61 m deep[b]
Solecurtidae	unidentified (razor clam family)	
	Tagelus spp. (jackknife clam)	Locally abundant in burrows 10–50 cm deep on sandy mud flats of bays, low intertidal zone[a]

Class and Family	Genus and Species	Habitat
Veneridae	unidentified (Venus clam family)	Most are found intertidally and in moderately deep water, buried in sand or mud offshore and in bays
	Amiantis callosa (Pacific white Venus	Common below the low-tide line along sandy beaches, to depths of 8 m. Living species may be washed ashore after storms[b]
	Chione spp. (Venus clam)	Intertidal to 45 m, in mud or sand flats in bays and estuaries and also offshore
	Protothaca staminea (Pacific littleneck clam)	Abundant in shallow burrows 3–8 cm below the surface in coarse sand or sandy mud in bays or coves, and in gravel under larger rocks on open coast, middle to low intertidal zones[a]
	Tivela stultorum (Pismo clam)	Low intertidal zone and offshore to 24 m, in sand flats[a,b]

[a]Morris, Abbott, and Haderlie 1980
[b]Rehder 1981

Table 11.2. NISP, MNI, and Weight by Family for LAN-63

Family	NISP	% NISP	MNI	% MNI	Weight (g)	% Weight
Veneridae	1,911	67.8	269	79.1	3,713.9	87.4
Ostreidae	267	9.5	42	12.4	185.6	4.4
Pectinidae	370	13.1	14	4.1	109.7	2.6
Potamididae	8	0.3	6	1.8	2.0	—
Mactridae	5	0.2	3	0.9	7.0	0.2
Calyptraeidae	2	0.1	2	0.6	1.4	—
Solecurtidae	4	0.1	2	0.6	4.3	0.1
Donacidae	1	—	1	0.3	0.2	—
Haliotidae	247	8.8	1	0.3	224.5	5.3
Cardiidae	3	0.1	0	—	0.9	—
Subtotal	2,818	100.0	340	100.0	4,249.5	100.0
Identifiable to family	2,818	52.0	340	6.3	4,249.5	85.0
Unidentifiable to family	2,603	48.0	5,081	93.7	747.0	15.0
Total	5,421	100.0	5,421	100.0	4,996.5	100.0

Table 11.3. NISP, MNI, and Weight by genera/species for LAN-63

Taxon	NISP	% NISP	MNI	% MNI	Weight	% Weight
Chione spp.	1,177	48.6	199	66.8	3,256.6	79.8
Ostrea lurida	147	6.1	42	14.1	139.0	3.4
Protathaca staminea	601	24.8	30	10.1	343.0	8.4
Argopecten circularis	137	5.7	10	3.4	59.8	1.5
Cerithidea californica	8	0.3	6	2.0	2.0	—
Crepidula sp.	2	0.1	2	0.7	1.4	—
Tresus sp.	3	0.1	2	0.7	4.8	0.1
Tagelus sp.	3	0.1	2	0.7	1.7	—
Pecten spp.	45	1.9	1	0.3	15.3	0.4
Haliotis sp.	247	10.2	1	0.3	224.5	5.5
Patinopecten caurinus	27	1.1	1	0.3	13.5	0.3
Donax sp.	1	—	1	0.3	0.2	—
Amiantis callosa	19	0.8	1	0.3	9.1	0.2
Tivela stultorum	3	0.1	—	—	9.2	0.2
Trachycardium sp.	3	0.1	—	—	0.9	—
Subtotal	2,423	100.0	298	100.0	4,081.0	100.0
Identifiable to genus	2,423	44.7	298	5.5	4,081.0	81.7
Unidentifiable to genus	2,998	55.3	5,123	94.5	915.5	18.3
Total	5,421	100.0	5,421	100.0	4,996.5	100.0

Table 11.4. Species by Feature at LAN-63

Taxon	Feature 15				Feature 337				Feature 486				Feature 587			
	NISP	% NISP	MNI	% MNI	NISP	% NISP	MNI	% MNI	NISP	% NISP	MNI	% MNI	NISP	% NISP	MNI	% MNI
Chione sp.	0	—	0	—	188	49.0	31	57.4	68	81.0	13	92.9	363	45.3	45	45.9
Ostrea lurida	0	—	0	—	44	11.5	11	20.4	0	—	0	—	82	10.2	31	31.6
Prototheca staminea	0	—	0	—	108	28.1	7	13.0	12	14.3	1	7.1	206	25.7	11	11.2
Argopecten circularis	0	—	0	—	27	7.0	3	5.6	4	4.8	0	—	77	9.6	4	4.1
Cerithidea californica	0	—	0	—	1	0.3	1	1.9	0	—	0	—	2	0.3	2	2.0
Crepidula sp.	0	—	0	—	0	—	0	—	0	—	0	—	1	0.1	1	1.0
Tresus sp.	0	—	0	—	1	0.3	1	1.9	0	—	0	—	1	0.1	1	1.0
Tagelus californianus	0	—	0	—	0	—	0	—	0	—	0	—	2	0.3	1	1.0
Pecten spp.	0	—	0	—	15	3.9	0	—	0	—	0	—	24	3.0	1	1.0
Haliotis spp.	219	100.0	1	100	0	—	0	—	0	—	0	—	28	3.5	0	—
Patinopecten caurinus	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—
Donax sp.	0	—	0	—	0	—	0	—	0	—	0	—	1	0.1	1	1.0
Amiantis callosa	0	—	0	—	0	—	0	—	0	—	0	—	14	1.8	0	—
Tivela stultorum	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—
Trachycardium sp.	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—
Total	219	100.0	1	100	384	100.0	54	100.0	84	100.0	14	100.0	801	100.0	98	100.0

Table 11.5. Fragmentation Index by Unit and Feature for LAN-63

Context	FI
Unit 19	1.5
Unit 36	2.7
Unit 53	2.3
Feature 15	3.1
Feature 337	3.1
Feature 468	7.4
Feature 587	2.2
Site Total	2.5

Note: FI = 0.50 in and larger/0.25 in

Table 11.6. Shell Density by Provenience for LAN-63

Provenience	Level 1		2		3		4		5		6		7		8		9		Feature Total	
	Wt.	n	Wt.	n	Wt.	n	Wt.	n	Wt.	n	Wt.	n	Wt.	n	Wt.	n	Wt.	n	Wt.	n
U 19	104.9	3	59.0	3	65.4	3	54.1	3	101.3	3									384.7	3
U 36	129.6	4	109.7	3	104.5	3	161.0	7	152.9	5	515.4	6	129.0	9	151.2	7	122.9	7	1,576.2	11
U 53	86.4	8	234.8	11															321.2	13
F 587	154.1	7	40.8	5	138.5	7	244.4	6	380.0	7	191.8	10	109.2	5					1,258.8	12
F 15																			220.6	1
F 337																			873.5	8
F468																			247.5	3
Site Total																			4,996.5	17

Key: n = number of genus and species; F = Feature; U = Unit; Wt. = weight

Table 11.7. NISP, MNI, and Weight by Family for LAN-64

Family	NISP	NISP (%)	MNI	MNI (%)	Weight	Weight (%)
Pectinidae	500	63.3	49	59.0	645.9	64.1
Veneridae	231	29.2	32	38.6	306.1	30.4
Ostreidae	57	7.2	1	1.2	48.1	4.8
Lucinidae	1	0.1	1	1.2	3.2	0.3
Haliotidae	1	0.1	0	0.0	3.8	0.4
Subtotal	790	100.0	83	100.0	1007.1	100.0
Identifiable to Family	790	81.4	83	8.6	1007.1	95.0
Unidentifiable to Family	180	18.6	887	91.4	52.8	5.0
Total	970	100.0	970	100.0	1059.9	100.0

Table 11.8. NISP, MNI, and Weight by Genera/Species for LAN-64

Taxon	NISP	NISP (%)	MNI	MNI (%)	Weight	Weight (%)
Chione spp.	176	22.3	31	37.4	276.5	27.5
Argopecten circularis	243	30.8	27	32.5	398.8	39.6
Pecten spp.	224	28.4	20	24.1	241.2	24.0
Lucina nuttalli	1	0.1	1	1.2	3.2	0.3
Ostrea lurida	38	4.8	1	1.2	38.3	3.8
Amiantis callosa	1	0.1	0	0.0	4.1	0.4
Crassostrea gigas	1	0.1	0	0.0	2.5	0.3
Haliotis sp.	1	0.1	0	0.0	3.8	0.4
Protothaca staminea	1	0.1	0	0.0	0.2	0.0
Subtotal	686	100.0	80	100.0	968.6	100.0
Identifiable to genus	686	70.7	80	8.2	968.6	91.4
Unidentifiable to genus	284	29.3	890	91.8	91.3	8.6
Total	970	100.0	970	100.0	1059.9	100.0

Table 11.9. Features Containing Scallop Versus Units and Features without Scallops

Taxon	Scallop Features				Non-scallop Features and Units			
	NISP	NISP (%)	MNI	MNI (%)	NISP	NISP (%)	MNI	MNI (%)
Chione spp.	26	4.9	5	9.3	[a]150	97.4	[b]26	100.0
Argopecten circularis	243	45.6	27	50.0	0	0.0	0	0.0
Pecten spp.	223	41.8	20	37.0	1	0.6	0	0.0
Lucina nuttalli	1	0.2	1	1.9	0	0.0	0	0.0
Ostrea lurida	38	7.1	1	1.9	0	0.0	0	0.0
Amiantis callosa	1	0.2	0	0.0	0	0.0	0	0.0
Crassostrea gigas	1	0.2	0	0.0	0	0.0	0	0.0
Haliotis sp.	0	0.0	0	0.0	1	0.6	0	0.0
Protothaca staminea	0	0.0	0	0.0	1	1.3	0	0.0
Total	533	100.0	106	100.0	[c]153	100.0	26	100.0

[a]140 of these are from Feature 60

[b]23 of these are from Feature 60

[c]142 of these are from Feature 60

Table 11.10. Shell Density by Unit and Feature at LAN-64

Provenience	Weight	No. Of Genus/Species
Feature 45	287.0	4
Feature 49	321.4	6
Feature 50	69.7	7
Feature 55	143.2	5
Feature 60	204.7	3
Feature 76	10.5	1
Feature total	1,036.5	11
Unit 11	7.0	1
Unit 12	7.1	1
Unit 13	3.0	1
Unit 14	6.3	1
Nonfeature	23.4	1
Site Total	1,059.9 [a]	11 [b]

[a] Does not include shell found in nonfeature context.

[b] Total represents genus and species that were present; may be repeated among features.

Table 11.11. Fragmentation Index by Unit and Feature for LAN-64

Context	FI
Unit	
11	1.8
12	1.1
13	—
14	0.7
Feature	
45	25.3
49	5.1
50	5.5
55	3.7
60	2.8
76	1.1
Site total	5.0

Table 11.12. LAN-63 Van Horn Comparison

Species	Van Horn (1987) n = 16,040		SRI (2004) n = 549	
	NISP	% NISP	NISP	% NISP
Chione spp.	13,483	84.0	367	66.9
Ostrea lurida	1,141	7.1	83	15.1
Argopecten circularis	730	4.6	19	3.5
Protathaca staminea	686	4.3	58	10.6
Total	16,040	100.0	527	96.1

Table 11.13. Comparison of Van Horn and SRI Invertebrate Recovery at LAN-64

Species	Van Horn (1987) n = 187		SRI (2004) n = 164	
	NISP	% NISP	NISP	% NISP
Chione spp.	176	94.0	61	37.2
Argopecten circularis	—	—	54	32.9
Pecten spp.	—	—	40	24.4
Ostrea lurida	8	4.3	2	1.2
Protathaca staminea	2	1.0	—	—
Haliotis sp.	1	0.5	—	—
Total	187	99.8	157	95.7

Table 11.14. Meat Yield Conversion Factors for Common Marine Shellfish

Taxon (Common Name)	Meat-Yield Conversion Factor	Meat Yield Compared to *Chione califoriensis*
Chione californiensis (California Venus clam)	0.171	1.00
Tivela stultorum (Pismo clam)	0.254	1.49
Haliotis spp. (abalone)	0.263	1.54
Ostrea lurida (native Pacific oyster)	0.292	1.71
Mytilus californianus (California mussel)	0.298	1.74
Septifer bifurcatus (bifurcate mussel)	0.364	2.13
Tegula funebralis (black turban snail)	0.365	2.13
Argopecten circularis (Pacific calico scallop)	0.400	2.34
Mytilus edulis (common or blue mussel)	0.438	2.56
Saxidomus nuttalli (Washington clam)	0.463	2.71
Protothaca staminea (Pacific littleneck clam)	0.610	3.57
Polinices lewisii (Lewis's moon snail)	0.722	4.22
Tagelus californianus (California jackknife clam)	1.240	7.25
Tresus nuttallii (horse or gaper clam)	1.700	9.94

Table 11.15. Comparison of Invertebrate Remains at Ballona Sites[a]

Sites by Location	NISP	NISP per m³	Number of Genera	Dominant Taxa	Dominant Taxa %
Bluff sites					
LAN-59 (Hughes)	2480	28.5	8	*Tivela stultorum*	86
				Chione spp.	8
				Argopecten circularis	6
LAN-61 (Loyola Marymount)	789	1.9	10	*Veneridae*	67
				Ostrea lurida	29
				Haliotis spp.	2
LAN-63 (Del Rey) SRI 2004	672		17	*Chione* spp.	67
				Ostrea lurida	15
				Protothaca staminea	11
				Argopecten circularis	3
LAN-64 (Bluff) SRI 2004	164		11	*Chione* spp.	37
				Argopecten circularis	33
				Pecten spp.	24
				Ostrea lurida	2
LAN-206 (Berger) 1987	776	161.7	15	*Chione* spp.	56
				Argopecten circularis	28
				Ostrea lurida	16
Lowland sites					
LAN-60 (Centinela)	976	116.2	12	*Chione* spp.[b]	72
				Protothaca staminea[b]	21
				Ostrea lurida[b]	3
				Tivela stultorum[b]	2
LAN-194	no data	no data	no data	*Tivela stultorum*[b]	38
				Chione spp.[b]	28
				Ostrea lurida[b]	19
				Argopecten circularis[b]	7
LAN-211/H	59	19.8	10	*Haliotis* spp.[b]	33
				Chione spp.[b]	27
				Protothaca staminea[b]	18
				Argopecten circularis[b]	8
				Saxidomus nuttalli[b]	3
LAN-2768	319	35.1	13	*Argopecten circularis*	34
				Protothaca staminea	23

Sites by Location	NISP	NISP per m^3	Number of Genera	Dominant Taxa	Dominant Taxa %
				Chione spp.	15
				Ostrea lurida	13
Lagoon-edge sites					
LAN-47 (Admiralty)	14,290	595.4	24	*Chione* spp.	43
				Ostrea lurida	32
				Protothaca staminea	13
				Argopecten circularis	5
LAN-62 (Peck)	1,273	252.5	15	*Veneridae*[b]	73
				Pectinidae[b]	8
				Haliotis sp.[b]	4
				Ostrea lurida[b]	3
LAN-62 SRI 2004	19,395	no data		*Chione* spp.	26
				Ostrea lurida	15
				Protothaca staminea	15
				Argopecten circularis	7
				Patinopecten caurinus	7
LAN-1932/H	230	511.1	10	*Chione* spp.	26
				Pecten spp.	25
				Ostrea lurida	21
				Pectinidae	15
LAN-2676	2,412	193.0	38	*Veneridae*[b]	49
				Ostrea lurida[b]	15
				Pectinidae[b]	7
				Haliotis sp.[b]	2

[a]Adapted from Keller 1999

[b] Percentage calculated from weight, not count.

Table 11.16. Distribution of Ballona-Area Sites by Temporal Period and Invertebrate-Assemblage Type

Environment	Period and Taxon Attribution			
	Millingstone	**Intermediate**	**Late**	**Protohistoric or Historical**
Bluff top	F LAN-206 *(Chione)*	F LAN-59 *(Tivela)*		
	F LAN-64 *(Pectinidae)*	F LAN-61 (Veneridae)		
		F LAN-63 *(Chione)*		
		F LAN-64 *(Chione)*		
Riparian		F LAN-60 *(Chione)*		G LAN-194 *(Tivela, Chione)*
		G LAN-2768 *(Argopecten, Protothaca)*		G LAN-211 *(Haliotis, Chione)*
Lagoon		F LAN-62 *(Chione)*	G LAN-47 *(Chione, Ostrea)*	G LAN-1932H *(Chione, Protothaca)*
		G LAN-2676 *(Chione)*		

Notes: F = Focused: (> 50 percent) of assemblage attributable to one taxon; G = General: no taxon dominates by majority (> 50 percent)

Table after Becker 2003:Table 24.

Pollen and Macrobotanical Analysis

Peter E. Wigand

A total of 58 sediment samples were submitted from the West Bluffs project for analysis of pollen content, and 70 prefloated sediment samples were submitted for macrobotanical analysis. The purpose of these analyses was to obtain proxy data that might be evidence of food or resource plants that might have been processed in several features used for food, or the production of material culture; and perhaps to reconstruct past environments.

Setting

The samples came from three sites, LAN-63 (the Del Rey site), LAN-64 (the Bluff site) and LAN-206A (the Berger site), located at the crest of the Del Rey Bluffs at the southern edge of the Ballona Lagoon, about 2.6 km from the current position of the Pacific coast (Figure 12.1).

The sites lie within the geographic subsection termed the Los Angeles Plain (Miles and Goudey 1997), which includes the Los Angeles Plain, the San Fernando Valley, the Verdugo Mountains, the San Rafael Hills, and the Palos Verdes Hills. The Los Angeles Plain itself is the largest part of this subsection, spanning the area south of the Santa Monica and San Gabriel Mountains and west of the San Jose and the Puente Hills. The Los Angeles River traversed the plain from northeast to southwest, and at times during prehistory, emptied into the Pacific through the Ballona Lagoon. There are small areas of marine terraces, but they are relatively restricted in extent in comparison to fluvial terraces. Steep mountains and moderately steep hills are small but important parts of the subsection. Dunes are present along the coast north of the Palos Verdes Hills, and sand has spread across Quaternary terraces behind those dunes. The elevational range of the subsection is from sea level to about 305 m (1,000 feet) on the Los Angeles Plain, slightly higher in the San Fernando Valley, and up to 938 m (3,077 feet) in the Verdugo Mountains. Fluvial erosion and deposition are the dominant geomorphic processes in the region. Mass wasting is important in the mountains, especially during El Niño cycles or after chaparral fires, and wind is an important geomorphic agent in sandy areas along the coast.

The project area is close enough to the Pacific Ocean for the climate to be greatly modified by marine influence. The sites are directly exposed to both on- and offshore winds generated daily in the Los Angeles basin, and to coastal fogs. The Santa Monica Mountains also channel marine air from the west into the Los Angeles Basin and, with the San Bernardino Mountains, contribute arboreal (tree) pollen that is swept down into the Los Angeles Basin and appears as a long-distance contribution to the pollen record. Daily changes of wind direction, diurnal shifts from onshore to offshore related to the differential heating of land and water, are sources for exotic pollen. Prior to the current development, urbanized areas had already encroached the sites on three sides (east, west, and south (Figure 12.2). These areas also provided potential sources for exotic pollen that might appear as contaminants in samples collected in the sites. Even the remnants of native marsh, prairie, mixed sage shrub, and pickleweed communities are severely restricted and contain many nonnative plants.

The soils are well drained, reflecting both the alluvial and aeolian origin of these coarser sediments. High evaporation rates have resulted in the accumulation of carbonates in some of the soils. Soil temperature regimes are thermic (warm). Soil moisture regimes are xeric (dry).

Climate

The climate is hot and subhumid, although it is moderated by marine influence. The mean annual precipitation is about 305–508 mm (12–20 inches), of which most falls as rain (Table 12.1), although precipitation can vary between 122.5 and 735 mm (5 and 30 inches) per year (Bailey 1975). Topography is the major factor influencing local differences in the distribution of rainfall. Rainfall increases at the rate of 15 mm per km (1 inch per mile). The mean annual temperature is about 14.4–17.8°C (58–64°F), and the mean freeze-free period is about 300–350 days. The Del Rey bluffs are encompassed by the southern California climatic region known as the Maritime Fringe (Bailey 1975), which is primarily confined to a coastal strip 5–25 km (3–15 miles) from the ocean and characterized by cool summers, during which the average temperature of the warmest month is less than 22.2°C (72°F), and warm winters, with the average temperature of the coldest month above 10°C (50°F). This region has the longest growing season of southern California. Cloudiness is limited in the region, with fewer than half of the days in the cloudiest month having 70 percent or more of the sky covered with clouds (Bailey 1975). Heavy fog occurs about 53 days of the year, with most of it limited to the cooler half of the year. The number of days with heavy fog (less than 0.4-km [0.25-mile] visibility) decreases southward from approximately 88 days in the north, where ocean temperatures are coolest, to approximately 30 days in the south, where ocean temperatures are warmer. During the summer months, relative humidity is high in the Maritime Fringe, with morning and late-afternoon humidity above 60 percent and reaching a peak of 80–90 percent around 4 a.m. (Bailey 1975). A comparison of weather records from the Santa Monica Pier, Culver City, and Los Angeles International Airport (LAX) weather stations provides a summary of the weather conditions in the western portion (Maritime Fringe) of the Los Angeles basin during the modern period of record (Figures 12.3–12.8; see Table 12.1).

The coldest months are December and January and the warmest are July, August, and September, although monthly average, maximum, and minimum temperatures vary little among the three stations (see Figure 12.3; see Table 12.1). The temperature record from the Santa Monica Pier station is slightly warmer in winter and cooler in spring, summer, and fall than either the Culver City or LAX records, reflecting the moderating effect of maritime air closer to the coast. In general, the Culver City weather record has greater monthly extremes, i.e., it has warmer monthly average maximum temperatures, but lower monthly minimum temperatures, which reflect the more continental nature of the local climate there. Whereas the LAX record has monthly maximum temperatures between those of the Santa Monica Pier and Culver City records, the airport record has warmer monthly average minimum temperatures from late spring to early fall than either of the other two stations. Its average monthly minimum temperature lies between that of the Santa Monica Pier and Culver City from late fall to early spring. These temperature records indicate that the climate of locations on the coastal plain near the ocean, such as the Santa Monica Pier, is moderated by moist ocean air. The Culver City record, even though it is only slightly inland, reflects greater swings in temperature characteristic of terrestrial locations. The Culver City record's much cooler average monthly minimum temperatures, especially during the winter, reflect the effect of cold-air drainage from the mountains to the east (see Figure 12.3c). Although the record from LAX is more terrestrial in nature, with warmer maximums than the Santa Monica Pier, LAX lies at an elevation high enough not to be affected by cold-air drainage from the mountains east of the Los Angeles basin (see Figure 12.3). The temperature record at the West Bluffs sites is probably most similar to that of LAX in that the West Bluffs area is more terrestrial in nature, cooled slightly by marine air during the summer, but high enough not to be affected by cold-air drainage from the eastern mountains.

Late-spring through early-fall drought characterizes the region (see Figure 12.4), with snow falling only very rarely. In general, though precipitation varies only slightly among the weather stations, it is greater at the Santa Monica Pier and Culver City stations than at LAX during most of the year, except in early fall, when precipitation is slightly greater at LAX. Most of the Pacific storms are channeled by the prevailing south-southeast winds into the Los Angeles basin and are deflected eastward by the Santa Monica range. Cooler temperatures in late fall and winter at inland locations, such as Culver City, wring more precipitation from these storms than at either the Santa Monica Pier or LAX (see Figure 12.4). The precipitation-to-evaporation ratio shows the same pattern for these stations as the actual precipitation (see Figure 12.5). Taking the LAX station precipitation record as representative of the West Bluffs sites, a slightly drier climate than much of the remaining Los Angeles basin was probably the norm.

The number of days between the last spring freeze and the first in autumn provides a good measure of the length of the growing season. In order to measure the efficiency of the growing season, however, degree-days are calculated. Degree-days are the number of degrees by which daily mean temperature is above or below a selected base temperature. To better characterize the actual impact of temperature on plant growth, upper and lower temperature limits are applied. Usually, temperate region plants do not respond with significant growth to temperature increases until about 10°C (50°F). Above 30°C (86°F), growth is also inhibited. As a result, "growing degree-days" is usually considered the temperature amount between 10°C (50°F) and 30°C (86°F) that contributes to plant growth. The number of growing degree-days is calculated with the formula (Houghton et al. 1975):

$$\tfrac{1}{2}\,[(30°\text{C} - \text{Temperature}^{\text{maximuum}}) + (\text{Temperature}^{\text{minimum}} - 10°\text{C})] - \text{Base Temperature}$$

where 10°C is the base temperature. English-system measurements require a slightly different formula, where base temperature is 55°F:

$$\tfrac{1}{2}\,[(86°\text{F} - \text{Temperature}^{\text{maximum}}) + (\text{Temperature}^{\text{minimum}} - 55°\text{F})] - \text{Base Temperature}$$

A comparison of the weather records from the Santa Monica Pier, Culver City, and LAX indicated that the mean monthly total growing degree-day averages during the summer have been much higher at the Culver City and LAX weather stations than at the Santa Monica Pier station (Figure 12.6). From November through February, all three stations recorded similar average monthly growing degree-days. Differences between the average monthly growing days at the Culver City and LAX stations were negligible (see Figure 12.6). The much lower average monthly growing degree-days recorded at the Santa Monica Pier weather station reflects the cooling effects of marine air, especially during the summer. The peak growing degree-days coincided with the driest part of the year, i.e., May through October. It is clear that greatest degree-day amounts were skewed toward late spring and summer, so that temperatures favoring the most plant growth were greatest after May but dropped off sharply by July. This pattern was the inverse of precipitation in the region, indicating that winter storage of precipitation is crucial for adequate plant growth during the following summer. Biotic production in the region is maximized during the spring, when conditions of increasing growing degree-days coincide with the highest levels of accumulated groundwater derived from winter rainfall. During late fall and winter, differences in average monthly growing degree-days between the stations were negligible. Under this climatic pattern, winter droughts can be regionally catastrophic for plant growth. During drier periods, plants will mature up to a month or more earlier than during wetter years. Under normal conditions, plants growing in the drier areas of the Los Angeles basin will mature earlier than in wetter areas. Therefore, with the diversity of microclimates found in the area, the harvest of specific plant species can be extended by collecting first in warmer, drier areas and then later at cooler, wetter locations.

The climatic pattern found in southern California is the opposite of that in the Southwest, where summer monsoons (the highest annual input of precipitation) coincide with the highest growing degree-days. Therefore, in the Southwest, plants are adapted to take advantage of dramatic inputs of surface water during the summer, whereas in southern California, they depend on the water stored in the soils during the winter rainy season.

The accumulation of some growing degree-days in winter indicates that some plant growth occurs in winter in southern California (in northern California and in the Great Basin, there is no accumulation of growing degree-days during the winter months). Plant species adapted to take advantage of this were available for collection by native populations throughout the year.

Corn growing degree-days are different than growing degree-days only in that the calculation uses a lower base temperature. The number of corn growing degree-days is calculated with this formula, based on U.S. Weather Service usage, and using 10°C as the base temperature:

$$\tfrac{1}{2}\,[(30^\circ\text{C} - \text{Temperature}^{\text{maximum}}) + (\text{Temperature}^{\text{minimum}} - 10^\circ\text{C})] - \text{Base Temperature}$$

or, in English system measurements and using 50°F as the base temperature:

$$\tfrac{1}{2}\,[(86^\circ\text{F} - \text{Temperature}^{\text{maximum}}) + (\text{Temperature}^{\text{minimum}} - 50^\circ\text{F})] - \text{Base Temperature}$$

Therefore, because a lower base temperature is used, higher degree-day values are accumulated (see Figure 12.7). This index reflects the potential for plants that are able to start growing at lower temperatures to start growing earlier in the year. Such plants extend the season during which growing plants are available to native populations. In the Los Angeles basin, this season is significantly longer than that east of the Sierra Nevada Mountains.

When these various patterns are compared with each other (Figure 12.8) and using the LAX record as a proxy for the West Bluffs sites, the climate in the West Bluffs area can be summarized as cool in winter and warm to hot in summer. The climate is drier than other Los Angeles basin locations to the north and northeast in the winter, and moister than further inland in the summer. The West Bluffs area has a relatively long growing season, similar to that found at inland sites. Its precipitation-to-evaporation index is lower than many other areas in the Los Angeles basin, which, coupled with the high growing degree-days, may explain the formation of the Los Angeles Coastal Prairie. Finally, rainfall in winter through spring is twice that of summer through fall. Only locales immediately on the coast have a higher proportion of winter–spring to summer–fall precipitation.

In summary, the West Bluffs sites lie in an area where marine air masses moderate the climate , and the sites lie high enough to avoid more extreme winter cooling caused by cool-air drainage from the eastern mountains. Higher evaporation rates result in relatively drier conditions than in the lowlands to the north and northeast.

Surface Water

Runoff is rapid, even from the alluvial fans where some does infiltrate. The Los Angeles River is the largest stream on the plain and drains the San Fernando Valley and much of the San Gabriel Mountains flowing in alluvial, and weak bedrock channels westward to the Pacific Ocean. The Los Angeles River was first described by Juan Crespi on the Portolá expedition in 1769 (Caughey et al. 1977) (see his description of the river and its surroundings). Ballona and Centinela Creeks are the two major streams that feed into the Ballona estuary. Ballona Creek flow rates have varied considerably in the past, due not only to changing precipitation rates but also to shifts in the channel of the Los Angeles River as it reached the northern edge of the Los Angeles basin. The river channel has shifted at least five times during the last 200 years, each time resulting in a change in the position of the river mouth.

The first historical-period shift occurred during an extreme flood event in 1815. The Los Angeles River diverted from the channel that it currently occupies to one through Ballona Creek into the Pacific at Santa Monica Bay (Weide 1967). During the 1815 flood, the original Plaza of Los Angeles was washed away as the river overflowed and changed its course at Alameda and Fourth Street, to cut west across the lowland and empty into Ballona Creek. Despite the destruction wrought by this flood, the great "council tree" in the Gabrielino village of Yangna, the original site of the Presidio of Los Angeles, survived.

Flooding in 1825 redirected the flow of the Los Angeles River into its previous channel, so that the river again emptied into the Pacific Ocean near Long Beach. Governor Pico recorded in his diary that the Los Angeles River changed its course back from the Ballona Wetlands to San Pedro. Woodlands between the pueblo and the ocean were destroyed, and marshland was drained by the new channel. Bernice Johnson wrote in her "History of Los Angeles River Floods" for the Friends of the Los Angeles River:

> With few exceptions old residents recalled that, until the floods of 1824–25 sent it careening off through the lowlands to the south, the Los Angeles River ran below a high bluff between the present Main and Los Angeles Streets, turning westward on its meandering way to the "cienegas", the great marshlands that lay between the Baldwin and the Beverly Hills. This course can be traced roughly today by observing the trend of the low ground in the region of Venice, Adams, and Washington, between La Brea and La Cienega Boulevards, in the present city of Los Angeles.
>
> From some unknown prior date, or perhaps always until the winter of 1824–25, this was the course the Los Angeles River followed to its mouth in the Santa Monica Bay. Thereafter, during every major storm . . . this was the way it threatened to take and deep sands exist to prove its right to such a course. "The river needed to rise only a few inches to send it down the old channel," reported on old resident. In 1867 this actually happened and for a while the water stood like a great lake all the way to the "cienegas". From that point to the sea the course had been that of the stream the Spanish were to call "La Ballona," although the low ground southward to the Dominguez country sometime coaxed the overflow in that direction.

From 1861 to 1862, there was heavy flooding. More than 50 inches of rain fell during December and January. Much of the San Fernando Valley was under water. Los Angeles's embankment along the river and the Los Angeles waterworks system, built in 1857 under the direction of William Dryden, were destroyed. In 1867, floods again spilled over the old channel and created a large, temporary lake out to Ballona Creek. In 1884, heavy flooding forced the river to change course again, turning it east to Vernon and then southward to San Pedro.

It is clear that most historical shifts between outlets of the Los Angeles River occurred during major episodes of flooding. Over the long term, however, tectonic movement on the floor of the Los Angeles basin, variations in sediment compression, and basin subsidence might have been the underlying determiners of which outlet became the easiest path to the sea to follow during these events.

With regards to other surface drainage in the Los Angeles basin, all but the larger streams are dry through the summer, suggesting that little water is stored in the surrounding hills. Prehistorically, natural lakes or ponds were absent, though "vernal pools" were common in many areas.

"Vernal pools" are ephemeral wetlands that occur during the spring and occasionally into early summer. They occupy depressions in both grasslands and forests. They were especially common in the Los Angeles Prairie south of the West Bluffs sites. The pools are temporarily filled depressions that receive their water through the accumulated runoff from surrounding areas. Their seasonal duration is limited by the amount of water that is accumulated (primarily during the winter months), their surface area, and seasonal air temperature. Differences in these three factors result in a highly variable annual life span through time. During the Holocene, their seasonal persistence might have varied considerably. During periods when winters were wetter and mean spring and summer temperatures were lower, these pools could have survived well into early or even mid-summer. During periods of drought and warmer mean spring and summer temperatures, however, these pools might have barely survived the spring. Although these pools might have provided an important and relatively stable source of water and resources during periods of wetter climate, they would have been unreliable during periods of drought. As such, they might have formed important foci for settlement or resource collection during certain periods of the Holocene.

Vegetation

Southern California coastal plant communities include riparian forest, woodland, scrub, and thicket vegetation series. Plant series commonly growing in riparian forests include: Arroyo Willow, Black Willow, California Sycamore, Fremont Cottonwood, Mixed Willow, Mulefat, Narrow-leaf Willow, Pacific Willow, Red Willow, and White Alder series. Grassland series include California Annual Grassland and Purple Needlegrass. Forest and woodland series include Bigcone Douglas-fir– Canyon Live Oak, California Bay, California Walnut, Coast Live Oak, Engelmann Oak, and Valley Oak series. Chaparral series include Bigpod Ceanothus, Bigpod Ceanothus–Hollyleaf Redberry, Chamise, Chamise–Mission Manzanita–Woollyleaf Ceanothus, Chamise–Black Sage, Mixed Scrub Oak, Scrub Oak, Scrub Oak–Chamise, Sumac, and Woollyleaf Manzanita series. Coastal scrub series include Black Sage, California Buckwheat, California Buckwheat–White Sage, California Encelia, California Sagebrush, California Sagebrush–California Buckwheat, California Sagebrush–Black Sage, Coast Prickly-pear, Coyote Brush, Mixed Sage, Purple Sage, and White Sage series. In addition, some plant series occur that are characteristic of special habitats. Dunes are characterized by Sand-verbena - Beach Bursage, and Dune Lupine-Goldenbush series. Salt marshes are characterized by Cordgrass, Ditch-Grass, and Pickleweed series.

The predominant natural plant communities in the Los Angeles basin are the California Sagebrush–California Buckwheat series and the Mixed Sage series. The Coast Live Oak series and California Walnut series are common, but not extensive. Chamise series and Mixed Chaparral Shrublands are common in the Verdugo Mountains and San Rafael Hills. California Sycamore series grows in riparian areas, and the Pickleweed series is common in estuarine areas.

Locally, the vegetation series that probably characterized the area around the Del Rey bluff sites prehistorically included variations of Mixed Sage series on the slopes north of and below the sites; California Annual Grassland series south of the sites in the Los Angeles Coastal Prairie; and Pickleweed series on the floor of the Ballona estuary below the bluffs north of the sites. The series are described in more detail below, based on descriptions in *A Manual of California Vegetation* (California Native Plant Society 1997).

Mixed Sage Series

This series may be defined as a mixed evergreen or deciduous shrubland with no single species or pair of species dominating the stands of this series. Instead, three or more species equally share commonness and cover. This shrub-dominated series is often regarded as part of the coastal scrub or as a collection of shrub series. The Mixed Sage series is more narrowly defined than coastal scrub, but Coast Bluff Scrub is included. Species included in this series are: California buckwheat *(Eriogonum fasciculatum),* California sagebrush *(Artemisia californica),* coyote brush *(Baccharis pilularis),* black sage *(Salvia mellifera),* purple sage *(S. leucophylla),* and white sage *(S. apiana).* Definitions differ in plant height and cover from coastal scrub, but contrast little in species composition. This community is found on slopes with shallow soils, commonly at elevations between 0 and 1,200 m.

California Annual Grassland Series

This series is defined as a temperate (or subpolar) annual grassland or herbaceous vegetation. This series is composed of many alien and native annual species. Its composition varies from stand to stand, and through time as well. It is dominated by herbaceous plants and is usually less than a meter tall. Stands of this series are now composed of nonnative, annual species mixed with native perennial grasses and herbs. Among those species commonly growing in these grasslands are ripgut grass *(Bromus diandrus),* soft and foxtail chess *(B. hordeaceus* and *B. madritensis),* storksbill *(Erodium botrys* and *E. cicutarium),* goldfields *(Lasthenia californica),* miniature lupine *(Lupinus bicolor),* slender wild oat *(Avena barbata)* and wild oat *(A. fatua),* and Italian ryegrass *(Lolium multiflorum).* Fall temperatures and precipitation are major factors determining grassland composition, along with light intensity affected by shading from plants and litter, and differences in microtopography. The series is found in upland localities in all topographic locations, commonly between 0 and 1,200 m.

Pickleweed Series

This series is defined as a temperate or subpolar grassland with a sparse shrub layer, with either a continuous or intermittent vegetation cover generally lower than 1.5 m high. In wetlands, pickleweed habitats can be regularly flooded, irregularly flooded, or permanently saturated with a shallow water table, and the water chemistry can be mixohaline, euhaline, hyperhaline, or saline. In estuaries, these habitats can be mud flats, banks, berms, margins of bays, deltas, sandbars, valley bottoms, or the lower portions of alluvial slopes. Cowardin et al. (1979) classed the Pickleweed series habitat as either estuarine intertidal persistent emergent wetlands, or palustrine persistent emergent saline wetlands. Five species of pickleweed *(Salicornia)* grow in California. Bigelow pickleweed *(S. bigelovii)* and common pickleweed *(S. virginica),* are frequently found in coastal salt marshes. *S. utahensis* grows in alkali meadows. On the other hand, *S. europaea* and *S. subterminalis* are found in both habitats. The Bulrush, Cordgrass, Ditchgrass, Pickleweed, Saltgrass, and Sedge series can be found in association in California salt marshes. It is commonly found at elevations between 0 and 1,200 m.

The Los Angeles Coastal Prairie, which during prehistoric and early historical times extended south-southeastward from Ballona Lagoon approximately 18 km and covered roughly 95 km^2, was an area of predominantly herbaceous vegetation and extensive vernal-pool habitat (Mattoni and Longcore 1997) (Figure 12.9). Its composition is a mixture of components recognized in at least three descriptions of southern California grasslands including: (1) southern coastal needlegrass grassland; (2) southern coastal grassland; and (3) pristine California grassland. The Los Angeles Coastal Prairie is a grassland characterized a higher number of flowering herbs than perennial grasses, and by numerous species associated with vernal pools (Mattoni and Longcore 1997). Historical descriptions of the prairie indicate the presence of patches of native shrubs on sandy rises. At its edges, the coastal prairie vegetation probably graded into the surrounding communities. Mattoni and Longcore (1997) suggested that the vegetation community which characterizes the Los Angeles Coastal Prairie most closely approximates that of the California Annual Grassland series mentioned above, but without the introduced species.

The "vernal pools" were characterized by certain plant species that occurred only in areas occupied by these ephemeral pools. These include California Orcutt grass *(Orcuttia californica)*, *Phalaris lemmonii, Elatine brachysperma, Epilobium pygmaeum,* woolly-heads *(Psilocarphus bresvissimus),* and *Naverretia prostrata* (Mattoni and Longcore 1997). Unfortunately, urbanization has destroyed most of the depressions in which these pools formed and, with them, their dependent communities, although remnants still grow on isolated slopes (e.g., the north-facing slopes of the Del Rey bluffs, which have been recently revegetated), abandoned areas near the Los Angeles International Airport (e.g., in the lee of the El Segundo dunes), and in portions of the Ballona Lagoon that have not yet been built up. The most extensive restoration of a vernal pool is occurring at the Madrona Marsh in Torrence, California, at the southern end of the former prairie.

Native American use of the rich and diverse mix of habitats is only hinted at by the macrobotanical record. Culbert (1996) suggested that the Los Angeles Prairie and the vernal pools in it must have been intensively used by ancient peoples. Ethnobotanical reports of native use of coastal and montane chaparral plant species also suggests that use of bluff plant communities must have been considerable (Appendix J).

Environmental and Climate History

Two events dominate the history of the Ballona estuary and the surrounding terrestrial landscape. The first event was the arrival of the sea level at its current elevation, and the second was the transformation of the southern California sagebrush steppe into coastal and higher-elevation chaparrals. The following discussions of estuarine and chaparral history are drawn from reanalysis of the pollen records from the Ballona Lagoon, reported by this author in 2004.

Estuary History

The best record for the encroachment of the sea level to its current levels and the subsequent history of the Ballona estuary was obtained from a melding of the proxy information derived from the analysis of diatoms, foraminifera, ostracodes, algae, and aquatic plants in Playa Vista Cores 1, 8, and 11 (Wigand 2004). From the record (Core 8) near the mouths of Ballona and Centinela Creeks, the first clear indication of marine transgression was at approximately 6206 B.P. Prior to that time, terrestrial freshwater marsh and terrestrial habitats characterized the floor of the Ballona estuary, north of and directly beneath the West Bluffs sites (Wigand 2004). A period of obviously oceanic incursion into the estuary characterized the period between 4994 and 6206 B.P. Between 4659 and 4989 B.P., a period of continental fluvial conditions prevailed when significant marine influences were absent. This episode was followed by the only other period (4123–4567 B.P.) of significant marine influence in the estuary during the remainder of the record. Between about 4037 and 4114 B.P., the absence of algae, littoral pollen, and low values of Chenopodiaceae family pollen suggest a hiatus, during which the site might have been exposed to the air and the sediments might have dried out. This was followed between 3765 and 4033 B.P. by some of the highest values of sedge and cattail pollen, indicating that the area beneath the West Bluffs sites lay in an extensive freshwater marsh. Renewed and heavy flows were filling the streams feeding the Ballona Lagoon and inundating areas that had been dry during the previous period. Marshes formed in the newly submerged lands of the Ballona Lagoon. This period corresponds to the highest inputs of Neogene Glacial period moisture elsewhere in the West (Wigand 1987; Wigand and Rhode 2002).

Between 3176 and 3765 B.P., a continental fluvial system in the estuary was characterized by a highly variable environment that was at times dominated by fresh through euryhaline conditions (Wigand 2004). Moderate values of cattail pollen during this period, centered at approximately 3331 B.P., seem to mirror an episode of wetter climate recorded elsewhere in pollen records from the Mojave Desert and the Great Basin during the Neogene Glacial period (Mehringer 1986; Wigand 1987; Wigand and Rhode 2002). Three previous increases in cattail pollen relative to sedge occurring at approximately 3,840, 4004, 4,211 and 4,793 also coincide with episodes of wetter climate in the interior West (Mehringer 1977, 1986; Wigand 1987; Wigand and Rhode 2002). During this period, the Ballona was a highly variable estuarine system with periods of extensive salt marsh or alkali flats alternating with freshwater marsh, and occasionally, with the absence of both. The dynamics of the estuary at this time reflected high climatic variability, the pattern that characterized the generally moister Neoglacial between 4,000 and 2,000 years ago.

The next two stages in the Ballona Lagoon record formed part of the Neoglacial also. The first, between about 3028 and 3176 B.P., reveals a sedge-dominated marsh with no significant inputs of fresh water (Wigand 2004), and mirrors a brief episode of drier conditions during the Neogene Glacial of the Great Basin (Wigand 1987). The following period, between approximately 3028 and 2525 B.P., had at least one major influx of fresh water from the interior, as shown by increased cattail abundance at about 3003 B.P. Much lesser episodes at approximately 2693 and 2853 B.P. indicated that the effects of the Neoglacial climate were weakening.

From approximately 2023 to 2525 B.P., the freshwater marsh seems to have contracted, and the salt marsh might have migrated further west in the estuary as it filled (Wigand 2004). A gap in the record between about 2000 and 1450 B.P. may reflect a period when the area below the West Bluffs sites was bare sand flats. From about 1428 to 1091 B.P., sedge marsh began reexpanding, along with salt marsh and alkali salt flats. During much of the period between about 2525 and 1091 B.P., the area lying below the West Bluffs sites might have been an intermittently or substantially exposed sandy flat. Finally, between approximately 1091 and 911 B.P., a cattail-dominated freshwater marsh expanded into the area lying below the sites. This was probably in response to a renewed input of fresh water from the streams feeding the lagoon.

From an area on the Ballona estuary floor just northwest of the West Bluffs sites, a core (Core 11) of sediments dating to the last millennium indicated the presence of a cattail-dominated freshwater marsh with nearby salt marshes, from about 500 to 440 B.P. (Wigand 2004). Although higher foraminifera values suggested at least one incursion of marine waters, the period between approximately 440 and 320 B.P. was primarily characterized by the presence of nearby salt marshes. Between about 320 and 250 B.P., a cattail-dominated freshwater marsh covered the estuary floor northwest of the West Bluffs sites, and salt marsh seems to have predominated in areas to west. From about 250 to 216 B.P., freshwater marsh still typified the area, but the salt marsh might have been inundated. Finally, during the period between approximately 216 B.P. and the present, although cattail and sedge marsh fringed the freshwater channels leading to the sea, salt marsh predominated.

The paleoenvironmental record from the westernmost Playa Vista core (Core 1) indicated that there has never been a freshwater marsh dominated by either sedge or cattail at that locality (Wigand 2004). Although there might have been a pickleweed-dominated salt marsh at some distance from the project area during the late Pleistocene and the early through middle Holocene, the marsh did not arrive at the Core 1 location until approximately 3,700 years ago (Wigand 2004). The marsh remained there until about 3300 B.P., when it began fluctuating in its extent. After approximately 2,500 years ago, the pickleweed community reexpanded into the area, becoming extremely dense between about 1,600 and 1,000 years ago. The record of the last 1,000 years was missing from the Core 1 record, but could be partially extrapolated from the Core 11 record just to the east.

Chaparral History

The three Playa Vista cores from the Ballona Lagoon also provide a unique opportunity for examining the terrestrial vegetation surrounding the Los Angeles basin. Playa Vista Cores 1 and 8 are the two longest records available from southern California, spanning the last 18,000 years. Perhaps the most important terrestrial vegetation events recorded in these cores are, first, the nature of late Pleistocene vegetation in southern California and its demise about 12,500 years ago; and, second, the establishment and history of Los Angeles basin chaparral communities after approximately 8000 B.P. Slight differences in the record of chaparral vegetation from Cores 1 and 8 can be taken into account through physical differences between the cores, including differential deposition rates, episodes of erosion, and sediment compaction.

In addition, the vagaries of sample collection (e.g., size and spacing) also result in differences in the appearance of the records.

The lower portion of the Playa Vista core record contains strong evidence of a late Pleistocene (between approximately 14,500 and 12,500 ^{14}C B.P.) subalpine woodland dominated by “limber” pine in the mountains surrounding the Los Angeles basin (Wigand 2004). The identification of limber pine is based on current species occurring in the region and the vegetation history derived from ancient woodrat middens in the Mojave Desert. At middle elevations, a nonchaparral shrub steppe, constituted in part of *Ceanothus* and Rosaceae species, characterized the vegetation. At low elevations, a sagebrush steppe (more widespread than that of today), characterized by higher proportions of Aster-type plant species and much less grass, predominated.

The most prominent event of the last 10,000 years is the shift from sagebrush dominance on the landscape just before about 8,000 years ago when a mixed chaparral seems to begin to be established. At that time, both Labiatae (primarily the genus *Salvia,* the true sages) and *Ceanothus* became more important relative to sagebrush (Wigand 2004). In addition, Rose-family pollen (probably in part or largely from chamise) began to increase in comparison to both sagebrush and true sage. The increasing regional abundance of pine versus oak pollen at the same time seems to mark a significant change in the nature of regional climate. The pine increase probably reflected regional increases in both ponderosa and Jeffery pine in the mountains to the north and east. Except for an early Holocene period of higher relative abundance of Rose-family pollen, its occurrence was both sporadic and dramatic. This kind of occurrence is attributable to either a high-frequency, short-duration climatic shift, or more likely as an increase in fire, brought on by winter drought (Wigand 2004). Vegetation assemblages were quite different before about 10,000 years ago than later ones mirroring the Pleistocene to Holocene climate shift.

About 6700 B.P., sagebrush dominance in the chaparral, and probably in the region, decreased significantly (Wigand 2004). Another change of lesser significance occurred approximately 6,100 years ago, when *Ceanothus* became more important in the chaparral, which suggests slightly more mesic (wetter) conditions. Labiatae dramatically increases at about 5500 B.P. (most likely marking an increase in the importance of true sage *[Salvia]* in the chaparral), indicating drier conditions. Much-decreased Labiatae *(Salvia), Ceanothus,* and even *Artemisia* abundance between about 4,300 and 3,200 years ago corresponded with a period of a marked decrease in the proportion of summer rainfall (Wigand 2004:Figure 21b). Total annual rainfall decreased throughout this period, though winter rainfall seems to have remained at relatively constant levels. A break approximately 2,600 years ago corresponds with regional, late Holocene pine *(Pinus)* expansion relative to oak *(Quercus).* Between about 3,200 and 2,200 years ago, the relative importance of Labiatae *(Salvia)* in the chaparral increased, especially with respect to sagebrush. A strong expansion of sagebrush *(Artemisia)* is centered between 2,200 and 2,000 years ago and is clearly in response to a strong pulse of winter rainfall. Between about 2000 and 1,400 years ago, there is a gap in the record. Most of the record between approximately 1,400 and 990 years ago suggests that elements of the much-reduced chaparral were relatively balanced. Finally, during the last 500 years, there have been three episodes of change in the chaparral. Between 500 and 300 years ago, Labiatae was more dominant. From 300 to 200 years ago, during the peak of the Little Ice Age, *Ceanothus* became relatively more common. During the last 200 years, sagebrush *(Artemisia)* increased in abundance at the expense of both Labiatae and *Ceanothus*.

The very close connection between climate and the history of chaparral is strongly suggested when the pollen record of chaparral from Playa Vista Cores 1 and 8 is compared to the reconstructions of late-Quaternary climate for the Los Angeles Airport area, provided by Dr. Reid Bryson of the Center for Climatic Research, Institute for Environmental Studies, University of Wisconsin—Madison (Wigand 2004:Figures 21a–c). Using macrophysical climatic modeling based on the relationship between large-scale atmospheric dynamics and synoptic climatology, these plots provide an uncanny correspondence between the reconstructed climate for the area and the vagaries of the chaparral (Bryson and Bryson 2000). It is clear that dramatically increased precipitation (primarily winter) after 8,000 years ago corresponded to the establishment and proliferation of chaparral vegetation (Wigand 2004:Figure 21a).

Declining annual precipitation after 6,000 years ago was mirrored by a decline in chaparral species dominance.

The chaparral record from Cores 1 and 8 also corresponded very well with the reconstruction of rainfall frequency (Wigand 2004:Figure 21b). Rainfall frequency dramatically increased simultaneously with a similar increase of annual and winter rainfall in Bryson's climatic reconstruction for the Los Angeles basin (Wigand 2004:Figures 21a and 21b). Although there is no clear relationship between the reconstructed temperature of the last 14,000 years and chaparral history, there may be a threshold effect. That is, once temperatures reached a certain level, they played a role, in concert with increased rainfall, to encourage formation and maintenance of the chaparral.

Finally, there seems to be a correspondence between the dramatic declines in winter rainfall as reconstructed by Dr. Bryson and fires in the chaparral as recorded by spikes in the Rosaceae pollen in the records from Playa Vista Cores 1 and 8 (Wigand 2004:Figure 22). If Rosaceae—chamise would be the best possible candidate—appeared as a secondary succession after fire, then the correspondence can be explained. Drought cannot explain increased Rosaceae pollen, which should decline during droughts. If, however, Rosaceae pollen reflects the rapid ability of chamise to recover before other species after a fire, then the correspondence can be explained.

Documentation of a Short-term Late Holocene Regional Climatic Event

A brief (approximately 150 years), though very strong, climatic event at 2,000–2,100 years ago was recorded in a high-resolution pollen record from Lower Pahranagat Lake in the Mojave Desert (Wigand and Rhode 2002). The event was marked there by huge increases in pine, juniper, and sagebrush pollen, indicating much wetter conditions. The pollen response that was seen there was not due to the establishment of new trees or shrubs on the landscape—the climatic event was too brief—but to increased pollen production by plants already on the landscape. This event was also recorded in the fluvial record from the Mojave River as a period of increased flows (Ely et al. 1993; Enzel et al. 1989, 1992). The Mojave River record is significant because the river's source is at the east end of the San Gabriel Mountains, which form the northeastern flank of the Los Angeles basin. Therefore, the Mojave River record is a proxy for rainfall in the Los Angeles basin, or at least along its eastern edge. In Playa Vista Core 1, this event was manifested as a dramatic increase in the abundance of pine vs. oak pollen (Wigand 2004:Figure 14). Sediments of this age did not appear in Playa Vista Core 8 (the sediments containing this event might have been washed away as a result of greatly increased stream flow into the estuary as a result of regionally increased rainfall). The magnitude and widespread impact of this event and its potential for disrupting fluvial systems is demonstrated from studies of the fluvial geomorphology of north-central Nevada. Several studies along the Humboldt River indicated that the entire channel was displaced by a flood event that cut a new and deeper channel for the river (House et al. 2001; Miller et al. 2004; Ramelli et al. 2001). After 2,000 B.P., the old channel was left isolated at a slightly higher elevation than the new channel into which sediments of the last 2,000 years have been deposited. The global impact of this event is also very clear in the reconstructed annual rainfall amount and frequency for the Los Angeles Airport (Wigand 2004:Figures 21a and 21b).

Pollen Analysis

Extraction

The 48 sediment samples taken from sites LAN-63, LAN-64, and LAN-206 were processed for pollen in the Paleoecology Laboratory at the Department of Geography, University of Nevada, Reno (Table 12.2). The pollen-extraction procedure is described below.

Processing of samples for pollen and selected spores began with three tablespoons (see Table 12.2 for exceptions) of sample placed in a 400-ml plastic beaker with triple-distilled water (see Table 12.2). For statistical purposes, four Lycopodium tracer spore tablets (batch no. 124,961 with 12,542 ± 3.3 percent spores per tablet) were added to each of the ten samples. This equaled 50,168 ± 1,656 tracer spores per sample.

Because of the high probability that the pollen in these samples might have been degraded (to be expected with samples from open sites), the extraction procedure was slightly modified to remove those steps that might be more damaging to the pollen during processing. The modified procedure was as follows. Samples were treated with concentrated hydrochloric acid (HCl) to remove carbonates, and rinsed through 150-mesh screen using distilled water. The samples were transferred to 15-ml test tubes and treated with hydrofluoric acid (HF) to remove inorganic materials (primarily silicates) and left to stand overnight. The next day, additional treatment with HF while in a 30-minute, hot-water bath was followed by two rinses of the samples with distilled water. Another HCl treatment, followed by a distilled water wash, removed silica gels generated during the HF treatment.

Omitted at this point were a series of steps that are meant to remove organic material from the sample, but which can be highly corrosive. These steps included: (1) a treatment of the samples with 10 percent HNO_3 to remove organic carbon; (2) a water wash; (3) a third treatment with HCl in a 2-minute boiling water bath to remove dissolved organic material; (4) a distilled-water wash to remove soluble organic carbon; (5) a treatment with glacial acetic acid to dry the samples; (6) then a treatment with an acetolysis mixture (9 parts acetic anhydride plus 1 part H_2SO_4) in a 1-minute boiling water bath; (7) another glacial acetic treatment to halt the reaction; (8) a distilled-water wash to remove the small particulate organic carbon; (9) a treatment with 10 percent KOH to remove soluble organic carbon samples; and (10) finally, four distilled-water washes to change the pH and remove the remaining soluble and fine-particulate carbon.

The processing of these samples was resumed by drying the pollen with two treatments of ethanol alcohol (the first, a 95 percent concentration, and the second, a 100 percent concentration). The pollen was then stained with safranin O, the samples were transferred to vials with tertiary butyl alcohol, and the process was completed with the addition of a mounting medium (2,000-cs silicone oil). Finally, the tertiary butyl alcohol was evaporated from the samples in a low-temperature oven for a couple of hours. Pollen samples were mounted on glass slides and at least 41 contiguous rows (all rows on the slide) were counted for each sample. Identification of certain unknown pollen types was assisted by the use of a reference slide collection, several online pollen floras (linked to Davis's Web site [2005]), and several pollen photomicrograph publications of Southwestern pollen types that were helpful for types that seem to be intrusive from the Southwest (Martin and Drew 1969, 1970; Solomon et al. 1973).

Results

Raw terrestrial and aquatic pollen counts (Table 12.3; Table K.1) were converted to percentages (Table 12.4) of total terrestrial pollen. Raw counts of spores (see Tables 12.3 and K.2) were converted to percentages of total spores (see Table 12.4). Using L. Maher's (1972) formulas for calculating pollen population estimates, the raw counts and Lycopodium tracer spores were used to generate estimates of

Aster-type pollen percentage per sample (Figure 12.10a), total Aster-type pollen per sample (Figure 12.10b), total pollen per sample (Figure 12.10c), and total pollen per cubic centimeter (Figure 12.10d), all with 95 percent confidence intervals (Table 12.5). The relative percentage of each type was plotted by feature number (Figure 12.11) and is compared with a 14,000-year long climate reconstruction provided by Dr. Reid Bryson for the Los Angeles International Airport area. Because pollen counts were low in many of the samples, the relative percentages of less-abundant pollen types vary erratically. “Unknown,” “undeterminable,” and “deteriorated” pollen grains were grouped in the category “undeterminable.”

Discussion

It was clear from the pollen counts that there were three and possibly four groups of pollen, based on their relative preservation, and on whether they were native species or exotic (introduced).

Group 1 included poorly preserved pollen grains with pitted surfaces or indistinct features, or that had been torn into fragments. The pollen grains in this group could date to the time of site occupation, having been deposited at the same time that people used the site. Conversely, the grains could predate the site use and have been present in the sediments that composed the site. After site abandonment, the grains entered cultural contexts as the site was buried by adjacent sediments through colluvial or aeolian deposition. The poorly preserved state of the pollen could be the result of age (long exposure to degradation), or the result of soil conditions that favored pollen degradation: high, or basic, soil pH or high Eh (oxidation potential). It could also have been the result of bacterial activity, which is favored by wetting and drying during cycles of warm, moist conditions. It was impossible to identify the grains in this group because their preservation is too poor. They are included in the “undeterminable” category.

Group 2 is composed of pollen grains that appear to be well preserved (Aster-type pollen), but whose abundance is much greater than would be expected in any “natural” plant community. As in Group 1, these could date to the time of site occupation, could predate the site use and have been present in the sediments that composed the site, or been incorporated into the site during feature burial through colluvial or aeolian deposition. Of the more common pollen types included in this group are most of the “Aster-type” pollen, all of the “Other Chenopodiaceae” pollen, *“Artemisia”* pollen, TCT (Tax Cupressaceae,), pine, Poaceae (grass), and Lamiaceae (mint family) pollen. Also the trilete spores (ferns) appear to be part of this group as well.

The pollen grains of *Group 3* were native species. They were background pollen, i.e., deriving from the local plant community, but they appeared to be much better preserved than most of the other pollen grains in the samples. Because they were much better preserved than most of the pollen grains in the samples, they might be pollen that was introduced during collection of the pollen samples. These pollen types include *Proboscidea* (devil’s claw), among others.

The *Group 4* pollen grains were well preserved and clearly represent nonnative species. Some of these even contained cytoplasm in the pollen grain. Primary among these pollen types are: *Ulmus* (elm) and Erodium (storksbill) which often appears in historical pollen records in southern California. These may reflect contamination during sample collection.

Group 5 consisted of at least one species, Onagraceae (evening primrose), which, although a modern native plant, appears much darker and flattened than most other pollen grains in the samples. These characteristics are typical of pollen eroded from much older deposits and redeposited into younger sediments. The much darker color could also be the result of burning of the pollen grains before deposition.

Pollen Preservation and Interpretation of the Record

There were several factors that suggested the pollen preservation in these samples was poor. Primary was the eroded appearance of many of the grains. Secondly was the overrepresentation of one or two pollen types, especially if they were pollen types that studies have shown were resistant to erosion (they usually have a much thicker pollen wall). Along with this factor was the lack of diversity in the pollen types in the samples. Finally, there were usually very low numbers of pollen grains per cubic centimeter of sediment in each sample; this could have been caused by rapid deposition rates also, but in combination with the other factors, it indicated poor preservation. All of these factors seem to be reflected in the pollen from West Bluffs sites.

Many pollen grains appeared highly eroded. This could have been as a result of bacterial action, oxidation or mechanical damage during aeolian transport. Thin-walled pollen grains were effected the greatest. However, even some of the thick-walled pollen grains, such as the Chenopodiineae and Aster-type pollen, were also highly eroded in these samples.

Low numbers of pollen per centimeter per year sample and especially per cubic centimeter indicate that pollen preservation was fair to poor in all samples (see pollen per cubic centimeter values in Figure 12.10d). In a semiarid to subhumid environment, the amount of pollen deposited per square centimeter per year will range from 6,000 to 8,000 pollen grains, and occasionally up to 10,000 in wet years. Each of the pollen samples submitted for analysis (given their initial volumes) should contain the sediment accumulated from several years, with a pollen abundance on the order of 18,000 to 30,000 grains per cubic centimeter. The pollen per cubic centimeter estimates of these samples did not even approach such values (see Table 12.5) and suggested either poor pollen preservation or rapid sediment deposition. Although rapid deposition does not effect pollen preservation, it exacerbates the problem of pollen abundance. That is, if sediment deposition rates are rapid, pollen will be more thinly distributed through the sediment. Add to this the issue of poor preservation, and the pollen will be even more thinly dispersed through the sediment. A pollen sample taken from such soil will yield very little pollen.

Another clue to the state of preservation of the pollen samples is how well the pollen assemblage reflected the current (or assumed past) vegetation community. In this case, the dominant types recovered from the pollen samples were Aster-type (sunflower-family plants), and Chenopodiaceae (saltbush-type plants). Although these grow in nearby modern vegetation communities, they are not the major pollen types that one would expect in the modern pollen rain. The detailed scan of the pollen samples undertaken for this study clearly indicated that the pollen samples from these features do not reflect the relative abundance of the pollen types to be expected in the current or past local or regional pollen accumulation. The lack of diversity, e.g., the extremely low abundance of grass, Fabiaceae (bean family), and sagebrush pollen, as well as other pollen types, strongly suggests that these types were eroded away after the deposition of these sediments.

Finally, the lack of pine pollen in most of these samples was another indication that preservation was poor. Even in a desert environment, long-distance transport of pine pollen on the regional winds should flood the local pollen record, and it was clearly present in the nearby cores from Ballona Lagoon.

Poor pollen preservation reflects any number of factors. It may not only reflect the basic pH of the soil (acid soils favor pollen preservation, but basic soils are inimical to pollen preservation), but may reflect the coarseness of the soil matrix in which it is found. The coarse texture of the sediments was noted during extraction of the pollen in the laboratory. This already hinted at poor pollen preservation. Coarse soils allow for the rapid flow of water through the soils. Frequent wetting and drying of the soils indicates a well-drained condition with plenty of air movement into the soil. These conditions are ideal for a high oxidation potential, + Eh , to occur. High oxidation potential is very destructive for pollen, especially because it creates an environment favorable to bacterial growth. Bacteria that thrive under such conditions literally eat pollen. The orangish to reddish soil color at the West Bluffs sites is a strong indication that wetting and drying of the soils and high oxidation has been an ongoing process.

Soils in the West Bluffs sites are probably of dual origin. Originally, they derived from the alluvium that was swept out of the mountains to the east. Subsequently, these sediments were reworked by local streams and the ocean to accumulate in beaches, spits, and estuarine sand flats around the Ballona estuary. From there, they have been deflated by wind and transported around the landscape. The Del Rey Bluffs themselves are composed of ancient shoreline beaches that provide a rich source of sands and silts. Aeolian winnowing processes, if they are ongoing, eliminate much of the pollen deposited on the ground surface. That is, because pollen is a silt-size particle, if prevailing winds are strong enough, silts will be blown away, leaving only sands. The West Bluffs sites contain some silts (and as a result, pollen) in the site matrix, but much of it is composed of sands. Aeolian activity also results in severe mechanical damage, as the surfaces can be heavily eroded through abrasion.

Any one of the factors above could result in poor pollen preservation, but together, they assure that pollen survival will be extremely poor or, at best, rare. Unfortunately, these conditions are similar to those encountered by many palynologists conducting archaeological palynological investigations throughout southern California and the American Southwest.

Having covered the cons with regard to the pollen record from the West Bluffs sites, we now turn to what other information can be gleaned from the record. Of the samples that were processed, 1- 4 are from an area that seems to have been intermittently filled with water. Only Samples 2 (2Ab1, 40–50 cm) and 4 (2ABb, 100–110 cm) contained sufficient pollen to draw conclusions regarding the environment. Although Sample 1 has a few Cyperaceae (sedge) pollen grains, there are no other indicators of aquatic environments in these samples. Sample 4 has the greatest abundance and diversity of pollen. It shows an array of pollen that would be expected in an area such as the West Bluffs site area. That is, there are pollen representative of shrub and grassland types of vegetation. Pollen of clearly identifiable salt marsh species are not present. The saltbush (Chenopodiaceae) pollen that does appear is not pickleweed *(Salicornia)* pollen. Sample 4 reflects and environment that probably was not much different from that which occurred in the area prior to the encroachment of modern Los Angeles. Samples 1–3 reflect the higher proportion of Aster-type pollen that indicates poorer preservation.

The abundant Aster-type pollen in these and the other samples derives from the many plants of the composite family that grow in the area. Perhaps one of the major sources of this pollen type is the genus *Baccharis.* Several species of this genus grow in the areas both below the West Bluffs sites in riparian areas and in the coastal chaparral on the bluffs below the site, and in the Los Angeles Prairie south of the site. *B. glutinosa* is found in the freshwater marshes and in riparian areas below the site (Gustafson 1981). *B. pilularis* ssp. *consanguinea* is found in disturbed areas and in coastal shrub communities on bluffs (Gustafson 1981). Another species, *B. emoryi,* was found in the dry bottoms of vernal pools of the Los Angeles Prairie and on the sandy edges of rivers, washes and salt marshes (Hickman 1993; Mattoni and Longcore 1997). As with all composite species, *Baccharis* produces copious amounts of pollen. It is to be expected that these species would be well represented in the pollen record, but not to the extent that occurs in the samples from the West Bluffs sites. An indication that much of the Aster-type pollen is from *Baccharis* is that the pollen is relatively small and has a morphology consistent to that expected for *Baccharis.*

Chenopodiaceae pollen, as mentioned above, is primarily from non-*Salicornia* (pickleweed) species. Much of it has a morphology consistent with the genus *Atriplex,* although other genera cannot be ruled out. Various species of *Atriplex* occur both in the Ballona estuary and on the bluffs below the West Bluffs sites. In particular, *A. lentiformis* (big saltbush) grows on bluffs near the seashore, and can also be found in the salt marsh with *A. californica* and *A. patula* ssp. *hastata*. These also produce copious amounts of pollen.

The abundance of these two types in site contexts probably does not relate to the processing of plant materials. Although not likely, *Baccharis* could have been collected during its blooming season for some use, thus shedding its pollen in site sediments during processing. The chenopod pollen probably came onto the site in a different manner, because the primary use for *Atriplex* was its seeds, which can only be collected from separate female plants.

The greater abundance of *Salicornia* pollen in two samples, Samples 22 (LAN-64, PD 1125, Feature 32, Level 1) and 30 (LAN-64, PD 1447, Feature 62) probably only suggests pollen blowing in from the marsh and not the processing of pickleweed. If beating baskets were being used to harvest seeds from pickleweed, only female shrubs would have been beaten for seeds, and male shrubs, where the pollen originates, would not have been touched.

One other anomalous pollen abundance was in Sample 4, described as being from the 100 to 110 cm depth of the intermittently filled ephemeral pond, and in Samples 22 (LAN-64, PD 1125, Feature 32, Level 1) and 34 (LAN-64, PD 1567, Feature 76). In these samples, a variety of non-*Salvia* mint pollen is present. Its abundance in Sample 4 could indicate that it was growing in the damp soil around the intermittently filled ephemeral pond, but its abundance in Samples 22 and 34 may actually indicate processing of some mint family species. It is impossible to determine which of the many mint species with distinctive three-furrow morphology could be represented in the record. Unlike *Atriplex* pollen, mint pollen could have been detached from the flower head of the plant during processing. Flower buds, blooming flowers, and fully developed seeds can all be found on the same (indefinite) inflorescence. This supposition would have to be confirmed by the appearance of seeds in the macrobotanical samples from the same contexts. The appearance of this pollen type may be purely environmental in both samples, i.e., although almost 2,000 years separate the time periods represented by the samples, they indicate the same kind of environment. It does not, however, mean that ephemeral ponds existed at this site throughout the last 2,000 years. These two samples may simply reflect two instances when this kind of environment appeared: it might have been the only two times, or it might have appeared quite regularly.

Finally, devil's claw *(Probosidea* cf. *parviflora)* pollen, although rare, was also in the samples processed from the West Bluffs sites (see Tables 12.3 and 12.4). The seed pods of this annual were used by native people to make basketry. There is little to no possibility that devil's claw pollen could have been collected along with the seed pod, because this plant flowers and produces mature seed pods many weeks apart. Collection and use by native peoples of these plants, however, might have led to the establishment of some of these plants adjacent to or in the settlements, perhaps even near the work areas in the sites. Alternatively, there might not have been any use of devil's claw on the site, and the appearance of its pollen in the record may be purely coincidental because it grew as a nearby weed.

Macrobotanical Analysis

Sample Processing

The residue from 70 flotation samples were submitted to this investigator for analysis of macrobotanical contents (Table 12.6). Small samples were scanned, sorted, and the contents identified without need of further processing. Of the original 70 samples, however, 50 required significant additional screening to remove silts and sands from the sample, accomplished by passing the samples through a set of nested screens (U.S. standard sieve sizes 8, 12, 25, and 45). In addition, to separate abundant roots from seeds and heavier materials, the chaff was gently rolled back and forth across a large piece of paper so that seeds, bone, and other materials would drop through the chaff and accumulate on the surface of the paper. All screen fractions and both the chaff and the residue were sorted under a Fisher Scientific pole-mounted dissecting microscope with zoom magnification ranging from ×7 to ×45. Macrofossils were identified using reference collections and seed keys, including Albee (1980), Martin and Barkley (1961), Montgomery (1977), Musil (1963), and Young and Young (1992). The sorted fractions were placed in gelatine capsules and stored in labeled, zip-closure plastic bags. Seed counts were recorded on a spreadsheet for analysis.

Results

Counts of the macrobotanical analysis are presented in Table 12.7 (Table K.3). Seeds were identified to species level when possible, but some were identified only to the genus or family level. A separate category for unidentified seeds included seeds that were in such poor condition that they could not be identified. Seeds that were in good condition, but had not been identified as to family, genus, or species were given an "unknown" designation with a letter. For example, the first unknown seed type was grouped under the designation "Unknown A." Seeds were also divided by their condition, i.e., carbonized or uncarbonized. The presence of charcoal in a sample was noted, but all was much too small to be identified (see Table K.3). Presence of bone, shell, and other materials was noted as present, but no identification or quantification of these materials was conducted (see Table K.3). Seed counts were converted to percentages of either uncarbonized or carbonized seeds, and the relative abundance of uncarbonized and carbonized seeds as a percentage of total seeds was recorded (Table 12.8).

Discussion

Seed Contents

The macrofossil record from the West Bluffs sites included seeds, fruits, charcoal, bone, and gastropod shells, as well as fragments of bivalve shells (see Table 12.7). In all, almost 8,800 seeds (carbonized and noncarbonized) were recovered from the West Bluffs site samples (see Table 12.7). The majority of these seeds were shorter than a millimeter along their greatest dimension.

Most of this material was not carbonized, but roughly 78 percent of the total seeds recovered were not carbonized. Noncarbonized seeds were generally identifiable to at least the genus level and occasionally to species. Of the noncarbonized seeds, more than 61 percent comprised just two species in the Caryophyllaceae (Pink) family (see Table 12.7). Seeds (actually seed coats of catchfly, *Silene* cf. *gallica*) composed almost 32 percent of the total seed count. Another member of the Caryophyllaceae family, *Spergula* cf. *arvensis* (spurry), constituted another 29 percent (see Table 12.7). Noncarbonized seeds of *Erodium* cf. *cicutarium* (storksbill) ranked third in abundance, with about 5 percent of the total seed count. Noncarbonized seeds of *Calandrinia* (redmaids), a member of the Portulaceae family, was the fourth most abundant seed type, with about 3.8 percent of the total seed count. Abundant flower parts and seeds of Aster family plants ranked fourth in abundance. Other identified types of noncarbonized seeds were rare (see Table 12.7). More than 77 percent of the seed total was identified (not including unknowns) noncarbonized seeds. Unidentified noncarbonized seeds were lumped in the category "noncarbonized" seeds (see Table 12.7).

Carbonized seeds were often fragmentary or had lost enough surface detail that they could only roughly be assigned to family or, occasionally, to a genus. In many of these seeds, the sugars had caramelized, creating a bubbly structure in the interior of the seed that often distorted the surface of the seed also. As a result, identification of carbonized seeds usually relied on the general morphology and size of the seed, a tenuous assignment at best. In these cases, the term "cf." (compares favorably with) is used. Because of the great variety of carbonized seeds and because of their often poor or fragmentary condition, most were categorized as "carbonized seeds." Of the carbonized seeds, those of the grass family were the most abundant, constituting about 20 percent of the total carbonized seeds (see Table 12.7). Of the grasses, *Hordeum* cf. *pusillum* type (little barley) was the most abundant. This was followed by *Poa* sp. type (annual bluegrass), *Leptochloa* sp. type (sprangletop), *Festuca* cf. *subverticillata (= obtusa)* type (fescue), and *Vulpia (= Festuca)* cf. *octoflora* type. Other grass types were relatively rare. Among the other clearly economic carbonized seeds, sedge (*Scirpus* sp.) was sporadic among the samples and rare when it did appear (except in one case discussed below). Carbonized seeds of

Rumex sp. (dock) were identified in only a few samples. There were several seed types that were not identified but were abundant enough to be carried as "Types" in Table 12.7. A few of these ranged up to 6.4 percent of all carbonized seeds, but they were in greater abundance in only a few of the samples (see Table 12.7).

Interpretation of the Seed Record

The seed record was composed of several categories reflecting two possible origins. The first and most obvious division was between carbonized and noncarbonized seeds (see Table 12.7). Carbonized seeds could have been intentionally carbonized by native peoples; equally possible, however, was that the seeds were accidentally dropped into hearth areas during toasting. Another possibility was that some of these seeds were the result of natural wild fires that might have swept through the area occasionally during prehistoric times. Native American collection, and possibly placement, of seeds is visible in perhaps only one sample, from Feature 56, a burial (discussed below).

A second division was between seeds that are very abundant and those that are not. Although seed abundance was occasionally a result of the amount of sediment floated for each feature, it usually was not (see Table 12.7). Dung in some of the samples indicated that rodent activity, such as seed caching in nests, may account for the high frequencies of some taxa (see Table 12.7). One of the modern seed types was very often split in two, suggesting that rodents might have eaten the meaty interiors and further evidence for rodent activity in the area.

A third division was between those seeds that were found throughout all the samples and those that appeared in only a few. The two most abundant types were in almost every sample from the West Bluffs sites, but a few of the less-common seed types were also found in almost all the samples.

These characteristics formed two main groups of seeds. First, those seeds that were not carbonized but very abundant and in most of the samples suggested that these plants were also widely distributed throughout the site areas. These are weedy species whose appearance in the samples was either purely accidental or the result of rodent activity. The seeds of these species can be considered the seed background for the West Bluffs sites. That is, they most likely derived from locally growing plants that are both common and prolific seed producers. Given the variable condition of these seeds, their age could also be variable.

The second group consisted of carbonized seeds, which were in only a few of the analyzed samples. Although the presence of these seeds in the samples was probably accidental (e.g., the seeds were lost during processing), the seeds were intentionally collected by people for food and therefore probably date to the occupation of the sites. Only in the case of the sample from the burial Feature 56, discussed below, was there a probability that the placement of the seeds was intentional.

Given the small size of some of the carbonized seeds, their use as a food source was doubtful. These small seeds could have been accidentally burned during the processing of other seeds, or, conversely, could have reflected past wildfires that might have periodically swept through the Los Angeles Prairie in the past.

As is evident from Table 12.7, most of the samples had only limited abundances of carbonized seeds. There were a few samples, however, that contained relatively abundant seeds that had been intentionally collected by native peoples and then either intentionally or accidentally deposited in the sampled features. Of these, the floated sample collected from LAN-64, PD 1260, Feature 56 (a burial flotation sample) is the most interesting (see Table 12.7). This sample had the same background seeds that were found in other samples from the West Bluffs sites, but it also had much greater abundances of seeds that were rare in other samples. In particular, this sample contained 35 carbonized sedge (*Scirpus* sp.) seeds, constituting about 10 percent of the carbonized seeds from that sample; numerous carbonized whole and fragmented grass seeds; and a great variety of other carbonized seeds, many of which were too broken to identify. The association of these seeds with the burial might have been intentional or purely coincidental.

Carbonized sedge seeds compose less than 0.6 percent of the total seed count, or about 2.45 percent of the carbonized seed count.

Seeds as Indications of Site Differences and Disturbances

The West Bluffs sites had very different seed assemblages. At LAN-63, out of a total of 4,298 seeds, about 17 percent were carbonized. At LAN-64, of 4,323 seeds, slightly more than 28 percent were carbonized. The seed total at LAN-206 was lower because there were only four samples; of the 174 seeds, only about 5 percent were carbonized. The difference between LAN-206 and the other sites may simply reflect sample size. Abundance of the noncarbonized seed content differed considerably as well, especially among the dominant types. Whereas catchfly seeds were almost five times more common at LAN-64, spurry seeds were about three times as abundant as catchfly seeds at LAN-63 (see Table 12.7). Values of catchfly and spurry were roughly equal at LAN-206. Storksbill seed abundance was low at both LAN-63 and LAN-64, but twice as abundant at LAN-63, but rare at LAN-206. Seeds of redmaid were most abundant at LAN-206, although total seed count was greatest at LAN-64 (see Table 12.7).

The modern weedy species in these samples were an excellent measure of site disturbance. In particular, storksbill, of European and Asian origin, reflected the degree of recent sediment mixing at these sites. Samples that contained abundant *Erodium* seeds also contained abundant *Spergula* and *Silene* (see Table 12.7). These abundances often correspond to increased abundance of carbonized seeds also (see Table 12.7). This may be explained by soil texture. Archaeological features contain organically rich sediments that are usually loose and easily tunneled by rodents, whose caching and tunneling activities can easily add modern weed seeds to the already rich mix of ancient seeds. The presence of rodent feces in some of the flotation samples with abundant noncarbonized seeds provided additional evidence of rodent harvesting and caching. Significant admixture of both modern noncarbonized and prehistoric carbonized seeds suggested considerable feature disturbance. Features in which there are abundant carbonized seeds but only limited numbers of noncarbonized seeds were probably only minimally disturbed.

Radiocarbon dates associated with most of the features from the West Bluffs sites cluster around 2100 B.P. A few features, however, might have dated to the early Holocene, between 7500 and 7000 B.P. Features 45, 49, 50, 55, and 60 from LAN-64 were compared with the other features to determine whether there were any differences in their pollen and macrofossil content. Unfortunately, these samples contained both very little pollen (see Table 12.3) and almost no seeds (see Table 12.7). The total number of carbonized seeds for all five samples is two, and the total number of noncarbonized (recent to modern) seeds is 37. The carbonized seeds consist of 1 unidentifiable seed and 1 unidentifiable grass. The noncarbonized seeds consist primarily of *Calandrinia* cf. *ciliata* (redmaids) (25 seeds), the common weedy Caryophyllaceae found in most of the other samples as well (see Table 12.7). As with all the other samples, a few of the typical intrusive seeds were present, including: seed coats of *Silene* (n = 3), *Spergula* (n = 1), *Erodium* (n = 1), *Amaranthus* (n = 1), *Sonchus* (n = 2), and *Chenopodium* (n = 2); 2 were unidentified (see Table 12.7). The total number of seeds and total noncarbonized seeds per liter was relatively low, although similar to several of the later samples from both LAN-63 and LAN-64 (see Table 12.7). The taxa in these samples were very similar to most of the macrobotanical samples from LAN-64, and those seeds that appeared to be modern in other samples from the West Bluffs sites appeared modern in these samples also.

Every macrobotanical analysis that identifies both carbonized and uncarbonized seeds confronts the same issue: are the two kinds of seeds contemporaneous or do they reflect more recent intrusions into older sediments containing prehistoric seeds? Carbonized seeds, especially when they were closely associated with radiocarbon-dated hearth or fire features, could be assigned a prehistoric age and were clearly contemporaneous with the ancient archaeology. Noncarbonized seeds, however, often showed no obvious differences from modern seeds found on the surface today, making the two impossible to distinguish. Sometimes there might have been subtle differences in the appearance of “modern” seeds. If such differences were used to separate them from modern seeds on the surface, however, distinguishing the two was still impossible unless confirmed with AMS dating. These very slight distinctions in appearance between seeds lying on the ground surface (or that have recently been buried), and those buried for a slightly longer period might have simply reflected the effects of burial and a single year of weathering. In the last analysis, AMS dating is the only reliable way to differentiate between intrusive and prehistoric macrobotanical materials.

As suggested above, the best indication that these "modern" seeds were intrusive was the presence of large numbers of the introduced European weed, *Erodium.* In general, these "modern" seeds appeared similar throughout the site, i.e., they all appeared to be little, if at all, degraded. The association of some of these seeds with rodent dung suggested the agent that mixed these seeds into the features (see Table 12.7). One or even two meters' depth is not a problem for rodents, especially if they encounter soft cultural deposits. In addition, poor pollen preservation suggested that seed preservation was also very poor. Carbonization is almost the only means to assure preservation of older seeds in a highly oxidizing soil context such as that at the West Bluffs sites.

The pollen from the 7000–7500 B.P. features was sparse, suggesting poor preservation. Between all five samples from those contexts, there were only 59 pollen grains, most of which (31 grains) were found in Feature 50. Of the 59 grains, 46 were Aster-type pollen grains. All of the features except Feature 50 had pollen counts that were too low to draw any kind of significant conclusions. Aster-type pollen predominated in each of them and composed more than 77 percent of the pollen from Feature 50 also. Other constituents included Onagraceae and chenopod pollen. The pollen and macrofossil content varies so little from the contents of the other sediment samples from LAN-64 that it might be concluded they were identical, suggesting considerable mixing.

Molluscan Evidence of Aquatic Environments

Gastropod shells, apparently of the genus cf. *Gyraulus* sp., were found in few samples (see Table 12.7). Although the genus identification needs to be confirmed, there were two possible explanations for this freshwater species in the sample. The shells might have been transported to the site in the roots of plants collected from either the eastern end of the Ballona estuary or from the "vernal pools" to the south. The snails might also have been washed onto the site from occasionally flooded depressions.

Local Environments Harvested by Native Americans and Season of Seed Collection

Several local environments were reflected in the seeds found in the West Bluffs sites. As indicated above, most of the noncarbonized seeds were purely local in origin, reflecting the bluff-top environment. Most of these seeds were probably recent, although a darkening (not carbonization) of some of these seeds might have reflected some age.

At least two additional environments from which the seeds might have been collected were indicated. Native grasses were abundant in the grassy shrublands and "vernal pools" of the Los Angeles Prairie south of West Bluffs (Table 12.9). Some grasses were also available in the Ballona estuary north of the bluffs.

Only a few of these species were identified among the carbonized grass seeds from the West Bluffs sites, but some of the other species could have been among the many unidentifiable seeds. Some types were identified that did not appear among those in Table 12.9. For example, the grass-seed categories in Table 12.7 are types of seeds: the genera designation is correct, but the species designation refers to a type of seed morphology characterized by that species.

It was evident that people at the West Bluffs sites could have been collecting seeds from the Los Angeles Prairie and the Ballona estuary. Two of the most common grass seeds, *Hordeum* and *Leptochola,* grow around "vernal pools" (see Table 12.9). The period of occupation at the West Bluffs sites was centered during a period when wetter winter climate would have favored large "vernal pools" that would have lasted well into the summer (see discussion below). These pools would probably have favored the proliferation of these and other grasses. In addition, the dunes would have been rich in fescues. *Rumex* (dock) would also have been abundant in sandy areas and dunes during this period.

Scirpus seeds clearly indicated that freshwater marshes were used. Whether these were the marshes north of the sites below the bluffs or perhaps ephemeral marshes that formed in and around the "vernal pools" of the prairie to the south could not be determined. It was evident, however, that during this period, marshes and "vernal pools" would have been more extensive than before or after this period.

Perhaps the most interesting result was the rarity of seeds of the Chenopodiaceae (saltbush) family. At most, they constituted only about 6 percent of the carbonized seed total, so they were no more important than any other seed source. In addition, none of these were of the Salicornia type. In fact, there was no real suggestion in the seed record that the salt marsh was extensively harvested for seeds.

Most of the identified carbonized seeds recovered from the West Bluffs sites would have been collected between middle spring into early summer (Miksicek 1994). The sedge seeds could have been collected in early spring. The range of the collection period would have varied from year to year depending on precipitation and temperature variations. Variable edaphic conditions from place to place in the Los Angeles Prairie and the Ballona estuary would have extended the season of collection also, by providing new areas of collection as seed maturity varied across the region.

Comparison of the Pollen and Macrobotanical Records

The pollen and macrofossil records from the West Bluffs sites revealed quite different species. Some species were abundant in the macrofossil record, but not in the pollen record, or the reverse. Much of this difference was due to the poor preservation of the pollen record, which resulted in a bias towards certain pollen types. Some of the differences reflected the fact that some of the more abundant seed types found in the West Bluffs sites are from insect-pollinated plants (catchfly and spurrey), species that would be poorly represented in the pollen record. Even when we compared several types of wind-pollinated plants that should have been well represented in the pollen record, however, we found major differences.

The two most dominant of these plant types in the West Bluffs record were species of the Aster and grass families. Both of these are wind-pollinated plant types, producing abundant and widely dispersed pollen. Whereas the pollen record was dominated by Aster-type pollen, however, Aster-type seeds were not abundant in the macrofossil record, possibly due, in part, to poor preservation: Aster-type seeds are thin-walled and decay easily. On the other hand, carbonized grass seeds were common, but grass pollen was not, again, possibly due to preservation, because grass pollen is thin walled and crumples easily, making it highly susceptible to mechanical damage and destruction by bacteria. Conversely, grass seeds are relatively tough, especially once they have been carbonized. The differences in preservation might explain part of the discrepancy between the records of these plants. Another explanation for these differences may reflect whether these plants grew nearby or were collected by people and brought to the site. For example, *Baccharis* is a rich source of Aster-type pollen when in flower, and even if it was never collected from the coastal chaparral lying just below the sites, the wind would have deposited *Baccharis* pollen on the sites in great abundance. Weeds in and around the sites could also have provided an abundant source of Aster-type pollen, but only a few of the seeds from these plants would have been deposited in the sites. The sites would have few seeds of these species because they were not being intentionally collected and do not preserve well. Grasses, on the other hand, might have been brought to the sites from disturbed areas specifically for their seeds. Low counts of grass in the pollen record, in addition to poor preservation, could also be explained by a lack of abundance at the sites. In addition, grass seeds are harvested well after grasses have bloomed, so if grass seeds were collected and then brought to the sites, there would not have been inclusions of pollen in the seeds that had been gathered. Plants like mints, on the other hand, have both mature seeds and blooming flowers on the same stalk; during collection, both seeds and pollen would have been gathered, and both would have been brought to the site and appeared in the macro- and microbotanical records.

Although modern seeds of both Caryophyllaceae and Geraniaceae were very abundant, their pollen was not in the record, probably because both of these species are insect pollinated. Such pollen consists of large, heavy grains that are usually poorly dispersed, and pollen production is much lower than by wind-pollinated plants. Although the lack of pollen from these plants could have been explained if the sediments were intact, the abundance of modern seeds in the features indicated significant mixing. The lack of pollen could also be blamed on poor preservation, but as the deposition of these pollen grains was relatively recent, however, more of these grains should have been encountered. Therefore, the more likely explanation was that the pollen of both Caryophyllaceae and Geraniaceae was poorly dispersed because they are insect pollinated. On the other hand, the seed coats of the Caryophyllaceae plants that we find in the record from West Bluffs are hard and resistant to degradation and have very efficient methods of dispersal, contributing to the seeds' abundance in the samples.

The Pollen and Seed Contents of Features as Evidence of Native American Lifeways

What does combining the pollen and macrobotanical data retrieved from the West Bluffs sites reveal regarding native lifeways? As indicated above, there was no correspondence between the pollen and the seeds found in the samples from the West Bluffs sites. Of the 39 samples containing either more than 30 pollen grains or more than 10 seeds, only 9 samples met both requirements: 7 samples from LAN-63 (PDs 3288, 3941, 4017, 4023, 4068, 4106, and 4727) and 2 from LAN-64 (PDs 1478 and 1567). These samples had neither the greatest number of pollen nor the greatest abundance of seeds, which was not surprising, as pollen and seeds are usually produced at different times of the year. Some of the plant materials might also have been collected at some distance from the site area, lowering the amount of pollen and seeds transferred to the site. There are a few tentative observations that can be made regarding the plants that were harvested by the prehistoric people at West Bluffs.

Pollen

As indicated above, because the preservation was so questionable, the pollen data revealed little regarding the economic activities of the peoples that lived at the West Bluffs sites. Slightly greater abundances of some taxa, however, hinted at possible human uses (Table 12.10). These abundances were not great but were above those that would normally be expected in the annual pollen rain, the normal spectrum of pollen types that would accumulate on the landscape during the course of a year. The key pollen abundances included: other Chenopodiaceae (possibly *Chenopodium* or *Atriplex*, but not *Salicornia*), Lamiaceae (mint), *Proboscidea* (devil's claw), *Artemisia* (sagebrush), Poaceae (grass), and Onagraceae (evening primrose) (see the shaded entries in Table 12.10). Given several factors, the appearance of these pollen types (except for one type) cannot relate to the harvesting or processing of seeds. Their inclusion in the pollen record might have been accidental or incidental to some other activity or event.

Lamiaceae pollen can be found in the flowers of the distal end of flower heads that have mature fruits with seeds near their base. If beating baskets were used, the pollen would be found mixed with the seeds and could have been brought back to the processing area. Various mints were collected and processed by the Gabrielino/Tongva for various purposes. For example, white sage *(Salvia apiana)* was used for religious purification, and both purple sage *(Salvia dorrii)* and chia *(Salvia columbarae)* were used for medicinal purposes. White sage was also used for medicinal purposes and as a food by both the Cahuilla (Bean and Saubel 1972) and the Diegueño (Hedges 1986). The Luiseño used its seeds as a food (Sparkman 1908). The Cahuilla also used white sage leaves to eliminate body odors and detection by game (Bean and Saubel 1972). Purple sage was used by the Paiute as a drug (Train 1941). Chia seeds were used as a drug by the Cahuilla (Bean and Saubel 1972), the Costanoan (Bocek 1984), and the Diegueño (Hedges 1986), and also as a staple food by the Cahuilla (Bean and Saubel 1972), the Costanoan (Bocek 1984), the Diegueño (Hedges 1986), Luiseño (Sparkman 1908), the Tubatulabal (Voegelin 1938), the Mojave (Castetter and Bell 1951), and the Paiute (Steward 1933). I have recovered chia seeds and seed coats in prehistoric human coprolites recovered from woodrat middens from the south side of the Coso Range just east of the Sierra Nevada Mountains. Black sage *(Salvia mellifera)* was used by the Costanoan peoples as a medicine (Bocek 1984) (see Appendix J). Its seeds were used as a food by the Cahuilla (Bean and Saubel 1972) and the Luiseño (Sparkman 1908). Many other mints were used as concoctions or teas to treat various ailments. For example, both the Miwok (Barrett and Gifford 1933), and the Yuki (Curtin 1957) mixed a nonmedicinal tea from spearmint (*Mentha* sp.) leaves.

The presence of Chenopodiaceae pollen does not relate to seed harvest, as chenopods are dieoscious (they have male and female plants). In addition, seeds on female plants are mature well after pollen is produced by male plants. Therefore, there is little chance for Chenopodiaceae pollen to have been included in the seeds harvested from female shrubs, which does not preclude the possibility that saltbush branches were being used for some other purpose, however. The leaves are rich in salts, and were used by several native peoples to salt meats and other foods during cooking. For example, the Cahuilla used saltbush for drugs, soap, and food (Bean and Saubel 1972); the Diegueño also used it a soap (Hinton 1975:214–222); and the Paiute used it as a food (Steward 1933).

Poaceae pollen also would not be included during harvesting of seeds, as the pollen is produced well before the seeds become mature. Grasses might have been used, however, during their blooming period to line containers, as insulation, as fuel, or any number of other purposes.

Various members of the Onagraceae family were used by Native Americans in California (Mendocino, Miwok, Cahuilla, Costanoan) for several purposes. Seeds were often charred and eaten, the foliage was steamed and eaten, and various parts were used for medicinal purposes (Barrett and Gifford 1933; Bean and Saubel 1972; Bocek 1984; Chestnut 1902). The pollen might easily have been brought to the site during the processing of Onagraceae-family plants for any of these purposes.

Sagebrush *(Artemisia californica)* was used as a drug by both the Cahuilla (Bean and Saubel 1972) and the Costanoan (Bocek 1984) peoples (see Appendix J). Aster-type pollen, probably much of it from coyote brush *(Baccharis pilularis),* was very common (see Table 12.10). Among many uses it was used by the Costanoan peoples as a drug (Bocek 1984; see Appendix J). Some of the Aster-type pollen may also be from goldenhills *(Encelia farinosa)* which was used by the Cahuilla (Bean and Saubel 1972), the Costanoan (Bocek 1984), the Diegueño (Hedges 1986), and other native peoples as a drug (see Appendix J).

Proboscidea (devil’s claw or devil’s horn) was used by many peoples in the Southwest for a variety of purposes. Its seeds were used by the Cahuilla as a food , and its hooked thorns were used as a tool for repairing basketry (Bean and Saubel 1972).

Seeds

The prehistoric macrobotanical remains are composed almost entirely of carbonized seeds. Although there is charcoal it is too small to identify, i.e., there is insufficient cell structure present to enable identification. Of the carbonized seeds, many were either too weathered to be identified or remained unidentified after a search of both reference collections and seeds floras (Table 12.11). Seventy-one percent of the carbonized seeds remained unknown and did not match any of the previously described seeds reported from archaeological sites in southern California. As suggested earlier, the large number of unidentified seeds indicated that a wide variety of plants were harvested for seeds. This suggests a broad knowledge of the uses for local, and probably regional vegetation.

Of the identified seeds, grasses were 17.9 percent of the total carbonized seed assemblage (see Table 12.11). As indicated above, the grasses came from a variety of habitats (see Table 12.9). A variety of Chenopodiaceae (saltbush family) seeds composed 6 percent of the carbonized seed total; sedge (*Scirpus* spp.) made up 2.5 percent of the carbonized seeds; and sorrel (*Rumex* spp.) about 2.2 percent (see Table 12.11). As indicated above, it was impossible to determine whether these seeds were intentionally buried in the features or whether they were lost during processing (e.g., the parching process). The presence of wood charcoal in most of these samples, however, suggested that these seeds were the result of loss during processing, therefore indicating that at least some of these features might have been the loci of seed processing.

Changing Regional Settlement Patterns and Paleoecology

Finally, occupation and variations in occupation intensity at the West Bluffs sites and around the Ballona Lagoon coincided with regional changes in climate and vegetation responses to those changes. As mentioned in the discussion of vegetation history, there was a close correspondence between climate and variations in the coastal and mountain chaparral in the Los Angeles basin. A comparison of the reconstructed climate for the Los Angeles International Airport and the chaparral history recorded in Playa Vista Cores 1 and 8 strongly suggested that a combination of increasing annual precipitation (Figure 12.12)—especially winter-dominated rainfall—and rising temperatures led to the formation and expansion of these communities at approximately 8000 B.P. (Wigand 2004:Figure 21a). Their decline corresponded with the initiation of a decline in annual precipitation at about 5000 B.P. (see Figure 12.12). The dates concentrated around 2000–2,100 B.P. coincide with a wet event in Core 1 from the Ballona Lagoon, the Los Angeles International Airport climate reconstruction by Bryson, and pollen records and river and lake histories from the Mojave Desert. Warm-season rainfall characterizes the period between 1600 and 1000 B.P. throughout the West, and the establishment of the middle Holocene climate pattern coincides with the cluster between 7,750 and 7,000 B.P.(see Figure 12.12). As noted above, this pulse corresponded with dramatic regional increase in pine and sagebrush. Were these paleoecological events mirrored in the archaeological record?

To investigate the correspondence of human activity in the Ballona region with environmental change, radiocarbon dates from archaeological contexts at the West Bluffs sites and from the Ballona region were plotted to emphasize their concentration in time (Figure 12.13). To analyze the radiocarbon dates from the Ballona, a simple technique was used that provided an indication of the midpoint of the archaeological culture, as well as its beginning and end points (Banks and Wigand in review; Wigand and Simmons 1999). All the radiocarbon ages were plotted as a normal curve around their means. Their 1-sigma standard deviations determined the end points of the curve, and the areas under all radiocarbon date curves was held constant (Geyh1969, 1980). Radiocarbon dates with smaller standard deviations (greater precision) will be leptokurtic (narrow and higher in shape), whereas radiocarbon dates with larger standard deviations will be more platykurtic (broader and lower in shape). The areas under these curves was added to derive a summed value through time that could be plotted as the summation of the curves. The summation was plotted, revealing the point(s) around which the radiocarbon dates were concentrated and their distribution through time. The plot of the radiocarbon dates from the West Bluffs sites indicated that, except for two outliers, all dates clustered between 2100 and 2000 B.P. (see Figure 12.13a).

A plot of the radiocarbon dates currently available for the Ballona region (see Figure 12.13b) showed three clear periods of concentration: the first between 7750 and 7000 B.P., another between 2100 and 2000 B.P., and the final one spanning the period between 1600 and 1000 B.P. Clearly, a brief episode of early Holocene occupation at the West Bluffs sites vanished as rapidly as it appeared. Late Holocene occupation in the Ballona region increased considerably between 2600 and 2500 B.P., and after 1000 B.P., there was an appreciable decrease in occupation in the region (see Figure 12.13b).

These dates are almost identical to significant climatic events in the West that resulted in significant changes in regional vegetation and surface-water availability. Evidence from the Ballona pollen record indicated that early Holocene climates in the Los Angeles basin were still relatively dry and cool until 8,000 years ago. At that time, annual temperatures and precipitation both began increasing dramatically and by 7000 B.P., had reached their Holocene maxima (Wigand 2004). The earliest occupation in the West Bluffs area was concentrated during this period of regional climatic transition, when both coastal and montane chaparral was being established. Playa Vista Core 8 in the Ballona estuary indicated that there was a rich cattail- and sedge-dominated body of fresh water established just north of the West Bluffs area. A saltbush (pickleweed) salt marsh was also nearby, probably just to the west (Wigand 2004). Reconstructions of the sea level indicated that it had reached within 8 m (27 feet) of its current elevation. At the Playa Vista Core 1 location, oligotrophic bay or lagoon conditions suggested that the area just east of the current coastline might have been periodically inundated by the sea. This area might have served as the source of the mollusks that were harvested during the early Holocene occupation at the West Bluffs. By about 6900 B.P., the bay or lagoon conditions at the Playa Vista Core 1 location had given way to terrestrial fluvial conditions, suggesting that there had been rapid infilling of the estuary. This might have been due to the increasingly wet conditions after 8000 B.P., which might have increased sediment load into the estuary via Centinela and Ballona Creeks (Wigand 2004). The sediment would have eliminated, or at least shifted, mollusks further west. The rich marsh that characterized the period between 7700 and 7000 B.P. disappeared from the area immediately north of the West Bluffs sites just after 6900 B.P. (Wigand 2004).

Late Neoglacial and post-Neoglacial occupation of the Ballona estuary might also have been conditioned by changes in climate that forced people to adjust their lifeways or settlement patterns. In the Great Basin and northern Mojave, the relatively cooler climates of the Neoglacial period (4000–2000 B.P.), which were dominated by winter precipitation, became increasingly unstable, and a significant trend toward drier climates began (Wigand and Rhode 2002). This led to significant changes in vegetation that might have forced people of the interior to look for resources elsewhere. They might have migrated to the southern California coast to find these resources. By 2100 B.P., when annual precipitation dramatically increased, these peoples were well established around the Ballona estuary (Figures 12.14 and 12.15; see Figure 12.13). The response of local plant resources to the increased rainfall would have been dramatic; in particular, both annual and perennial grasses, and forbs would have become abundant. "Vernal pools" in the Los Angeles Prairie would have been both more extensive and of longer duration, probably lasting well into the summer (see Figure 12.9), and addition, the increase in freshwater flow from both Ballona and Centinela Creeks would have led to freshening of the freshwater marsh and its expansion. The increase in local plant resources, together with the diversity offered by terrestrial, freshwater marsh, and salt marsh resources would have drawn native peoples to the area. The effects of this input of precipitation lasted at least 150–200 years (see Figure 12.12). This event may explain the sudden growth in population around the Ballona suggested by the clustering of radiocarbon dates.

The second period of population concentration around the Ballona between 1,600 and 1,000 years ago corresponded to a climatic episode recorded in the intermountain West, during which annual precipitation was only slightly increased, but it was more concentrated in the late spring through early summer months (Wigand and Rhode 2002). Although the timing of this event was different, the effects would have been similar to the event centered between 2,100 and 2,000 years ago. Both annual and perennial grasses and forbs would have flourished, providing rich plant resources to native peoples. This period differed from the 2100 to 2000 B.P. event not only in its duration, but also in its stability. A pollen record from Lower Pahranagat Lake in the northern Mojave Desert suggests that episodes of very wet climate alternated with extreme drought in roughly 12- to 14-year cycles (Wigand and Rhode 2002). Such strong variation of climate would have significantly affected terrestrial and freshwater marsh plant resources. Salt-marsh resources would have remained relatively unaffected, however, and might even have expanded during this period. Unfortunately, the record from the Playa Vista cores is incomplete during this period. When drier conditions returned about 1000 B.P., occupation intensity in the Ballona, as reflected in the radiocarbon-date record, seemed to have declined. Bryson's reconstruction of the climate at the Los Angeles International Airport for the last 14,000 years suggested a decrease in both annual and winter precipitation, and a decline in January and July temperatures (Wigand 2004:Figures 21a–c). Although a model of summer precipitation was not generated, data from other pollen records from the Mojave Desert and the Great Basin suggested a significant decline in summer precipitation at that time also.

Summary and Conclusions

Although the poorly preserved pollen record showed a primarily local record, the carbonized seeds from the West Bluffs sites were composed of a diverse mixture of very small seeds from various habitats, suggesting that a great variety of plants were harvested for seeds from early spring through mid-summer. Dominated mostly by small grasses (about 20 percent), this assemblage were similar to seed collections recovered from other archaeological sites (see Table 12.11). Although seeds of the Chenopodiaceae (saltbush) family were present, they were no more abundant than other seeds in the assemblage (see Table 12.7).

The seed assemblage evidences use of both the Los Angeles Prairie south of the site and either the freshwater marshes north of and below West Bluffs in the Ballona estuary, or the "vernal pools" that lay in the Los Angeles Prairie, as suggested by Culbert (1996). Eventual identification of some of the remaining unknown seed types may strengthen the link to the "vernal pools."

Finally, the concentration of occupation around the Ballona Lagoon around 2100 to 2000 B.P. and again between 1600 and 1100 B.P. suggested a strong correlation with climatic conditions that promoted an environment conducive to the production of plant resources that were favored by native peoples. Increased precipitation during these periods promoted the production of grasses and other forbs in the prairie and would have led to expansion of the freshwater marshes in the Ballona Lagoon and the Los Angeles Prairie "vernal pools."

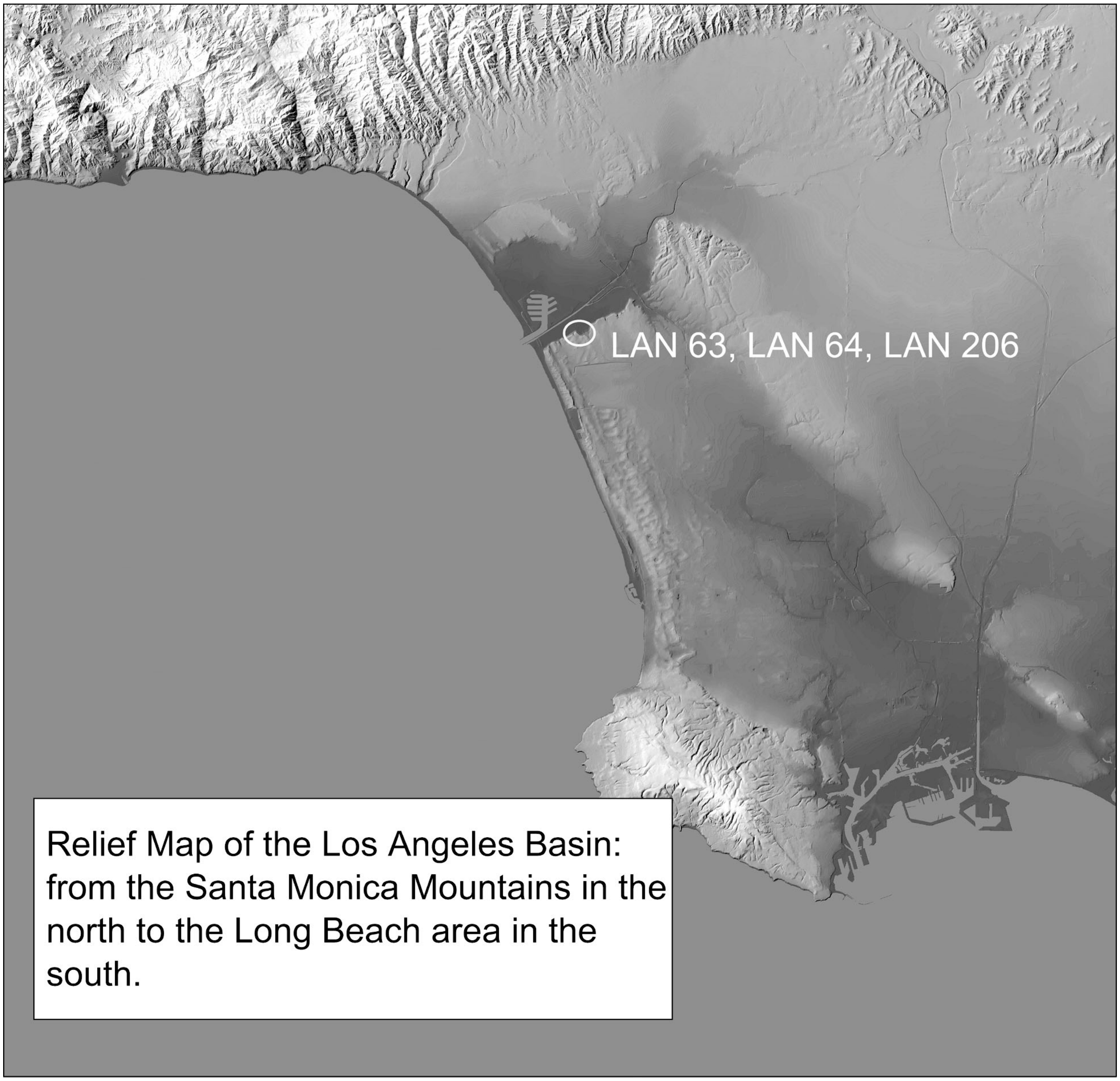


Figure 12.1. Relief map of the region surrounding the West Bluffs project area.

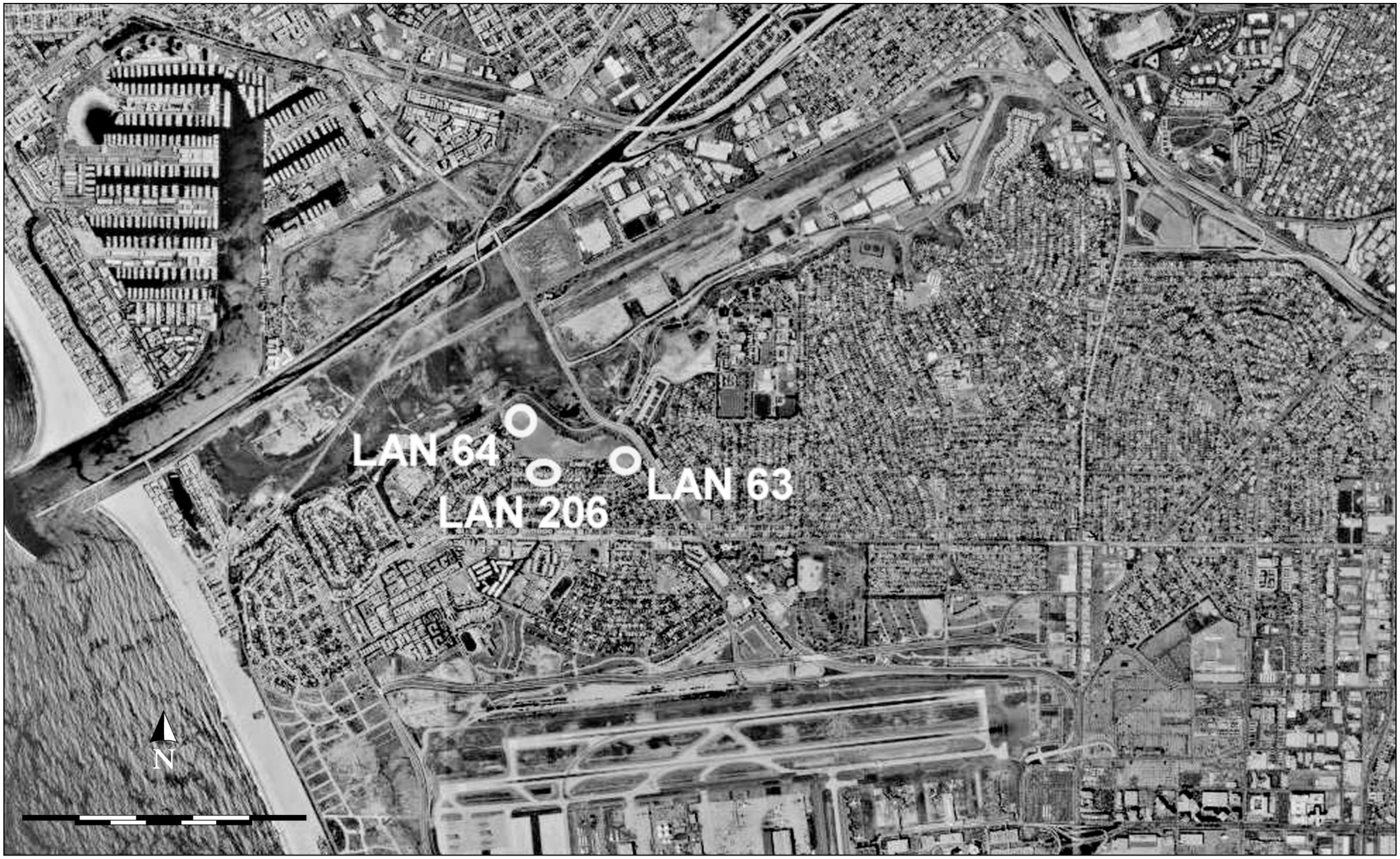


Figure 12.2. Air photos of the region surrounding LAN-63, LAN-64, and LAN-206A that reveal the encroachment of urban areas.

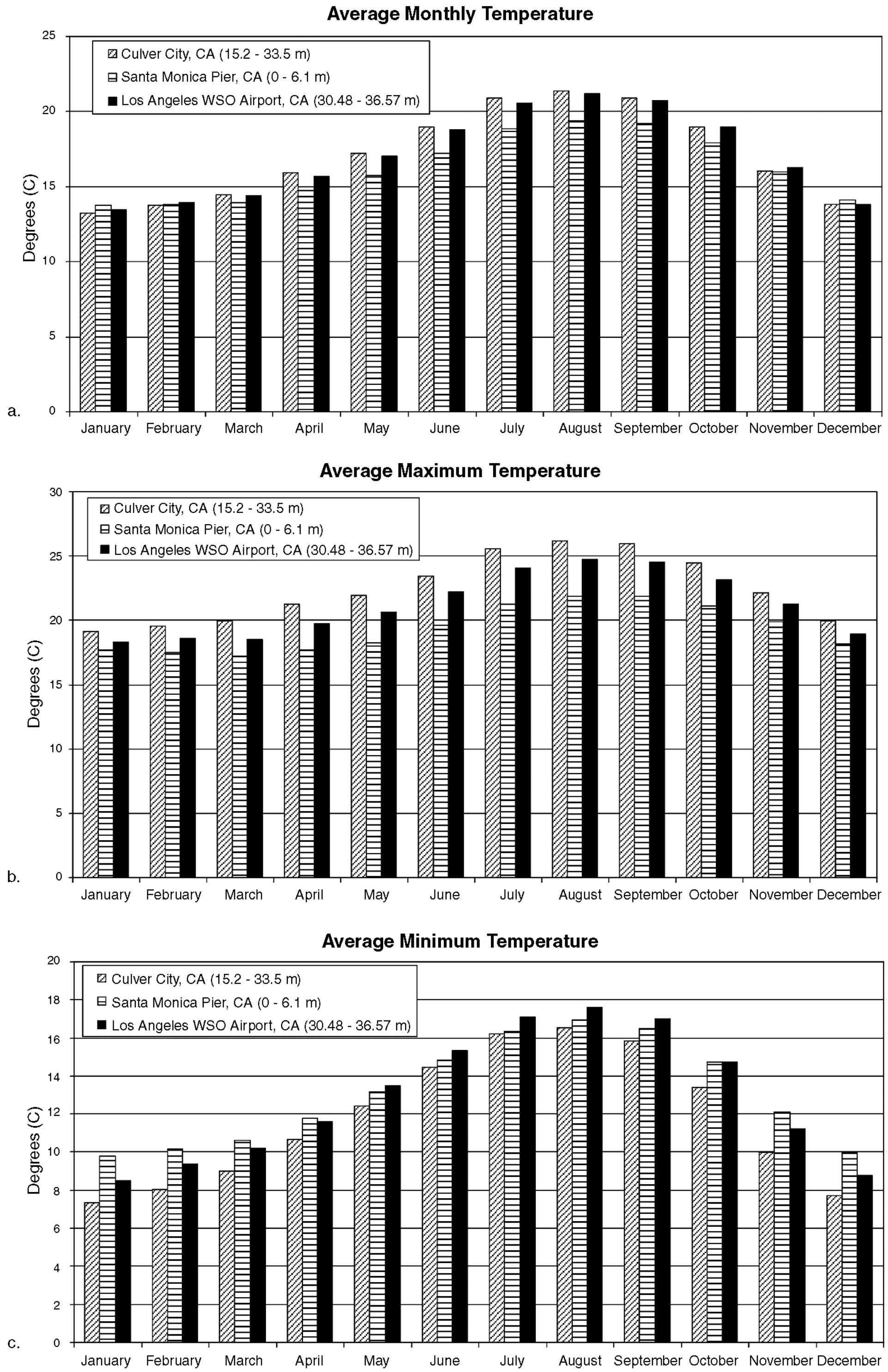


Figure 12.3. Temperature data for the Santa Monica Pier, Culver City, and Los Angeles International Airport weather stations summarized in Table 1: (a) monthly average of the average daily temperatures; (b) monthly average of the maximum daily temperatures; (c) monthly average of the minimum daily temperatures.

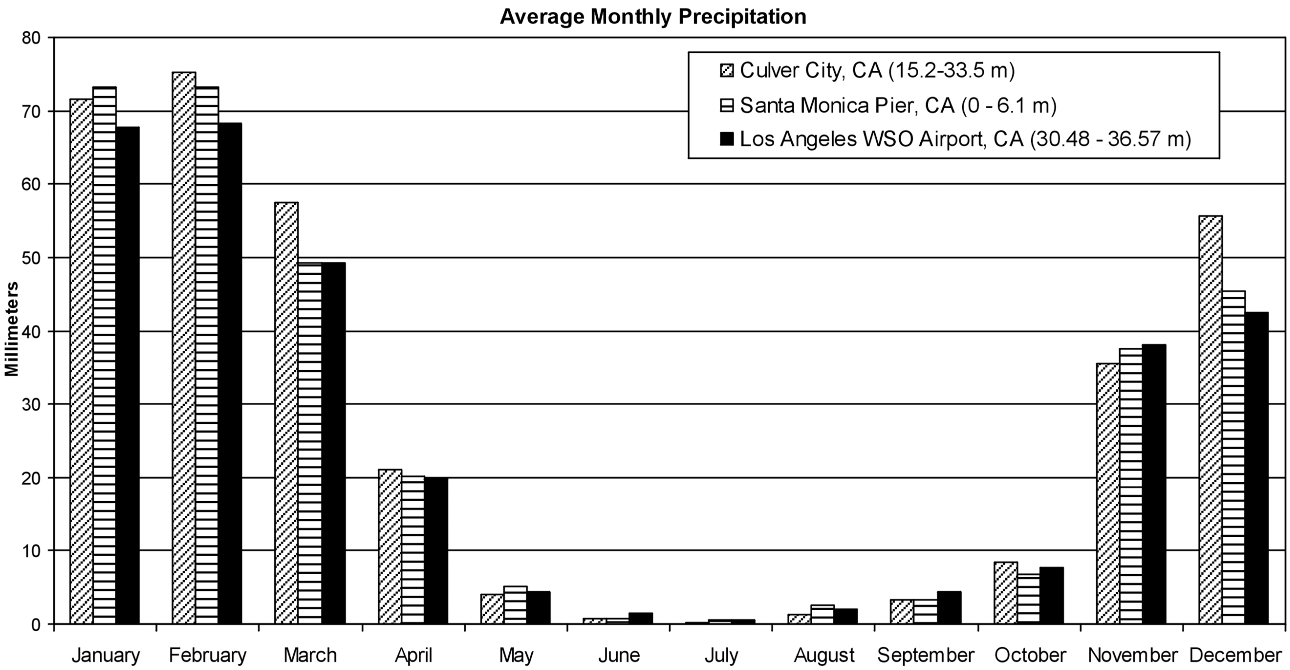


Figure 12.4. Monthly average of daily precipitation.

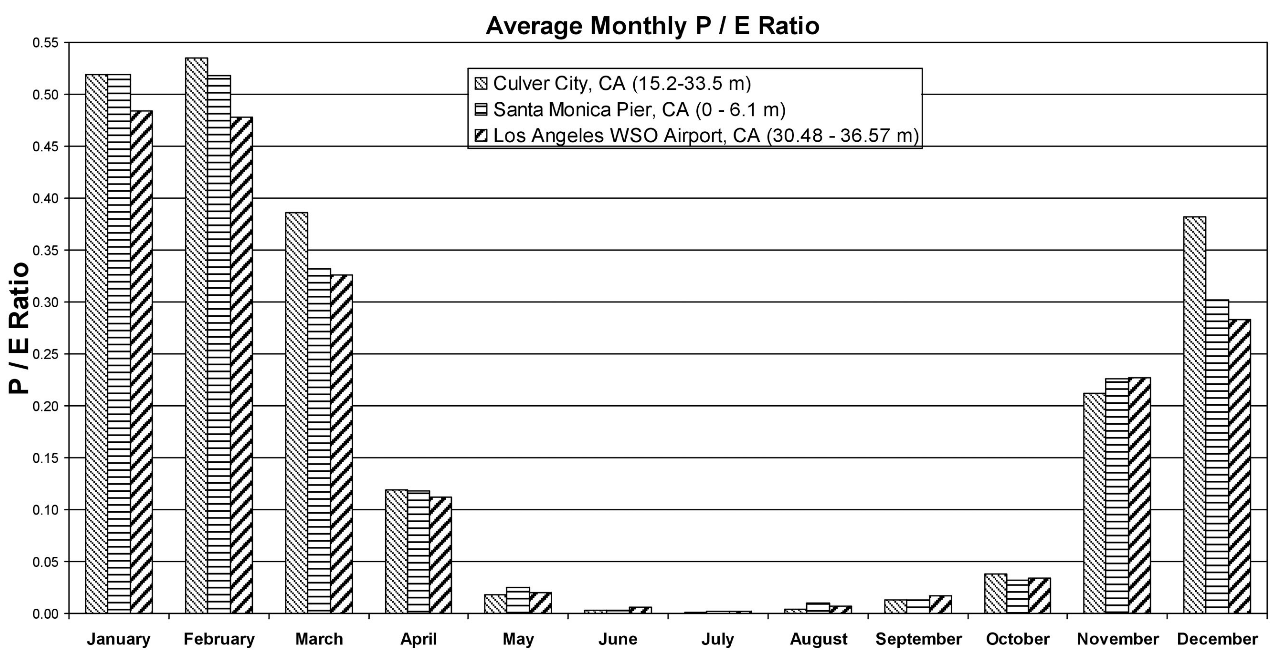


Figure 12.5. Monthly precipitation-to-evaporation ratio.

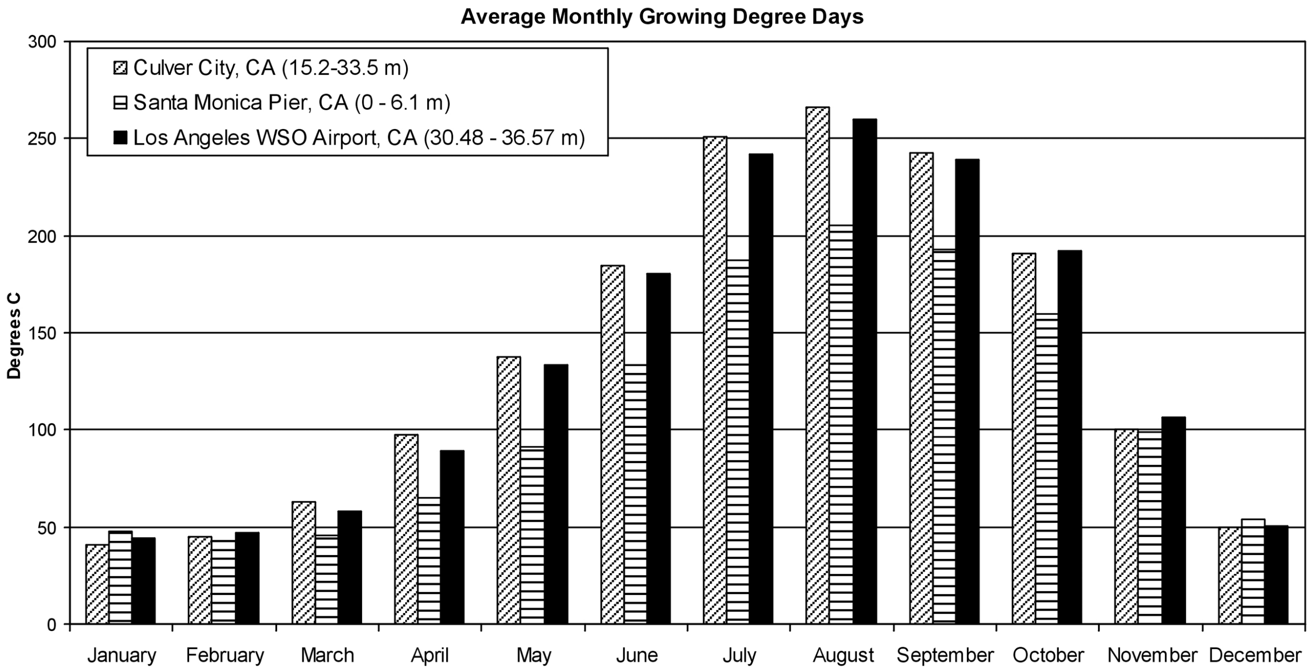


Figure 12.6. Monthly average growing degree-days based on the formula in the text.

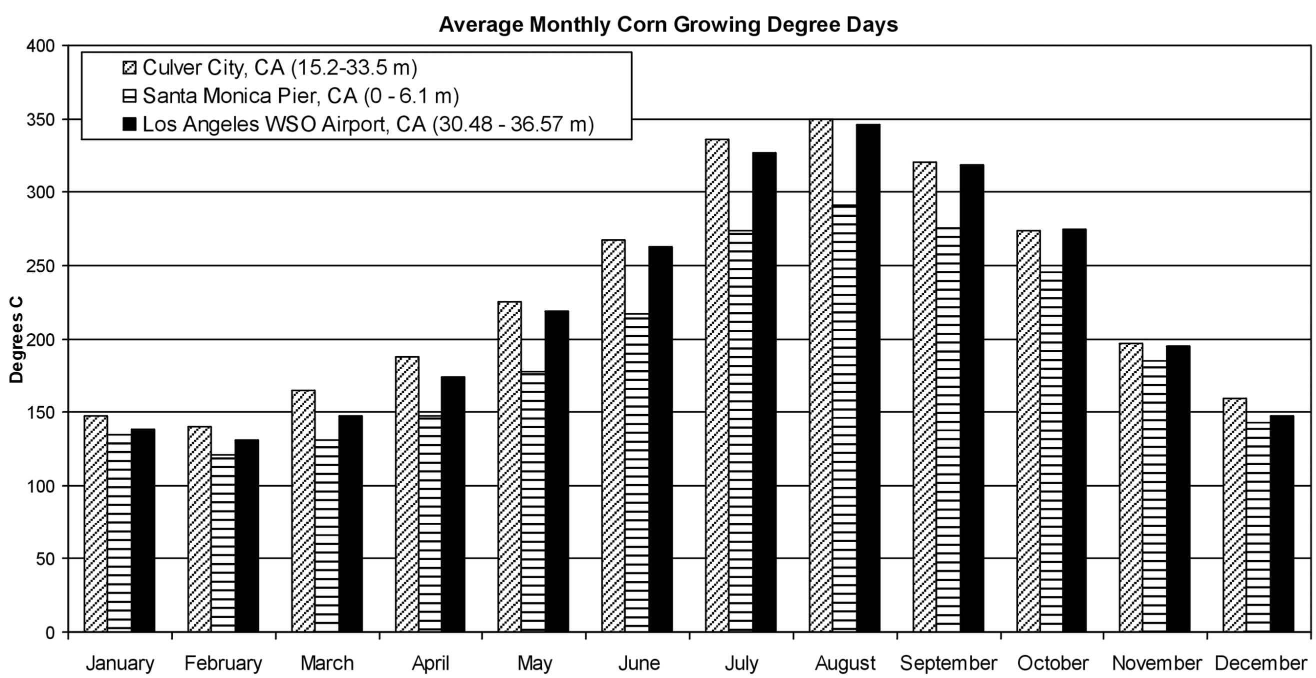


Figure 12.7. Monthly average corn growing degree-days based on the formula in the text.

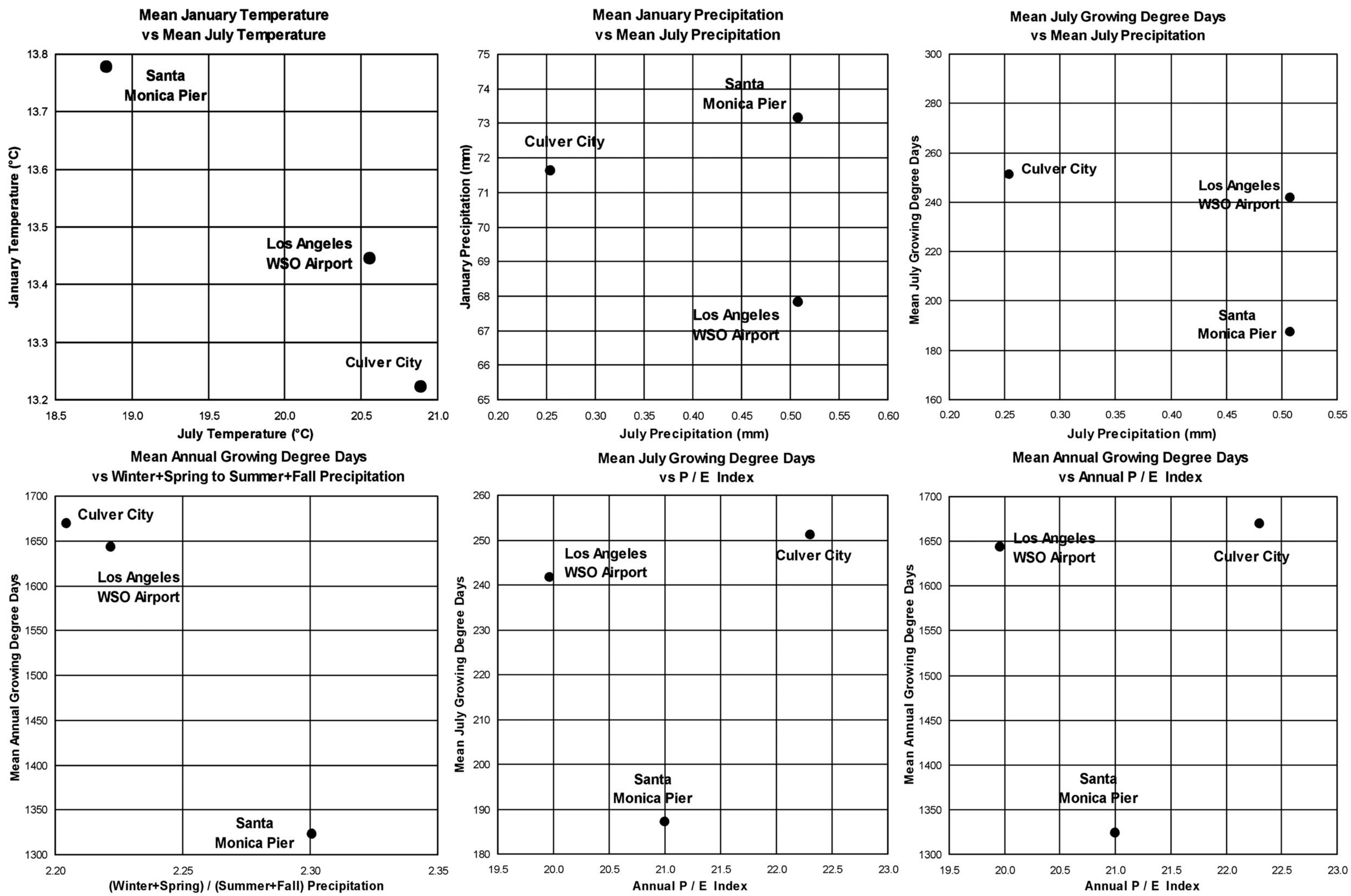


Figure 12.8. Comparison of the major climate parameters contrasting the records from the Santa Monica Pier, Culver City, and the Los Angeles International Airport. Summer and winter, and temperature and precipitation are contrasted. Growing degree days are compared with annual effective precipitation (PE index).

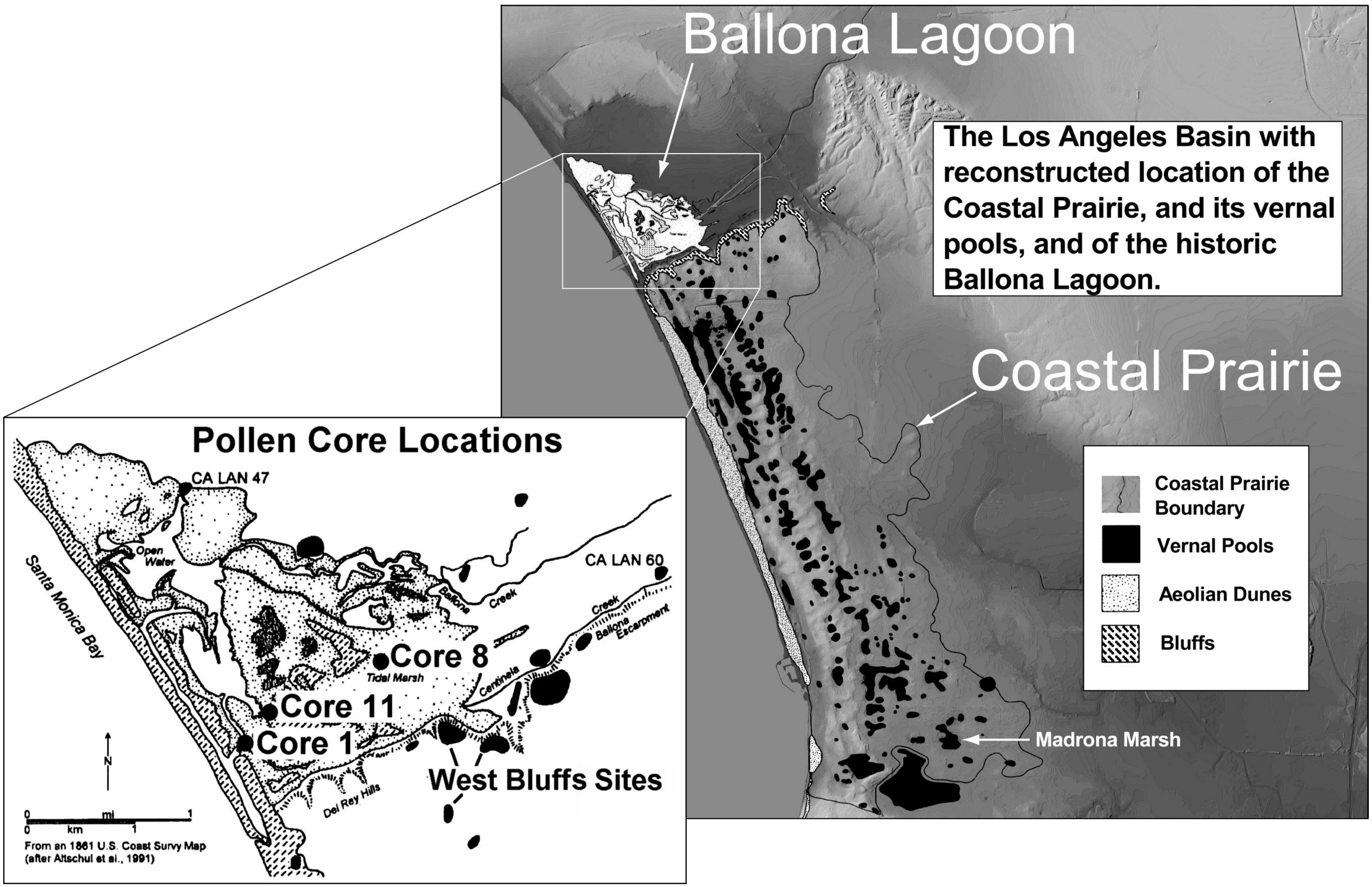


Figure 12.9. The southern coast of the Los Angeles Basin, with the location and extent of the Los Angeles Coastal Prairie (fine black line) and the Ballona Estuary. The location of "vernal pools" in the prairie is also indicated. LAN-63, LAN-64, and LAN-206 lay on the bluffs between these two resource-rich habitats. The insert indicates where pollen cores mentioned in the text were recovered.

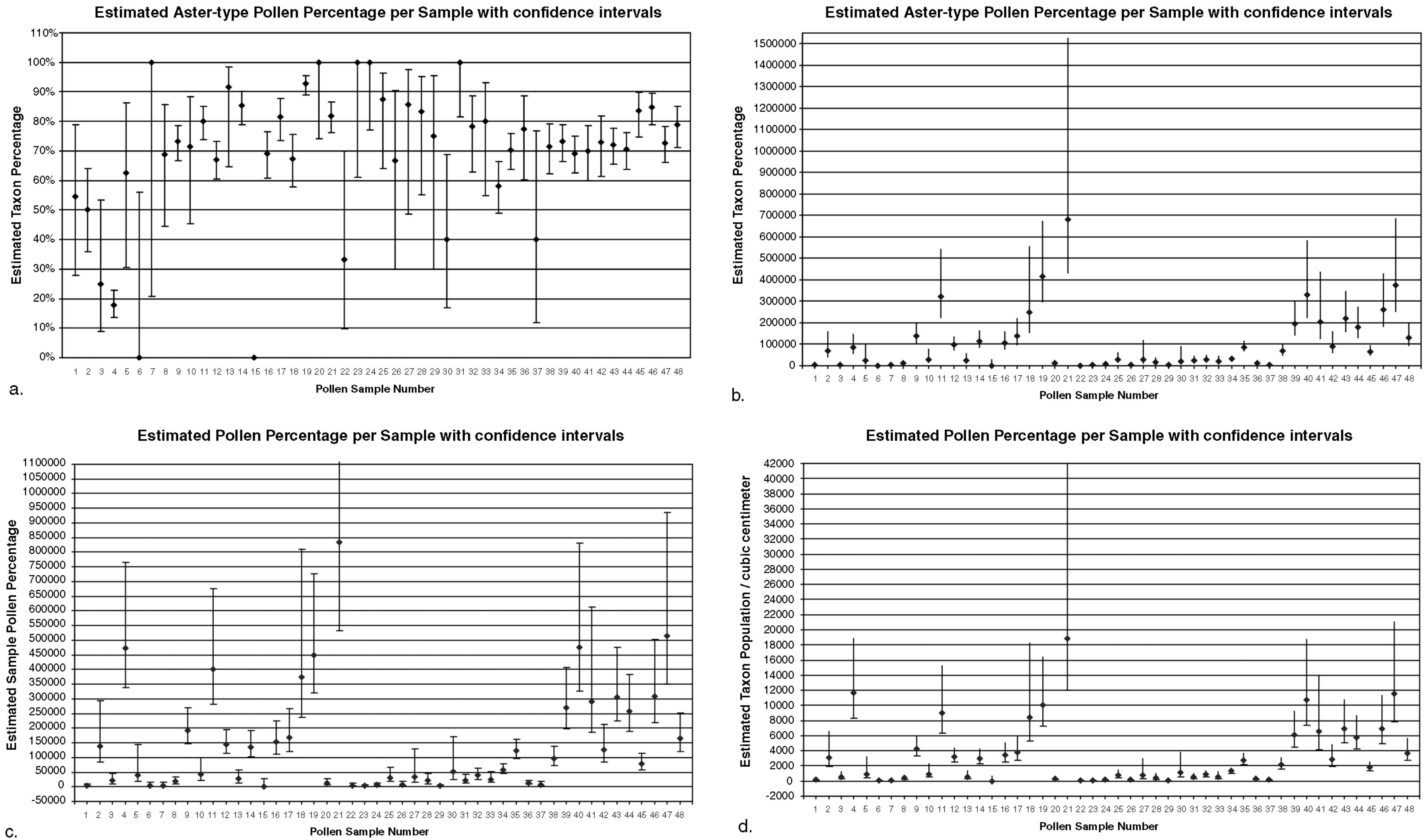


Figure 12.10. Statistical estimates of: (a) the percentage of Aster-type pollen grains in each sample; (b) the number of Aster-type pollen in each sample; (c) the pollen population of each sample; (d) the pollen population per cc of each sample. All samples were estimated with 95 percent confidence intervals based upon Maher's formula.

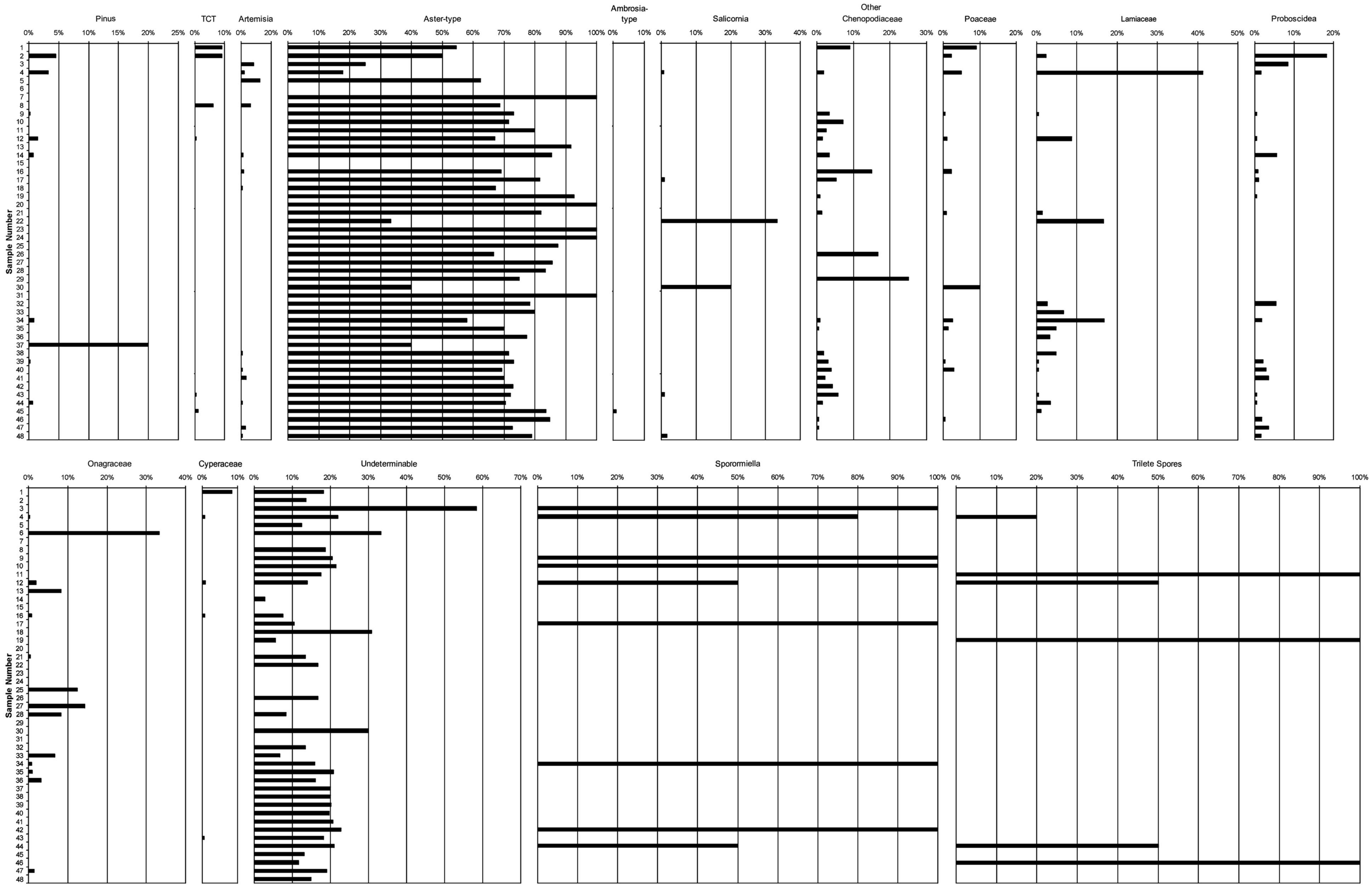


Figure 12.11 Relative percentage pollen diagram of the pollen recovered from the 48 sediment samples analyzed for the West Bluffs project.

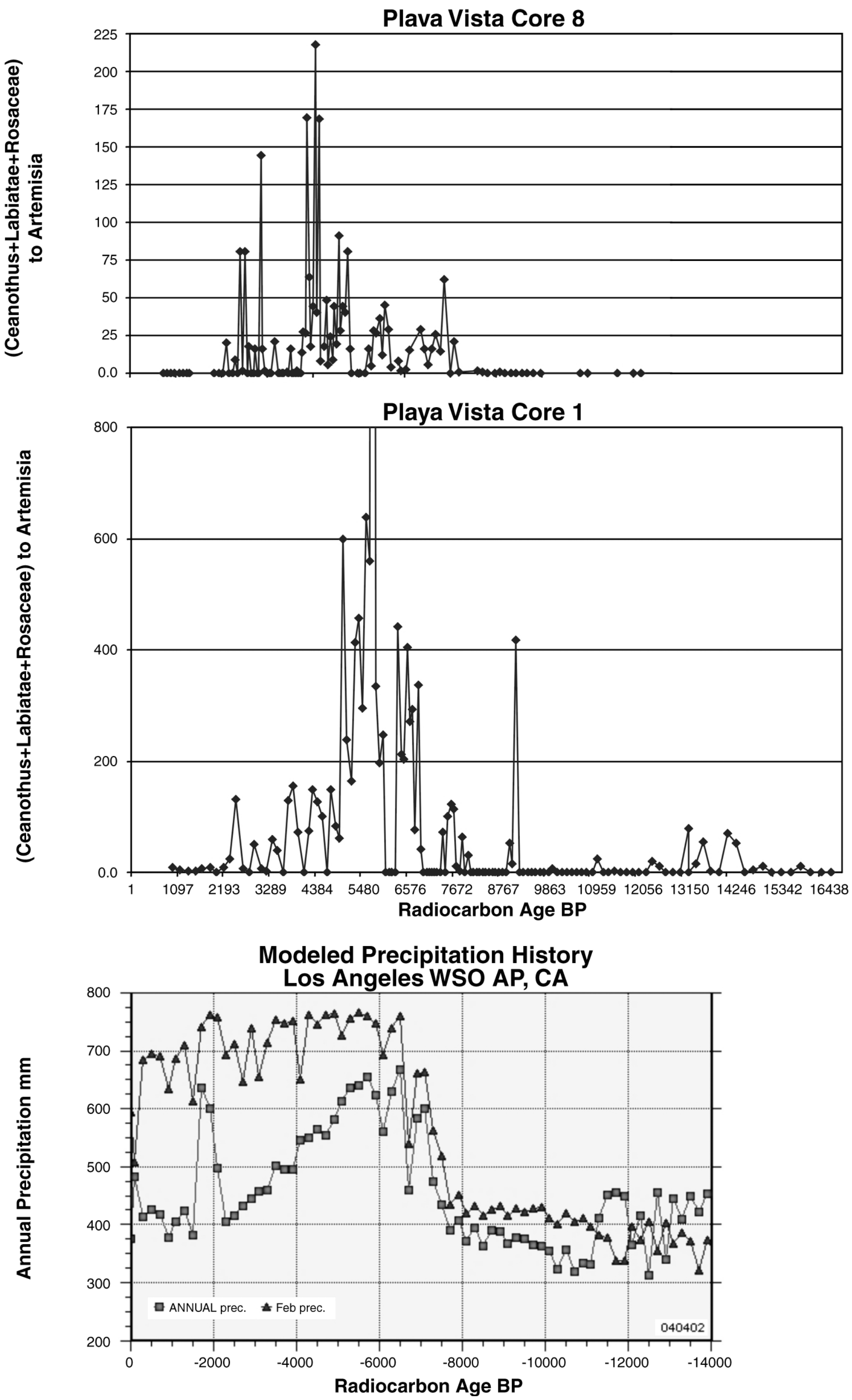
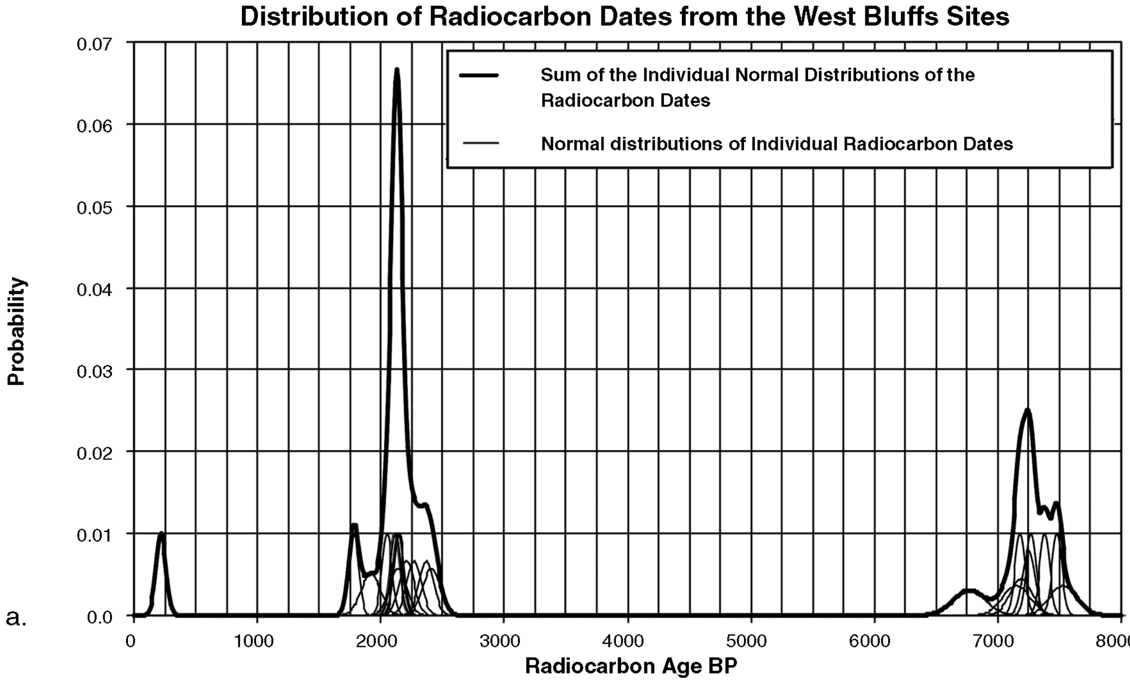


Figure 12.12. Plots of the ratio of chaparral *(Ceanothus* + Labiatia + Rosaceae) to sagebrush *(Artemisia)* pollen from the longest of the Playa Vista cores, showing the relative abundance of chaparral in the Los Angeles Basin. This is compared with a 14,000-year climate reconstruction provided by Dr. Reid Bryson for the Los Angeles International Airport area. Note that increased annual precipitation mirrors the chaparral record from Core 1.



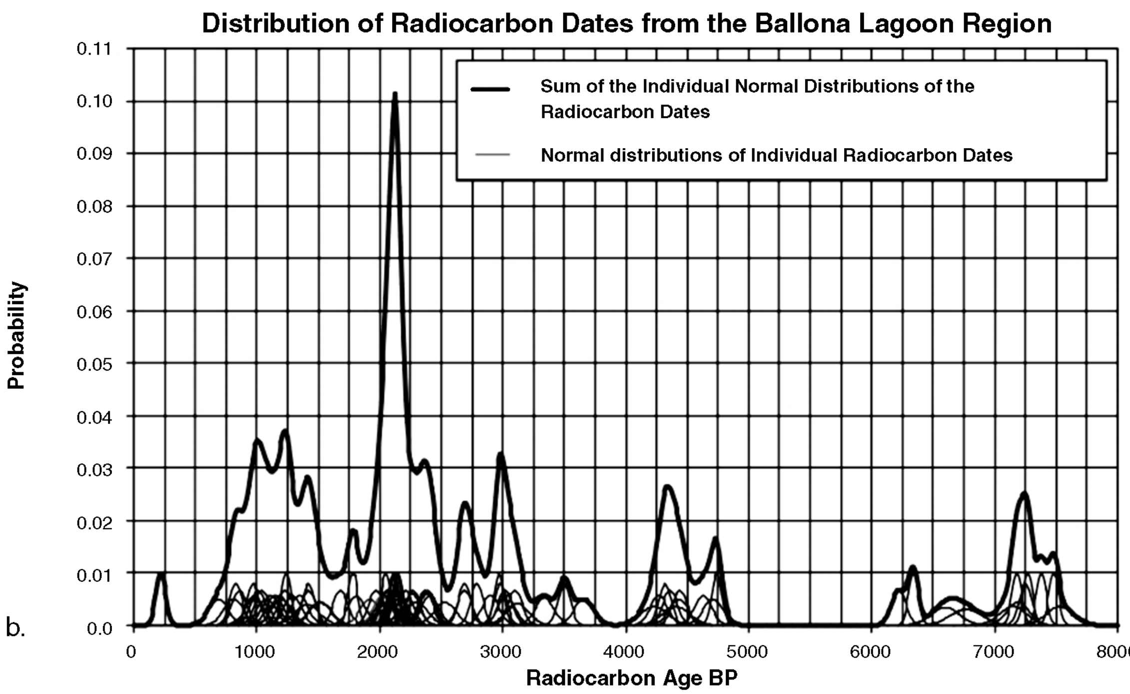


Figure 12.13. The distribution of radiocarbon dates from (a) LAN-63, LAN-64, and LAN-206A, and from (b) most of the archaeological sites in the Ballona Lagoon area.

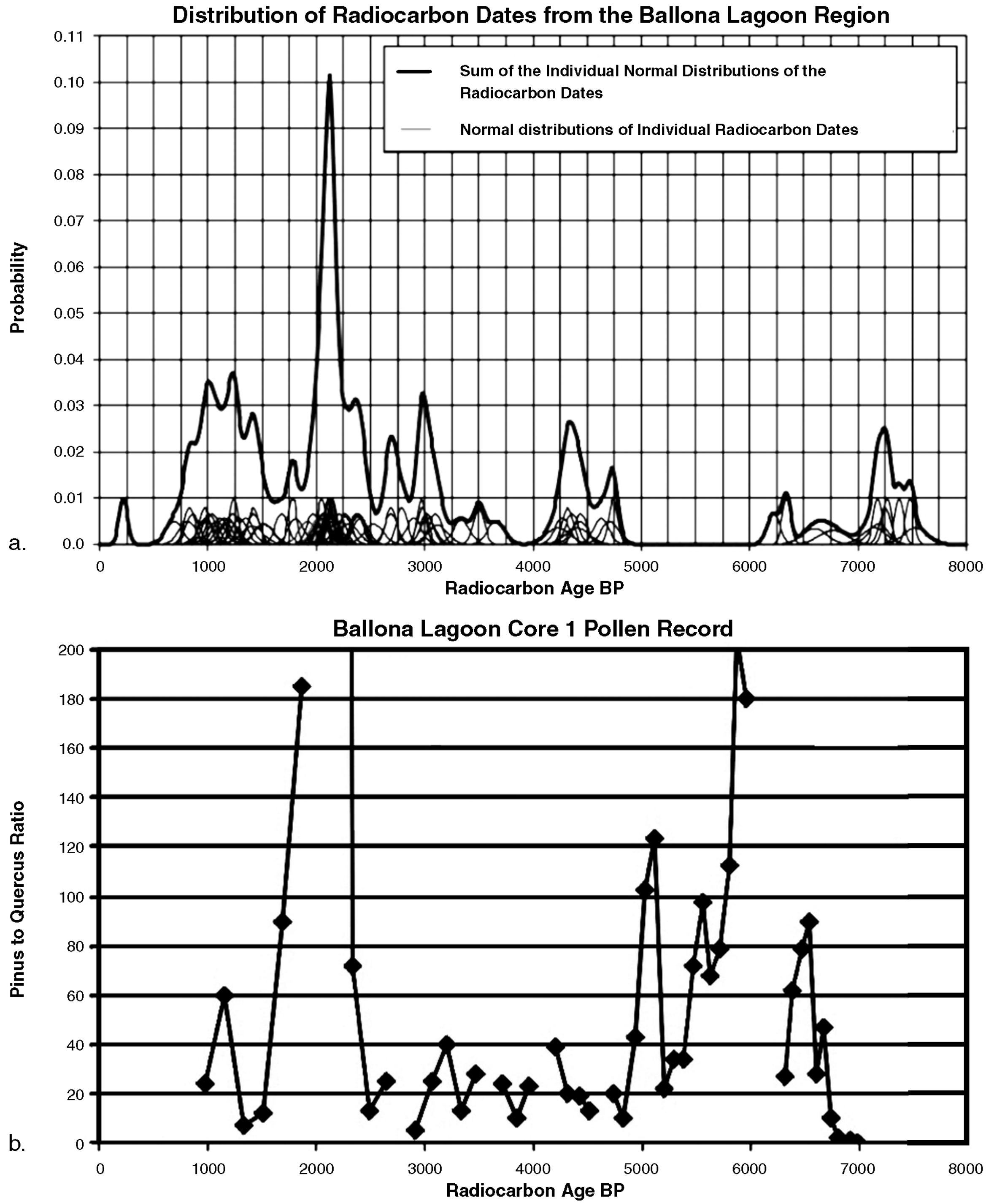


Figure 12.14. Comparison of the archaeological radiocarbon dates from the Ballona Lagoon with episodes of dramatically wetter winters during the last 7,000 years, as indicated by the ratio of pine *(Pinus)* to oak *(Quercus)* pollen. The event from 2,100 to 2,000 years ago was the most dramatic increase in winter rainfall during the last 5,000 years. The event around 5,500–5,700 years ago is seen in many of the paleoenvironmental records of western North America.

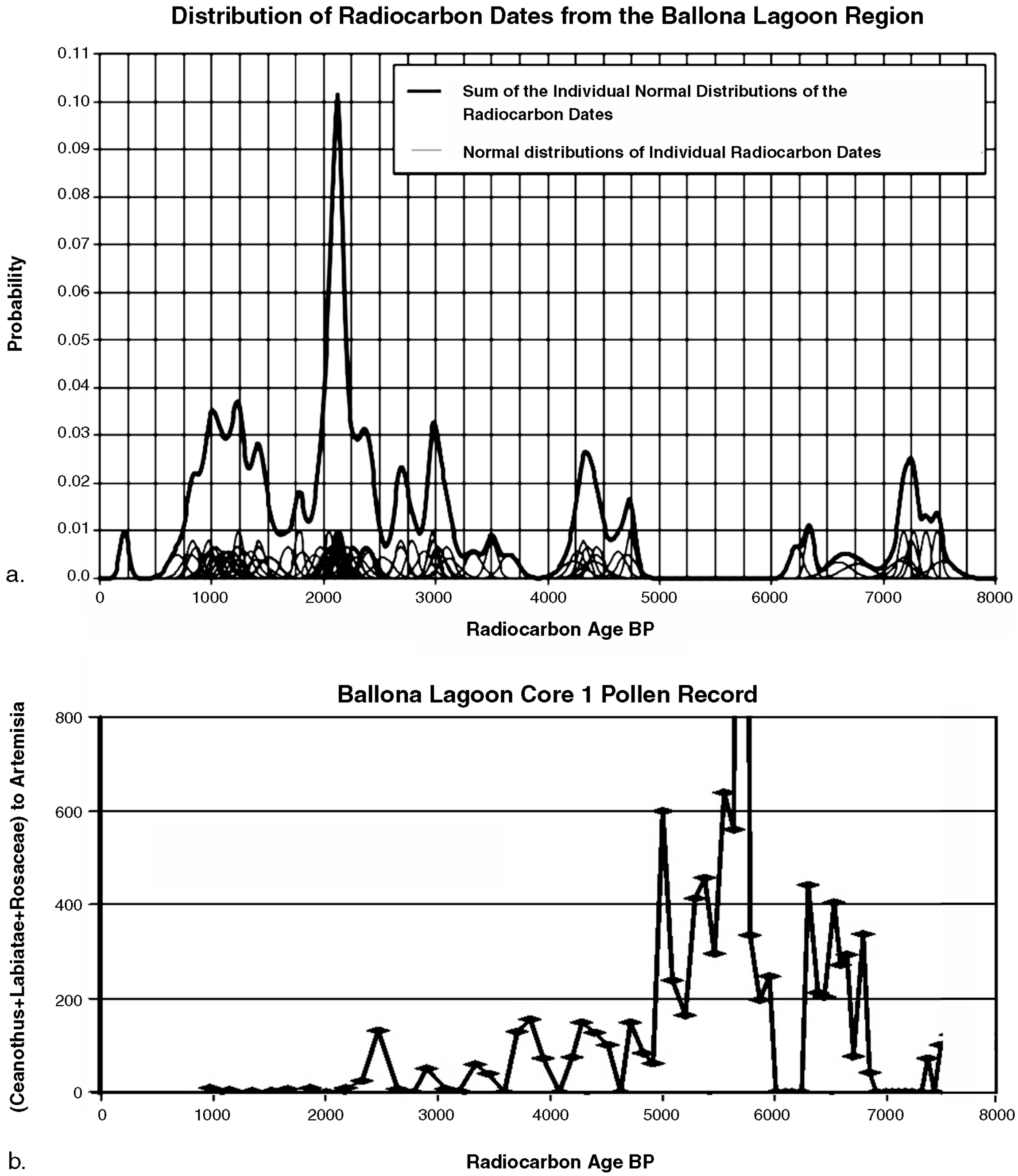


Figure 12.15. Comparison of the distributions of radiocarbon dates from Ballona Lagoon archaeological sites with episodes of more-abundant coastal chaparral vegetation (reconstructed from the pollen record of Playa Vista Core 1).

Table 12.2. West Bluffs Sites: Pollen Count Statistics

Sample No.		Provenience [a]		Taxon (Aster-Type)	Pollen Sum	Total Pollen	Total Spores	Lycopodim Recovered	Volume (cc)
1	vernal pool	Stratum A	20–30 cm	6	11	12	1	121	29.57
2	vernal pool	Stratum 2Ab1	40–50 cm	22	44	44	1	16	44.36
3	vernal pool	Stratum 2Ab2	80–90 cm	3	12	13	1	29	36.97
4	vernal pool	Stratum 2ABb	100–110 cm	47	264	268	5	28	40.66
5	LAN-206A	PD 2074	F 102	5	8	8	—	10	44.36
6	LAN-206A	PD 2112	F 105	—	3	3	—	33	44.36
7	LAN-206A	PD 2113	F 106	1	1	2	—	22	44.36
8	LAN-206A	PD 2137	F 107	11	16	16	—	44	44.36
9	LAN-63	PD 4068	F 475	153	209	209	1	55	44.36
10	LAN-63	PD 4078	F 480	10	14	14	1	17	44.36
11	LAN-63	PD 4079	F 48	160	200	200	1	25	44.36
12	LAN-63	PD 4106	F 492	139	207	209	2	72	44.36
13	LAN-63	PD 4131	F 498	11	12	12	—	23	44.36
14	LAN-63	PD 4282	F 567	123	144	144	—	54	44.36
15	LAN-63	PD 4475	F 617	0	0	0	—	11	44.36
16	LAN-63	PD 4489	F 620	92	133	134	—	44	44.36
17	LAN-63	PD 4718	F 587	93	114	114	3	34	44.36
18	LAN-63	PD 4727	V 213	70	104	104	—	14	44.36
19	LAN-63	PD 5331	F 496	232	250	250	1	28	44.36
20	LAN-63	PD 5621	F 600	11	11	11	—	43	44.36
21	LAN-63	PD 199	F 4	177	216	216	—	13	44.36
22	LAN-64	PD 1125	F 32, L-1	2	6	6	—	58	44.36
23	LAN-64	PD 1194	F 43	6	6	6	—	112	44.36
24	LAN-64	PD 1197	F 45	13	13	13	—	103	44.36
25	LAN-64	PD 1252	F 52	14	16	16	—	25	44.36

Sample No.		Provenience [a]		Taxon (Aster-Type)	Pollen Sum	Total Pollen	Total Spores	Lycopodim Recovered	Volume (cc)
26	LAN-64	PD 1236	F 49	4	6	6	—	40	44.36
27	LAN-64	PD 1260	F 56	6	7	7	—	10	44.36
28	LAN-64	PD 1350	F 61	10	12	12	—	29	44.36
29	LAN-64	PD 1343	F 60	3	4	4	—	73	44.36
30	LAN-64	PD 1447	F 62	4	10	10	—	10	44.36
31	LAN-64	PD 1476	F 65	17	17	17	—	37	44.36
32	LAN-64	PD 1478	F 64	29	37	37	—	48	44.36
33	LAN-64	PD 1503	F 66	12	15	15	—	29	44.36
34	LAN-64	PD 1567	F 76	69	119	119	3	103	44.36
35	LAN-64	PD 1065	F 17	148	211	211	—	86	44.36
36	LAN-64	PD 1241	F 50	24	31	31	—	116	44.36
37	LAN-64	PD1259	F 55	2	5	5	—	35	44.36
38	LAN-63	PD 3288	F 318	75	105	106	—	55	44.36
39	LAN-63	PD 3797	F 409	145	198	199	—	37	44.36
40	LAN-63	PD 3938	F 521	144	208	208	—	22	44.36
41	LAN-63	PD 3941	F 444	61	87	87	—	15	44.36
42	LAN-63	PD 3950	F 446	51	70	70	1	28	44.36
43	LAN-63	PD 4017	F 462	150	208	210	—	34	44.36
44	LAN-63	PD 4023	F 468	144	204	204	2	40	44.36
45	LAN-63	PD 4376	F 601	77	92	92	—	59	44.36
46	LAN-63	PD 4727	F 587 v 213	146	172	172	1	28	44.36
47	LAN-63	PD 5349	F 509 I 30	149	205	205	—	20	44.36
48	LAN-63	PD 5597	F 594	101	128	128	—	39	44.36

Note: Lycopodium was introduced in all samples.

[a]PD = provenience designation; F = feature

Table 12.3. West Bluffs Sites: Raw Pollen and Spore Counts

Sample No.	Pollen																			Spores		
	Pinus	TCT	*Quercus*	*Alnus*	*Artemisia*	Asteraceae	Liguliflorae	*Salicornia*	Other Chenopodiaceae	Poaceae	*Eriogonum*	Lamiaceae	*Ribes*	*Proboscidea*	Onagraceae	Undeterminable	Cyperaceae	*Typha* monad	Other	*Sporomiella*	Trilete Spore	Other
1	—	1	—	—	—	6	—	—	1	1	—	—	—	—	—	2	1	—	—	—	—	1
2	2.0	4	—	—	—	22	—	—	—	1	—	1	—	8	—	6	—	—	—	—	—	1
3	—	—	—	—	1	3	—	—	—	—	—	—	—	1	—	7	—	1	—	1	—	—
4	8.7	—	2	1	5	47	1	2	5	13	—	109	1	4	1	58	2	2	6	4	1	—
5	—	—	—	—	1	5	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	1	—	—	—
7	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
8	—	1	—	—	1	11	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—
9	0.3	—	—	1	1	153	—	—	7	1	1	1	—	1	—	43	—	—	—	1	—	—
10	—	—	—	—	—	10	—	—	1	—	—	—	—	—	—	3	—	—	—	1	—	—
11	—	—	—	—	—	160	—	—	5	—	—	—	—	—	—	35	—	—	—	—	1	—
12	3.0	1	2	1	1	139	—	—	3	2	—	18	—	1	4	29	2	—	3	1	1	—
13	—	—	—	—	—	11	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
14	1.0	—	—	—	2	123	1	—	5	—	—	—	—	8	—	4	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16	—	—	—	—	2	92	1	—	20	3	—	—	2	1	1	10	1	—	1	—	—	—
17	—	—	—	—	—	93	—	1	6	—	—	—	—	1	—	12	—	—	1	3	—	—
18	—	—	—	—	1	70	—	—	—	—	—	—	—	—	—	32	—	—	1	—	—	—
19	—	—	—	—	—	232	—	—	2	—	1	—	—	1	—	14	—	—	—	—	1	—
20	—	—	—	—	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21	—	—	—	—	1	177	—	—	3	2	—	3	—	—	1	29	—	—	—	—	—	—
22	—	—	—	—	—	2	—	2	—	—	—	1	—	—	—	1	—	—	—	—	—	—
23	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24	—	—	—	—	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	—	—	—	—	—	14	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—
26	—	—	—	—	—	4	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—
27	—	—	—	—	—	6	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
28	—	—	—	—	—	10	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
29	—	—	—	—	—	3	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
30	—	—	—	—	—	4	—	2	—	1	—	—	—	—	—	3	—	—	—	—	—	—
31	—	—	—	—	—	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32	—	—	—	—	—	29	—	—	—	—	—	1	—	2	—	5	—	—	—	—	—	—
33	—	—	—	—	—	12	—	—	—	—	—	1	—	—	1	1	—	—	—	—	—	—
34	1.0	—	—	—	—	69	—	—	1	3	2	20	—	2	1	19	—	—	1	3	—	—
35	—	—	1	—	1	148	—	—	1	3	1	10	—	—	2	44	—	—	—	—	—	—
36	—	—	—	—	—	24	—	—	—	—	—	1	—	—	1	5	—	—	—	—	—	—
37	1.0	—	—	—	—	2	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—
38	—	—	—	—	1	75	—	—	2	—	1	5	—	—	—	21	—	—	1	—	—	—

Sample No.	Pollen																			Spores		
	Pinus	TCT	*Quercus*	*Alnus*	*Artemisia*	Asteraceae	Liguliflorae	*Salicornia*	Other Chenopodiaceae	Poaceae	*Eriogonum*	Lamiaceae	*Ribes*	*Proboscidea*	Onagraceae	Undeterminable	Cyperaceae	*Typha* monad	Other	*Sporomiella*	Trilete Spore	Other
39	0.3	—	—	—	1	145	—	—	6	1	—	1	—	4	—	40	—	1	—	—	—	—
40	—	—	—	—	2	144	—	—	8	6	—	1	—	6	—	41	—	—	—	—	—	—
41	—	—	—	—	3	61	—	—	2	—	—	—	—	3	—	18	—	—	—	—	—	—
42	—	—	—	—	—	51	—	—	3	—	—	—	—	—	—	16	—	—	—	1	—	—
43	—	1	—	1	1	150	—	2	12	—	1	1	—	1	—	38	1	1	—	—	—	—
44	1.3	—	1	—	2	144	—	—	3	—	1	7	—	1	—	43	—	—	1	1	1	—
45	—	1	—	—	—	77	—	—	—	—	—	1	—	—	—	12	—	—	1	—	—	—
46	—	—	—	—	1	146	—	—	1	1	—	—	—	3	—	20	—	—	—	—	1	—
47	—	—	—	—	6	149	—	—	1	—	—	—	—	7	3	39	—	—	—	—	—	—
48	—	—	—	—	1	101	3	2	—	—	—	—	—	2	—	19	—	—	—	—	—	—
Sum	18.7	9	6	4	35	2,972	6	11	100	38	9	182	3	57	21	677	7	5	18	16	6	3

Table 12.4. West Bluffs Sites: Relative Percentages of Pollen and Spore Values

Sample No.	Pollen																			Spores		
	Pinus	TCT	*Quercus*	*Alnus*	*Artemisia*	Asteraceae	Liguliflorae	*Salicornia*	Other Chenopodiaceae	Poaceae	*Eriogonum*	Lamiaceae	*Ribes*	*Proboscidea*	Onagraceae	Undeter-minable	Cyperaceae	*Typha* monad	Other	*Sporo-miella*	Trilete Spore	Other
1	—	8.3	—	—	—	50.0	—	—	8.3	8.3	—	—	—	—	—	16.7	8.3	—	—	—	—	100.0
2	4.5	9.1	—	—	—	50.0	—	—	—	2.3	—	2.3	—	18.2	—	13.6	—	—	—	—	—	100.0
3	—	—	—	—	7.7	23.1	—	—	—	—	—	—	—	7.7	—	53.8	—	7.7	—	100.0	—	—
4	3.2	—	0.7	0.4	1.9	17.6	0.4	0.7	1.9	4.9	—	40.7	0.4	1.5	0.4	21.7	0.7	0.7	2.2	80.0	20.0	—
5	—	—	—	—	12.5	62.5	—	—	—	—	12.5	—	—	—	—	12.5	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	33.3	33.3	—	—	33.3	—	—	—
7	—	—	—	—	—	100.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100.0
8	—	6.3	—	—	6.3	68.8	—	—	—	—	—	—	—	—	—	18.8	—	—	—	—	—	—
9	0.2	—	—	0.5	0.5	73.1	—	—	3.3	0.5	0.5	0.5	—	0.5	—	20.5	—	—	—	100.0	—	—
10	—	—	—	—	—	71.4	—	—	7.1	—	—	—	—	—	—	21.4	—	—	—	100.0	—	—
11	—	—	—	—	—	80.0	—	—	2.5	—	—	—	—	—	—	17.5	—	—	—	—	100.0	—
12	1.4	0.5	1.0	0.5	0.5	66.5	—	—	1.4	1.0	—	8.6	—	0.5	1.9	13.9	1.0	—	1.4	50.0	50.0	—
13	—	—	—	—	—	91.7	—	—	—	—	—	—	—	—	8.3	—	—	—	—	—	—	—
14	0.7	—	—	—	1.4	85.4	0.7	—	3.5	—	—	—	—	5.6	—	2.8	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16	—	—	—	—	1.5	68.7	0.7	—	14.9	2.2	—	—	1.5	0.7	0.7	7.5	0.7	—	0.7	—	—	—
17	—	—	—	—	—	81.6	—	0.9	5.3	—	—	—	—	0.9	—	10.5	—	—	0.9	100.0	—	—
18	—	—	—	—	1.0	67.3	—	—	—	—	—	—	—	—	—	30.8	—	—	1.0	—	—	—
19	—	—	—	—	—	92.8	—	—	0.8	—	0.4	—	—	0.4	—	5.6	—	—	—	—	100.0	—
20	—	—	—	—	—	100.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21	—	—	—	—	0.5	81.9	—	—	1.4	0.9	—	1.4	—	—	0.5	13.4	—	—	—	—	—	—
22	—	—	—	—	—	33.3	—	33.3	—	—	—	16.7	—	—	—	16.7	—	—	—	—	—	—
23	—	—	—	—	—	100.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24	—	—	—	—	—	100.0	—	—	—	—	—	—	—	—	—	0.0	—	—	—	—	—	—
25	—	—	—	—	—	87.5	—	—	—	—	—	—	—	—	12.5	0.0	—	—	—	—	—	—
26	—	—	—	—	—	66.7	—	—	16.7	—	—	—	—	—	—	16.7	—	—	—	—	—	—
27	—	—	—	—	—	85.7	—	—	—	—	—	—	—	—	14.3	—	—	—	—	—	—	—
28	—	—	—	—	—	83.3	—	—	—	—	—	—	—	—	8.3	8.3	—	—	—	—	—	—
29	—	—	—	—	—	75.0	—	—	25.0	—	—	—	—	—	—	—	—	—	—	—	—	—
30	—	—	—	—	—	40.0	—	20.0	—	10.0	—	—	—	—	—	30.0	—	—	—	—	—	—
31	—	—	—	—	—	100.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32	—	—	—	—	—	78.4	—	—	—	—	—	2.7	—	5.4	—	13.5	—	—	—	—	—	—
33	—	—	—	—	—	80.0	—	—	—	—	—	6.7	—	—	6.7	6.7	—	—	—	—	—	—
34	0.8	—	—	—	—	58.0	—	—	0.8	2.5	1.7	16.8	—	1.7	0.8	16.0	—	—	0.8	100.0	—	—
35	—	—	0.5	—	0.5	70.1	—	—	0.5	1.4	0.5	4.7	—	—	0.9	20.9	—	—	—	—	—	—

Sample No.	Pollen																			Spores		
	Pinus	TCT	*Quercus*	*Alnus*	*Artemisia*	Asteraceae	Liguliflorae	*Salicornia*	Other Chenopodiaceae	Poaceae	*Eriogonum*	Lamiaceae	*Ribes*	*Proboscidea*	Onagraceae	Undeter-minable	Cyperaceae	*Typha* monad	Other	*Sporo-miella*	Trilete Spore	Other
36	—	—	—	—	—	77.4	—	—	—	—	—	3.2	—	—	3.2	16.1	—	—	—	—	—	—
37	20.0	—	—	—	—	40.0	—	—	—	—	—	—	—	—	—	20.0	—	—	20.0	—	—	—
38	—	—	—	—	0.9	70.8	—	—	1.9	—	0.9	4.7	—	—	—	19.8	—	—	0.9	—	—	—
39	0.2	—	—	—	0.5	72.7	—	—	3.0	0.5	—	0.5	—	2.0	—	20.1	—	0.5	—	—	—	—
40	—	—	—	—	1.0	69.2	—	—	3.8	2.9	—	0.5	—	2.9	—	19.7	—	—	—	—	—	—
41	—	—	—	—	3.4	70.1	—	—	2.3	—	—	—	—	3.4	—	20.7	—	—	—	—	—	—
42	—	—	—	—	—	72.9	—	—	4.3	—	—	—	—	—	—	22.9	—	—	—	100.0	—	—
43	—	0.5	—	0.5	0.5	71.4	—	1.0	5.7	—	0.5	0.5	—	0.5	—	18.1	0.5	0.5	—	—	—	—
44	0.7	—	0.5	—	1.0	70.5	—	—	1.5	—	0.5	3.4	—	0.5	—	21.0	—	—	0.5	50.0	50.0	—
45	—	1.1	—	—	—	83.7	—	—	—	—	—	1.1	—	—	—	13.0	—	—	1.1	—	—	—
46	—	—	—	—	0.6	84.9	—	—	0.6	0.6	—	—	—	1.7	—	11.6	—	—	—	—	100.0	—
47	—	—	—	—	2.9	72.7	—	—	0.5	—	—	—	—	3.4	1.5	19.0	—	—	—	—	—	—
48	—	—	—	—	0.8	78.9	2.3	1.6	—	—	—	—	—	1.6	—	14.8	—	—	—	—	—	—

Note: All numbers are percentages.

Table 12.5. Pollen Population Estimates for the West Bluffs Site Samples

Sample No.	Aster-type Pollen Relative Percentage Estimate Per Sample			Aster-type Pollen Population Estimate Per Sample			Total Pollen Population Estimate Per Sample			Total Pollen Population Estimate Per cc		
	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit
1	28.01	54.55	78.73	1,131	2,488	5,653	2,511	4,561	8,554	85	154	289
2	35.83	50.00	64.17	39,708	68,981	157,696	85,293	137,962	293,664	1,923	3,110	6,620
3	8.89	25.00	53.23	1,735	5,190	17,890	11,211	20,759	44,307	303	562	1,198
4	13.68	17.83	22.90	55,748	84,211	147,432	338,181	472,415	764,871	8,317	11,619	18,811
5	30.57	62.50	86.32	9,937	25,084	102,821	18,240	40,134	143,395	411	905	3,233
6	—	—	56.15	—	—	6,610	1,528	4,561	15,405	34	103	347
7	20.65	100.00	100.00	400	2,280	15,739	400	2,280	15,739	9	51	355
8	44.40	68.75	85.84	6,750	12,542	25,532	10,702	18,243	34,074	241	411	768
9	66.70	73.09	78.64	105,649	139,558	198,194	146,170	190,942	268,158	3,295	4,304	6,045
10	45.35	71.43	88.28	14,781	29,511	76,118	22,239	41,315	99,161	501	931	2,235
11	73.91	80.00	84.95	223,950	321,075	543,900	281,547	401,344	675,988	6,347	9,047	15,239
12	60.49	67.15	73.18	74,574	96,852	132,876	112,893	144,233	194,659	2,545	3,251	4,388
13	64.61	91.67	98.51	12,535	23,993	55,133	13,951	26,175	58,955	314	590	1,329
14	78.73	85.42	90.26	85,535	114,272	164,354	100,862	133,781	191,036	2,274	3,016	4,306
15	—	—	—	—	—	26,923	—	—	26,923	—	—	607
16	60.88	69.17	76.39	75,971	104,897	158,690	111,863	151,644	225,237	2,522	3,418	5,077
17	73.47	81.58	87.62	97,047	137,224	218,752	120,132	168,210	265,533	2,708	3,792	5,986
18	57.82	67.31	75.57	156,587	250,840	553,786	236,357	372,677	809,838	5,328	8,401	18,256
19	88.91	92.80	95.40	296,809	415,678	674,723	320,325	447,929	725,966	7,221	10,098	16,365
20	74.12	100.00	100.00	6,902	12,834	26,205	6,902	12,834	26,205	156	289	591

Sample No.	Aster-type Pollen Relative Percentage Estimate Per Sample			Aster-type Pollen Population Estimate Per Sample			Total Pollen Population Estimate Per Sample			Total Pollen Population Estimate Per cc		
	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit
21	76.27	81.94	86.50	433,915	683,057	1,526,274	531,374	833,561	1,856,085	11,979	18,791	41,841
22	9.68	33.33	70.00	472	1,730	6,792	2,338	5,190	12,336	53	117	278
23	60.97	100.00	100.00	1,221	2,688	6,127	1,221	2,688	6,127	28	61	138
24	77.19	100.00	100.00	3,632	6,332	11,466	3,632	6,332	11,466	82	143	258
25	63.98	87.50	96.50	15,559	28,094	59,940	18,254	32,108	66,729	411	724	1,504
26	30.00	66.67	90.32	1,919	5,017	14,511	3,365	7,525	18,614	76	170	420
27	48.69	85.71	97.43	12,638	30,101	116,412	15,412	35,118	129,930	347	792	2,929
28	55.20	83.33	95.30	8,935	17,299	38,607	11,211	20,759	44,307	253	468	999
29	30.06	75.00	95.44	696	2,062	6,443	1,059	2,749	7,531	24	62	170
30	16.82	40.00	68.73	7,337	20,067	89,128	24,011	50,168	170,210	541	1,131	3,837
31	81.57	100.00	100.00	13,573	23,050	43,681	13,573	23,050	43,681	306	520	985
32	62.80	78.38	88.61	19,785	30,310	50,473	26,062	38,671	62,374	588	872	1,406
33	54.81	80.00	92.95	11,211	20,759	44,307	14,707	25,949	52,776	332	585	1,190
34	49.00	57.98	66.47	25,193	33,608	46,570	45,267	57,961	77,089	1,020	1,307	1,738
35	63.65	70.14	75.91	67,500	86,336	115,591	97,686	123,087	162,343	2,202	2,775	3,660
36	60.19	77.42	88.61	6,798	10,380	16,390	9,164	13,407	20,287	207	302	457
37	11.76	40.00	76.93	779	2,867	11,846	2,990	7,167	19,296	67	162	435
38	62.15	71.43	79.19	49,771	68,411	101,092	71,206	95,775	138,496	1,605	2,159	3,122
39	66.54	73.11	78.80	143,038	196,604	301,538	197,616	268,919	408,345	4,455	6,062	9,205
40	62.66	69.23	75.11	224,575	328,372	581,725	327,397	474,316	832,541	7,380	10,692	18,768
41	59.81	70.11	78.72	127,731	204,017	438,051	185,277	290,974	614,296	4,177	6,559	13,848

Sample No.	Aster-type Pollen Relative Percentage Estimate Per Sample			Aster-type Pollen Population Estimate Per Sample			Total Pollen Population Estimate Per Sample			Total Pollen Population Estimate Per cc		
	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit	Lower Limit	Mean	Upper Limit
42	61.46	72.86	81.88	60,910	91,377	158,884	85,519	125,420	213,186	1,928	2,827	4,806
43	65.66	72.12	77.77	159,768	221,329	345,667	223,708	306,910	474,692	5,043	6,919	10,701
44	63.89	70.47	76.30	132,418	180,605	272,498	190,057	256,275	382,278	4,284	5,777	8,618
45	74.83	83.70	89.86	47,967	65,473	95,594	58,013	78,228	112,834	1,308	1,763	2,544
46	78.77	84.88	89.47	184,513	261,590	429,840	218,449	308,175	503,889	4,924	6,947	11,359
47	66.21	72.68	78.32	252,564	373,752	684,582	350,140	514,222	934,740	7,893	11,592	21,072
48	71.05	78.91	85.08	93,535	129,922	200,183	119,852	164,654	250,919	2,702	3,712	5,656

Table 12.6. Macrofossil Samples Analyzed from the West Bluffs Sites

Site No. Sample No	PD No.	CS No.	Provenience
LAN-63			
1	18	—	F 1, L 7
2	57	CS 1001	L4
3	289	—	F 5, L 1
4	290	—	F 6
5	291	—	F 7
6	293	—	F 10, L 1
7	308	—	F 11
8	324	—	F 9
9	325	—	F 8
10	328	—	F 12
11	330	—	F 14
12	332	—	F 15
13	334	—	F 13, L 1
14	367	CS 1	T 1, L 2
15	369	CS 1	T 1, L4
16	371	CS 1	T 1, L 6
17	373	CS 1	T 1, L 8
18	374	CS 1	T 1, L 9
19	414	CS 3	T 1, L 2
20	416	CS 3	T 1, L 4
21	418	CS 3	T 1, L 6
22	420	CS 3	T 1, L 8
23	421	CS 3	T 1, L 9
24	3,288	—	F 318
25	3,797	—	F 409
26	3,938	—	F 521
27	3,941	—	F 444
28	3,950	—	F 446
29	4,017	—	F 462
30	4,023	—	F 468
31	4,068	—	F 475
32	4,078	—	F 480
33	4,079	—	F 48
34	4,106	—	F 492
35	4,131	—	F 498

Site No. Sample No	PD No.	CS No.	Provenience
36	4,282	—	F 567
37	4,376	—	F 601
38	4,475	—	F 617
39	4,489	—	F 620
40	4,718	—	F 587
41	4,727	—	F 587, U 213
42	5,331	—	F 496
43	5,349	—	F 509, I 30
44	5,597	—	F 594
45	5,621	—	F 600
LAN-64			
46	55	CS 1001	L 2
47	59	CS 1001	L 6
48	61	CS 1001	L 8
49	63	CS 1001	L 10
50	65	CS 1001	L 12
51	1,065	—	F 17
52	1,125	—	F 32, L 1
53	1,194	—	F 43
54	1,197	—	F 45
55	1,236	—	F 49
56	1,241	—	F 50
57	1,252	—	F 52
58	1,259	—	F 55
59	1,260	—	F 56
60	1,343	—	F 60
61	1,350	—	F 61
62	1,447	—	F 62
63	1,476	—	F 65
64	1,478	—	F 64
65	1,503	—	F 66
66	1,567	—	F 76

Site No. Sample No	PD No.	CS No.	Provenience
LAN-206A			
67	2,112	—	F 105
68	2,113	—	F 106
69	2,137	—	F 107
70	2,074	—	F 102

Notes: PD = provenience designation, F = feature number, L = level number, T = Trench

For each sample, additional screening was performed and seeds were recovered.

Table 12.7a. West Bluffs Sites: Seeds Recovered from Archaeological Features, Sample Numbers 1–35

Taxa by Carbonization	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Sum
Non-carbonized seeds																																				
Caryophyllaceae																																				
Silene cf. *gallica*	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	286	—	—	3	1	16	20	22	27	—	189	—	566
Spergula cf. *arvensis*	—	1	3	2	—	—	—	—	—	—	—	—	1	—	—	—	1	2	—	—	—	—	—	123	—	—	1	—	2	—	2	16	—	536	—	690
Geraniaceae																																				
Erodium cf. *cicutarium*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	11	—	22	—	267	—	304
Portulacaceae																																				
Calandrinia cf. *ciliata*	—	5	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	6	—	—	1	—	—	—	39	2	—	—	—	57
Asteraceae																																				
Sonchus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	2	—	4
Hieracium-type	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	4	—	160	—	166
cf. *Anthemis* (mayweed)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	7	—	146	—	154
cf. *Hemizonia* sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	1	—	—	—	—	4
Fabaceae																																				
cf . *lupinus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	5	1	—	—	4	—	12
Solanaceae																																				
Solanum sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	10
Oxalidaceae																																				
Oxalis cf. *stricta*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	—	—	1	—	—	—	7
Amaranthaceae																																				
Amaranthus sp.	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	1	4	—	12	27	1	32	—	48	—	139
Chenopodiaceae																																				
Chenopodiaceae	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	3	1	—	2	1	9
Poaceae																																				
Poaceae	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	2
Unknown seeds																																				
Uncarbonized	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	1	—	3	—	—	2		17		27
Carbonized seeds																																				
Chenopodiaceae																																				
Chenopodiaceae	—	—	1	1	—	—	—	1	—	1	—	—	—	—	—	—	4	22	1	—	—	—	—	3	—	1	7	—	3	1	3	4	—	—	—	53
Cyperaceae																																				
Scirpus spp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	5	2	—	1	—	—	1	10
Poaceae																																				
Agropyron sp.	—	1	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	4
Agrostis sp.	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	5
Festuca cf. *obtusa*	—	—	1	1	1	—	—	—	1	—	—	—	—	—	—	—	1	1	1	—	—	—	1	—	—	—	—	—	—	—	—	3	—	2	—	13
Festuca cf. *octoflora*	—	—	2	3	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	1	—	—	1	—	1	6	—	2	—	1	—	19
Hordeum cf. *pusillum*	—	—	1	5	3	—	2	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	2	—	—	—	1	1	11	1	16	—	4	—	50
Lolium cf. *temulentum*	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12
Leptochloa sp.	—	—	—	4	1	—	1	—	—	—	—	—	—	—	1	—	1	8	—	—	—	—	1	4	—	—	1	1	—	3	—	1	—	—	—	27

Taxa by Carbonization	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Sum
Poa sp.	—	—	1	6	—	—	—	—	—	2	—	1	—	—	—	—	4	8	—	1	1	1	—	—	—	—	1	1	2	1	—	3	—	1	—	34
Stipa sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	5
Other unidentified grasses	—	1	7	4	3	—	2	1	2	2	—	—	—	—	1	—	3	10	—	1	—	—	2	18	1	—	—	—	5	8	1	—	—	26	2	100
Polygonaceae																																				
Rumex sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unknown seeds																																				
Carbonized	0	19	15	17	0	1	3	3	1	2	1	6	0	0	8	1	35	19	2	3	1	1	0	10	1	0	23	0	5	16	13	54	—	51	0	311
Total non-carbonized seeds	1	7	13	5	0	0	0	0	0	0	0	0	2	0	0	0	2	2	1	0	0	0	0	439	1	1	12	1	37	64	69	115	—	1,381	1	2,154
Total carbonized seeds	0	33	31	41	9	1	8	6	5	9	1	7	2	0	10	1	48	69	4	5	2	2	4	43	2	1	34	3	22	48	18	84	—	89	3	645

Table 12.7b. West Bluffs Sites: Seeds Recovered from Archaeological Features, Sample Numbers 36–70

Taxa by Carbonization	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	Sum
Non-carbonized seeds																																				
Caryophyllaceae																																				
Silene cf. *gallica*	1	1	39	—	—	2	1	—	2	—	34	77	8	—	—	48	176	1	1	—	2	146	—	55	—	5	110	18	24	1,107	315	—	—	1	51	2,225
Spergula cf. *arvensis*	—	2	1,335	—	1	—	—	1	—	—	1	—	—	—	—	66	272	15	1	—	—	76	—	5	—	—	2	2	4	7	4	—	—	—	68	1,862
Geraniaceae																																				
Erodium cf. *cicutarium*	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	13	57	1	—	—	—	15	1	6	—	2	—	1	—	—	37	—	—	—	1	136
Portulacaceae																																				
Calandrinia cf. *ciliata*	—	—	12	—	—	—	—	—	—	—	—	52	9	—	—	2	62	—	—	24	—	13	1	5	—	—	17	1	10	22	21	—	—	—	29	280
Asteraceae																																				
Sonchus sp.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2	—	1	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	7
Hieracium-type	—	—	1	—	—	—	—	—	—	—	1	2	3	—	—	5	34	—	—	—	—	1	—	3	—	—	—	—	1	—	1	—	—	—	—	52
cf. *Anthemis* (mayweed)	—	—	2	—	—	—	—	—	—	—	1	—	—	—	—	2	1	—	—	—	—	—	—	—	—	1	—	1	—	1	—	—	—	—	—	9
cf. *Hemizonia* sp.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	7
Fabaceae																																				
cf . *lupinus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	3	4
Solanaceae																																				
Solanum sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxalidaceae																																				
Oxalis cf. *stricta*	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Amaranthaceae																																				
Amaranthus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	26	—	—	—	—	—	—	2	—	—	1	6	36
Chenopodiaceae																																				
Chenopodiaceae	—	—	2	—	—	1	—	—	—	—	—	1		—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	9
Poaceae																																				
Poaceae	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	3	7
Unknown seeds																																				
Uncarbonized	—	—	—	—	—	1	—	—	—	—	7	1	—	—	—	1	5	1	—	—	2	1	—	4	—	1	—	1	—	1	2	—	—	—	2	30
Carbonized seeds																																				
Chenopodiaceae																																				
Chenopodiaceae	—	1	—	1	2	3	—	—	—	—	—	—	—	—	—	1	10	2	—	—	—	13	—	6	—	—	1	1	—	6	18	—	—	—	1	66
Cyperaceae																																				
Scirpus spp.	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	35	—	—	—	—	—	1	—	—	—	—	—	38
Poaceae																																				
Agropyron sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	9

Taxa by Carbonization	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	Sum
Agrostis sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
Festuca cf. *obtusa*	—	3	—	—	—	—	—	—	1	—	—	—	—	—	—	2	2	—	—	—	—	1	—	2	—	—	—	—	2	1	4	—	—	—	—	18
Festuca cf. *octoflora*	—	1	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	2	—	3	—	—	—	—	—	—	—	—	—	—	—	8
Hordeum cf. *pusillum*	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	6	1	—	2	—	—	1	12
Lolium cf. *temulentum*	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
Leptochloa sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	2	—	—	—	—	3	4	2	—	—	—	—	14
Poa sp.	1	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	1	1	—	—	—	—	8
Stipa sp.	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	1	—	—	—	—	—	—	6
Other unidentified grasses	—	—	2	—	—	—	—	—	2	—	—	—	—	—	—	1	1	—	—	—	—	—	—	22	1	—	1	—	11	2	4	—	—	—	—	47
Polygonaceae																																				
Rumex sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	6	—	—	—	—	—	1	—	7	23	—	—	—	—	40
Unknown seeds																																				
Carbonized	0	3	15	2	2	24	0	0	3	1	0	41	1	—	3	0	40	113	0	0	0	130	0	251	1	0	23	9	33	222	121	1	—	0	2	1,041
Total non-carbonized seeds	1	5	1,392	0	1	4	1	2	2	0	46	133	20	—	1	139	608	20	5	25	5	253	2	110	0	9	130	24	43	1,138	382	0	—	2	163	4,666
Total carbonized seeds	1	8	21	3	4	28	1	1	8	1	0	47	1	—	3	4	56	116	0	0	0	156	0	327	2	0	25	11	56	245	173	3	—	0	6	1,307

Table 12.8a. West Bluffs Sites: Relative Percentages of Seed Samples Recovered from Archaeological Features, by Sample Numbers 1–35

Taxa by Carbonization	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Sum
Non-carbonized seeds																																				
Caryophyllaceae																																				
Silene cf. *gallica*	—	14	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	65	—	—	21	100	42	31	32	24	—	14	—	
Spergula cf. *arvensis*	—	14	23	40	—	—	—	—	—	—	—	—	50	—	—	—	50	100	—	—	—	—	—	28	—	—	7	—	5	—	3	14	—	39	—	
Geraniaceae																																				
Erodium cf. *cicutarium*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	17	—	19	—	19	—	
Portulacaceae																																				
Calandrinia cf. *ciliata*	—	72	23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100	—			—	1.4	—	—	7	—	—	—	57	2	—	—	—	
Asteraceae																																				
Sonchus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.5	—	0.9	—	0.1	—	
Hieracium-type	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	50	—	—	—	—	—	—	—	100	—	—	—	—	—	—	3	—	12	—	
cf. *Anthemis (mayweed)*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	6	—	11	—	
cf. *Hemizonia* sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.7	—	—	—	—	—	—	1	—	—	—	—	
Fabaceae																																				
cf . *lupinus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	7	—	—	8	1	—	—	0.3	—	
Solanaceae																																				
Solanum sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.7	—	
Oxalidaceae																																				
Oxalis cf. *stricta*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.4	—	—	—	—	—	—	—	0.9	—	—	—	
Amaranthaceae																																				
Amaranthus sp.	—	—	31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.3	—	100	29	—	32	41.5	1	27	—	3.5	—	
Chenopodiaceae																																				
Chenopodiaceae	—	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—	—	4	0.9	—	0.1	100	
Poaceae																																				
Poaceae	—	—	—	—	—	—	—	—	—	—	—	—	50	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	
Unknown seeds																																				
Uncarbonized	100	—	15	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.5	—	—	21	—	11	1.5	—	3.4	—	1.3	—	
Carbonized seeds																																				
Chenopodiaceae																																				
Chenopodiaceae	—	—	3	3	—	—	—	17	—	11	—	—	—	—	—	—	8	32	25	—	—	—	—	7	—	100	21	—	14	2	17	5	—	—	—	
Cyperaceae																																				
Scirpus spp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	23	4	—	1.2	—	—	33	
Poaceae																																				
Agropyron sp.	—	3.0	—	—	—	—	—	—	20	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.1	—	
Agrostis sp.	—	—	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.4	—	
Festuca cf. *Obtusa*	—	—	3	3	11	—	—	—	20	—	—	—	—	—	—	—	2	1	25	—	—	—	25	—	—	—	—	—	—	—	—	3.5	—	2.2	—	
Festuca cf. *Octoflora*	—	—	6.5	8	—	—	—	—	—	—	—	—	50	—	—	—	—	1	—	—	—	—	—	2	—	—	3	—	4.5	12.5	—	2	—	1.1	—	
Hordeum cf. *Pusillum*	—	—	3	13	33	—	22	17	—	11	—	—	50	—	—	—	—	—	—	—	—	—	—	5	—	—	—	33	4.5	23	6	19	—	4.5	—	
Lolium cf. *Temulentum*	—	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	

Taxa by Carbonization	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Sum
Leptochloa sp.	—	—	—	10	11	—	11	—	—	—	—	—	—	—	10	—	2	12	—	—	—	—	25	9	—	—	3	33	—	6	—	1.2	—	—	—	
Poa sp.	—	—	3	15	—	—	—	—	—	22	—	14	—	—	—	—	8	12	—	20	50	50	—	—	—	—	3	33	9	2	—	3.5	—	1.1	—	
Stipa sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	—	—	—	—		—	—	—	—	—	—	
Other unidentified grasses	—	3	23	10	33	—	22	17	40	22	—	—	—	—	10	—	6	14.5	—	20	—	—	50	42	50	—	—	—	23	17	6	—	—	29	67	
Polygonaceae																																				
Rumex sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Unknown seeds																																				
Carbonized	—	56	52	38.5	—	—	44	50	20	22	100	86	—	—	80	100	73	27.5	50	60	50	50	—	23	50	—	68	—	23	33	72	65	—	57	—	
Total non-carbonized seeds	100	17	29.5	11	—	—	—	—	—	—	—	—	50	—	—	—	4	3	20	—	—	—	—	91	33	50	29	25	63	57.5	79	58	—	94	25	
Total carbonized seeds	—	83	70.5	89	100	—	100	100	100	100	100	100	50	—	100	100	96	97	80	100	100	100	100	9	67	50	71	75	37	42.5	21	42	—	6	75	

Note: All numbers are percentages.

Table 12.8b. West Bluffs Sites: Relative Percentages of Seed Samples Recovered from Archaeological Features, Sample Numbers 36–70

Taxa by Carbonization	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	Sum
Non-carbonized seeds																																				
Caryophyllaceae																																				
Silene cf. *gallica*	100	20	3	—	—	50	100	—	100	—	74	58	40	—	—	34.5	29	5	20	—	40	58	—	49	—	56	85	75	54.5	97	82.5	—	—	50	31	
Spergula cf. *arvensis*	—	40	96	—	100	—	—	50	—	—	2.2	—	—	—	—	47.5	45	75	20	—	—	30	—	4.5	—	—	1.5	8	9	0.6	1	—	—	—	42	
Geraniaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Erodium cf. *cicutarium*	—	—	—	—	—	—	—	50	—	—	—	—	—	—	100	9	9	5	—	—	—	6	50	5	—	22	—	4.2	—	—	10	—	—	—	0.6	
Portulacaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Calandrinia cf. *ciliata*	—	—	0.9	—	—	—	—	—	—	—	—	39	45	—	—	1.4	10	—	—	96	—	5	50	4.5	—	—	13	4.2	23	2	5.5	—	—	—	18	
Asteraceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Sonchus sp.	—	—	0.1	—	—	—	—	—	—	—	—	—		—	—	0.7	—	10	—	4	20	—	—	—	—	—	—	—	2.3	—	—	—	—	—	—	
Hieracium-type	—	—	0.1	—	—	—	—	—	—	—	2.2	1.5	15	—	—	4	6	—	—	—	—	0.4		2.7	—	—	—	—	2.3	—	0.3	—	—	—	—	
cf. *Anthemis (mayweed)*	—	—	0.1	—	—	—	—	—	—	—	2.2	—	—	—	—	1.4	0.2	—	—	—	—	—	—	—	—	11	—	4.2	—	0.1	—	—	—	—	—	
cf. *Hemizonia sp.*	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	
Fabaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
cf . *lupinus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	—	—	—	—	—	—	—	—	—	—	—	—	2	
Solanaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Solanum sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Oxalidaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Oxalis cf. *stricta*	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Amaranthaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Amaranthus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	—	—	—	—	23		—	—	—	—	—	0.5	—	—	50	4	
Chenopodiaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Chenopodiaceae	—	—	0.1	—	—	25	—	—	—	—	—	0.8	—	—	—	—	—	—	40	—	—	—	—	—	—	—	—	—	7.0	—	—	—	—	—	—	
Poaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Poaceae	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	0.7	—	—	—	—	—	—	—	—	—	—	0.8	—	—	—	—	—	—	—	2	
Unknown seeds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Uncarbonized	—	—	—	—	—	25	—	—	—	—	15	0.8	—	—	—	0.7	0.8	5	—	—	40	0.4	—	5	—	11	—	4.2	2.3	0.1	0.5	—	—	—	1.2	
Carbonized seeds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Chenopodiaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Chenopodiaceae	—	12.5	—	25	50	11	—	—	—	—	—	—	—	—	—	25	18	2	—	—	—	8	—	2	—	—	4	9	—	2.4	10	—	—	—	17	
Cyperaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Scirpus spp.	—	—	—	—	—	—	—	100	—	—	—	—	—	—	—	—	—	0.9	—	—	—	—	—	11	—	—	—	—	—	0.4	—	—	—	—	—	
Poaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Agropyron sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.6	—	—	—	—	—	—	—	—	—	—	—	—	—	
Agrostis sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	33	
Festuca cf. *obtusa*	—	37.50	—	—	—	—	—	—	12.50	—	—	—	—	—	—	50	4	—	—	—	—	0.6	—	0.6	—	—	—	—	4	0.4	2.3	—	—	—	—	

Taxa by Carbonization	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	Sum
Festuca cf. *octoflora*	—	12.50	5	—	—	—	—	—	12.50	—	—	—	—	—	—	—	—	—	—	—	—	1.3	—	0.9	—	—	—	—	—	—	—	—	—	—	—	
Hordeum cf. *pusillum*	—	—	—	—	—	—	—	—	12.50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.3	—	—	—	—	11	0.4	—	67	—	—	17	
Lolium cf. *temulentum*	—	—	—	—	—	—	—	—	—	—	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Leptochloa sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.9	—	0.6	—	—	—	—	5	1.6	1	—	—	—	—	
Poa sp.	100	—	—	—	—	4	100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.9	—	—	—	—	—	0.4	0.6	—	—	—	—	
Stipa sp.	—	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.6	—	—	—	—	2	—	—	—	—	—	—	
Other unidentified grasses	—	—	9.5	—	—	—	—	—	25	—	—	—	—	—	—	25	2		—	—	—	—	—	7	50	—	4	—	20	0.8	2.3	—	—	—	—	
Polygonaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Rumex sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5		—	—	—	3.8	—	—	—	—	—	9	—	3	13	—	—	—	—	
Unknown seeds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Carbonized	—	37.5	71	75	50	86	—	—	37.5	100	—	87	100	—	100	—	71	97	—	—	—	83	—	77	50	—	92	82	59	91	70	33	—	—	33	
Total non-carbonized seeds	50	38.5	98.5	—	20	12.5	50	67	20	—	100	74	95	—	25	97	92	15	100	100	—	62	100	25.5	—	100	84	69	44	82	69	—	—	100	96	
Total carbonized seeds	50	61.5	1.5	100	80	87.5	50	33	80	100	—	26	5	—	75.0	3	8	85	—	—	—	38	—	74.5	100	—	16	31	56	18	31	100	—	—	4	

Note: All numbers are percentages.

Table 12.9. Native Grasses Present in the Ballona Estuary and Los Angeles Prairie

Scientific Name	Common Name	Ballona Estuary			Los Angeles Prairie	Dunes	Vernal Pools
		Salt Marsh	Freshwater Marsh	Dry Shrub-lands			
Alopecurus saccatus	foxtail						X
Bromus carinatus	California brome					X	
B. marginatus	brome			X			
Deschampsia danthonioides	annual hairgrass						X
Distichlis spicata	saltgrass	X			X		
Elymus condensatus	giant rye grass			X			
E. triticoides	wild rye					X	
Festuca megalura	fescue			X		X	
F. microstachys	fescue					X	
F. hirsuta	fescue					X	
Hordeum intercedens (=H. Pusillum)	little barley						X
Koeleria macrantha	June grass				X		
Leptochola univervia	Mexican sprangletop		X	X			X
Melica imperfecta	Melic grass			X			
Monanthochloe littoralis	shoregrass		X				
Orcuttia californica	California orcutt grass						X
Phalaris lemmonii							X
Stipa cernua	nodding needlegrass			X	X		

Note: Data from Mattoni and Longcore 1997; Gustafson 1981; and Henrickson 1991.

Table 12.10. West Bluffs Sites: Relative Percentage Values of Samples with Contents of Potential Archaeological Significance

Site No. / Sample No.	PD No.	Total Pollen	*Artemisia*	*Asteraceae*	Other Chenopodiaceae	Poaceae	Lamiaceae	*Proboscidea*	Onagraceae
LAN-63									
21	199	216	0.5%	81.9%	1.4%	0.9%	1.4%	—	0.5%
38	3288	106	0.9%	70.8%	1.9%	—	4.7%	—	—
39	3797	199	0.5%	72.7%	3.0%	0.5%	0.5%	2.0%	—
40	3938	208	1.0%	69.2%	3.8%	2.9%	0.5%	2.9%	—
41	3941	87	3.4%	70.1%	2.3%	—	—	3.4%	—
42	3950	70	—	72.9%	4.3%	—	—	—	—
43	4017	210	0.5%	71.4%	5.7%	—	0.5%	0.5%	—
44	4023	204	1.0%	70.5%	1.5%	—	3.4%	0.5%	—
9	4068	209	0.5%	73.1%	3.3%	0.5%	0.5%	0.5%	—
11	4079	200	—	80.0%	2.5%	—	—	—	—
12	4106	209	0.5%	66.5%	1.4%	1.0%	8.6%	0.5%	1.9%
14	4282	144	1.4%	85.4%	3.5%	—	—	5.6%	—
45	4376	92	—	83.7%	—	—	1.1%	—	—
16	4489	134	1.5%	68.7%	14.9%	2.2%	—	0.7%	0.7%
17	4718	114	—	81.6%	5.3%	—	—	0.9%	—
18	4727	104	1.0%	67.3%	—	—	—	—	—
46	4727	172	0.6%	84.9%	0.6%	0.6%	—	1.7%	—
19	5331	250	—	92.8%	0.8%	—	—	0.4%	—
47	5349	205	2.9%	72.7%	0.5%	—	—	3.4%	1.5%
48	5597	128	0.8%	78.9%	—	—	—	1.6%	—

Site No. Sample No.	PD No.	Total Pollen	*Artemisia*	*Asteraceae*	Other Chenopodiaceae	Poaceae	Lamiaceae	*Proboscidea*	Onagraceae
LAN-64									
35	1065	211	0.5%	70.1%	0.5%	1.4%	4.7%	—	0.9%
36	1241	31	—	77.4%	—	—	3.2%	—	3.2%
32	1478	37	—	78.4%	—	—	2.7%	5.4%	—
34	1567	119	—	58.0%	0.8%	2.5%	16.8%	1.7%	0.8%

Note: PD = provenience designation.

Pollen abundances of potential archaeological significance are shaded. Only those samples (n = 24) with at least 30 grains of total pollen are used in the table.

Table 12.11. West Bluffs Sites: Archaeologically Significant Carbonized Seeds Recovered from Site Features, by Site and Sample Number

	CA-LAN-63															CA-LAN-64										Seed Total	Total Carbonized Seeds (%)
	2	3	4	15	17	18	24	27	29	30	31	32	34	38	41	47	52	53	57	59	62	63	64	65	66		
PD no.[a]	57	289	290	369	373	374	3,288	3,941	4,017	4,023	4,068	4,078	4,106	4,475	4,727	59	1,125	1,194	1,252	1,260	1,447	1,476	1,478	1,503	1,567	n/a	n/a
Chenopodiaceae																											
Undifferentiated	—	1	1	—	4	22	3	7	3	1	3	4	—	—	3	—	10	2	13	6	1	1	—	6	18	109	6.0%
Cyperaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Scirpus sp.	—	—	—	—	—	—	—	1	5	2	—	1	—	—	—	—	—	1	—	35	—	—	—	1	—	46	2.5%
Poaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Agropyron sp.	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	3	0.2%
Agrostis sp.	—	2	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	5	0.3%
Aristida sp.	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	3	0.2%
Festuca cf. *obtusa*	—	1	1	—	1	1	—	—	—	—	—	3	2	—	—	—	2	—	1	2	—	—	2	1	4	21	1.1%
Festuca cf. *octoflora*	—	2	3	—	—	1	1	1	1	6	—	2	1	1	—	—	—	—	2	3	—	—	—	—	—	24	1.3%
Hordeum cf. *pusillum*	—	1	5	—	—	—	2	—	1	11	1	16	4	—	—	—	—	—	—	1	—	—	6	1	—	49	2.7%
Lolium cf. *temulentum*	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	18	1.0%
Leptochloa sp.	—	—	4	1	1	8	4	1	—	3	—	1	—	—	—	—	—	—	3	2	—	—	3	4	2	37	2.0%
Panicum sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2	0.1%
Poa sp.	—	1	6	—	4	8	—	1	2	1	—	3	1	—	1	—	—	—	—	3	—	—	—	1	1	33	1.8%
Stipa sp.	—	—	—	—	—	—	5	—	—	—	—	—	—	3	—	—	—	—	—	2	—	—	1	—	—	11	0.6%
Other Poaceae	1	7	4	1	3	10	18	—	5	8	1	—	23	2	—	—	1	—	—	20	1	—	11	2	4	122	6.7%
Total Poaceae[b]	14	14	23	2	9	28	30	3	9	29	2	25	38	6	1	6	3	0	7	35	1	0	23	9	11	328	17.9%
Polygonaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rumex	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	6	—	—	1	—	7	23	41	2.2%
Unknown	20	16	15	8	35	19	10	23	5	16	13	54	51	15	24	41	40	113	130	251	23	9	33	222	121	1307	71.4%
Total carbonized seeds	34	31	39	10	48	69	43	34	22	48	18	85	89	21	28	47	56	116	156	328	25	13	56	245	174	1835	—

Note: Only those samples that had 10 or more carbonized seeds were used in this table. Only 25 samples qualified.

[a]PD = provenience designation

[b]Carbonized grass seeds constitute 39.75% of 722 carbonized seeds recovered at CA-LAN-63, 8.08% of 1,226 carbonized seeds recovered at CA-LAN-64, and 55.56% of 9 carbonized seeds recovered at CA-LAN-206a.

Analysis of Human Skeletal Remains

Bonnie Yoshida, Rebecca Richman, Phillip L. Walker,
Korri Dee Turner, and Lorrie Lincoln-Babb

Archaeological excavations of LAN-63, LAN-64, and LAN-206A resulted in the discovery of several concentrations of poorly preserved human remains (Tables 13.1, 13.2, and 13.3). Although these three sites are located in the area historically occupied by the Gabrielino/Tongva tribe, earlier groups living in this area might have been more closely affiliated with Chumashan-speaking people who at the time of European contact were living in the Santa Barbara Channel area to the north (Kerr et al. 2002). The goal of this osteological analysis was to obtain as much data as possible to determine the population affinities, health status, and lifeways of the people whose remains were recovered from these sites.

Excavation Methods

The poor preservation of the skeletal material and the hard, extremely compact soil surrounding them necessitated the development of special recovery techniques. Once concentrations of bone were located and identified as human in the field, excavation proceeded using trowels, small implements, and brushes. When the soil matrix was especially hard and dense, water was used to soften the area to facilitate bone removal. Bone was removed in the soil matrix in small blocks and placed in cloth bags; when possible, skeletal elements were separated by bone and by side, and labeled accordingly. All fill around the bone concentrations (a ca. 0.30-m diameter, according to guidelines set by the Most Likely Descendant [MLD]) was removed and saved in buckets as “burial fill.”

Inventory and Analysis Methods

Analysis of all human skeletal remains took place in the laboratory of Dr. Phillip Walker in the Department of Anthropology at the University of California, Santa Barbara. Following the instructions of the MLD, no destructive analyses were performed and no photographs were taken of the human remains while they were in the laboratory. In preparation for analysis, the remains were carefully cleaned. The extremely poor preservation of the bone made this a difficult, time-consuming process.

In the laboratory, the skeletal remains were first removed from the cloth bags and visually examined. Brushes and bamboo probes were used to remove as much of the surrounding soil matrix as possible without damaging the bone. Preliminary observations were made on these dry bones. To minimize damage to the remains, water was used to remove the hardened soil matrix surrounding them. This was done at an outdoor wet-screening station. Bone fragments were carefully removed from the water-softened matrix, cleaned, allowed to dry, and placed in cardboard boxes labeled with provenience information. In some cases, soil was not washed completely from the remains because it was contributing significantly to the structural integrity of the bone. Following the instructions of the MLD, the soil associated with the skeletal remains was saved in basins during the wet-screening process, allowed to dry, and then repacked with the associated human remains.

The analysis of the West Bluffs skeletal material followed the protocol described by Buikstra and Ubelaker (1994). All human bone fragments from the burial features were sorted using a ¼-inch mesh screen; this step separated fragments smaller than ¼ inch, which typically provide little anthropologically significant information, from those larger than ¼ inch, which were more useful from an analytical perspective. An inventory was made of all elements present. Inventory data included the identification of bone or bone type, side, segment, and completeness (Appendix L). Each bone or bone fragment larger than ¼ inch was sorted, counted, and weighed. Bone fragments smaller than ¼ inch were weighed but not counted.

Owing to the poor bone preservation, observations of the field excavators proved to be a valuable source of information that aided bone identification and age and sex determinations. These determinations were completed following criteria described by Buikstra and Ubelaker (1994). Sex was determined for adult skeletons when the necessary elements were present. Sexually dimorphic characteristics of the ox coxae and skull were independently evaluated, as described by Buikstra and Ubelaker (1994). In the absence of pelvic or cranial indicators of sex, we used measures of relative postcranial robusticity, including long-bone dimensions, that were based on comparative data on size differences between males and females from other southern California Indian skeletal samples that have been analyzed in our laboratory.

Estimates of age at death were made for all individuals. For subadult individuals, dental calcification and eruption were the primary criteria, along with the degree and pattern of epiphyseal fusion. Adult age estimates were based on all feasible age estimation methods, including auricular surface changes, the degree of cranial suture closure, the severity of tooth wear, and indications of age-related degenerative joint disease. Owing to the extremely poor preservation of most of the remains, it was sometimes possible to determine only that the individual was adult, based on the relative size of long bones and other skeletal elements.

The skeletal remains were visually examined for pathological conditions with the unaided eye. A hand lens and microscope were also used when necessary. All pathological conditions were scored in accordance with the recommendations by Buikstra and Ubelaker (1994), and the locations of such conditions were drawn on data-collection sheets. Cranial and postcranial measurements, cranial and postcranial nonmetric traits, tooth-wear scores, and tooth measurements were collected when possible. The bone fragments were also examined for taphonomic changes such as variations in color and texture, evidence of burning, and cultural modifications.

Nonhuman bone as well as shell, stone, and other materials discovered during the analysis were separated from the human remains and bagged separately. For analytical purposes, we divided the osteological material into four categories: human, probable human, indeterminate, and nonhuman.

Burial Feature Descriptions

Preservation

The poor preservation of the West Bluffs skeletal material greatly reduced the amount of bioarchaeological data that could be obtained from it. This preservation problem limited our analysis in a number of respects. Poor preservation decreases the accuracy of age and sex determinations, significantly reduces the probability of identifying certain types of pathological conditions, and also distorts paleodemographic profiles (Walker 1995; Walker et al. 1988; Walker et al. 1996). These problems, along with the small size of the West Bluffs skeletal collection make meaningful paleodemographic and paleopathological comparisons with other, better preserved collections difficult.

For most of the burials, the quality of the bone was very poor. Almost no skeletal elements were complete, and the bone that was preserved was very friable because of its low collagen content. Bioturbation was also a major factor responsible for the damage, fragmentation, and dispersal of bones in the sites; bones often bore evidence of damage from plant roots and rodent gnawing. All of these taphonomic factors limited the amount of bioarchaeological data that could be obtained from the remains.

The extent of the preservation problem was indicated by the low average total weight (358 g) of osseous material recovered from the burial features (Figure 13.1). This is about one-tenth the average weight of a complete human skeleton (Trotter and Hixon 1974; Trotter and Peterson 1970). The total weight of the human remains in each of 5 (36 percent) of the 17 features analyzed was less than 100 grams. Most of these features containing less than 100 g of bone (e.g. Features 61, 62, and 66) are incomplete interments that appear to have been previously disturbed by rodent burrowing and other site-formation processes (Douglass and Altschul 2004).

Based on their state of preservation, the human remains from West Bluffs features can be divided into three groups (Figure 13.2). Feature 43 stands out because it is the only comparatively well-preserved burial, with a large proportion (92 percent) of the bone fragments smaller than $^1/_4$ inch. Another group of poorly preserved features (Features 52, 64, 480, and 492) are characterized by a high proportion of bone fragments larger than $^1/_4$ inch. In contrast, the remaining skeletons are very incomplete (Features 56, 61, 62, 65, 66, 100, 475, 600, and 617) and each has less than 300 g of preserved bone (Table 13.4; see Figures 13.1 and 13.2). The weight ratios of bone fragments greater than $^1/_4$ inch in diameter to those less than $^1/_4$ inch in diameter do not suggest any significant preservation differences between LAN-63 and LAN-64, the West Bluffs sites that contained more than one burial feature; very poorly preserved burials and those with somewhat better preservation were present in both sites.

LAN-63

Feature 475

Feature 475 consisted of a disturbed primary burial or the secondary deposition of a child's remains. Due to the haphazard location of the remains, body position could not be determined. Rampant rodent disturbance had relocated portions of the burial into krotovina.

Skeletal completeness of this subadult was less than 25 percent; the elements present were some deciduous teeth; part of the cranium and mandible; rib fragments; portions of humerus, radius and ulna shafts; and phalanges. In addition to a child, the feature contained part of an adult clavicle, yielding a minimum number of individuals (MNI) of two.

No pit or formal burial preparation was identified in the fill matrix. Elements consistent with a child's age, as well as indeterminate unburnt bone fragments, were excavated from various krotovina that were in the immediate and nearby area of the feature. A carved steatite object was located near the cranium and portion of a mandible, and might have been intentionally included with the burial. The context of this feature was highly disturbed, however, and the fill contained various shells and faunal bone also, typical of the surrounding midden fill.

Feature 480

Feature 480 was a disturbed primary adult inhumation. The individual was oriented west, with the legs tightly flexed. Due to extensive rodent disturbance, neither the position of the arms nor the direction of the face could be determined. The paucity of diagnostic bone prevented sex determination. An age range of 30–40 years was estimated based on dental attrition and arthritic lipping on the margin of an acetabulum. Pathological conditions observed were the arthritic lipping of the acetabulum and a rib fragment, and lesions (increased porosity) on the right carpal.

This burial contained less than 25 percent of a complete individual. Identifiable elements included parts of the cranium, mandible, and teeth; radius and ulna shaft fragments; parts of both femora shafts; fragments from unsided tibia and fibula shafts; innominate fragments; and various hand elements.

No pit outline or preparation of a pit was observed. A small piece of red ochre was noted in the lower region of the body. Krotovina below the main portion of the burial were also excavated in order to retrieve transported human bone fragments.

Feature 492

The jumbled yet concentrated nature of Feature 492 most likely represented a secondary deposit of adult human remains rather than a disturbed primary burial. No identifiable body position or complete skeletal articulation was noted. Cranial remains and dentition were absent. The postcranial remains included nonrepeated elements, suggesting that only one individual was represented in the mortuary feature. The adult age estimation was made based on the general appearance of the bone. No sex determination was possible due to lack of diagnostic morphology. No pathology, trauma, peri- or postmortem damage was observed.

Identifiable but not articulated elements included part of a possible right scapula; unsided shaft fragments from a humerus, radius, and ulna; part of a sacrum; six unsided rib-body fragments; a left femur shaft; two fibula shaft sections; a section of a tibia shaft; tarsal fragments; and carpal and tarsal phalanges. Some of the remains exhibited rodent gnaw marks.

There was no evidence of a pit. Rodent disturbance was present, resulting in various indeterminate bone fragments, collected from the general fill and underlying krotovina. An abalone shell was located in proximity to the human remains and was probably placed with the remains at the time of deposition. Several pea-sized asphaltum nodules were in the west portion of the feature. One flaked stone was also near the remains, and a few others were collected from the general fill. Whether the lithic artifacts were associated with the burial is unknown.

Feature 600

Feature 600 consisted of a tightly flexed, primary adult inhumation. The probable female was placed in a supine position, with the body oriented west, and the face turned to the north. Dental development and attrition supported an adult age determination. A sex estimation of female was based on the gracile and small nature of the long-bone elements.

Skeletal completeness for this feature was less than 25 percent. A portion of the cranial vault was preserved, along with part of the left mandible and associated dentition. The left tibia and fibula were resting with anterior aspect up. Long-bone fragments above the left tibia were interpreted as the left lower arm based on location and assumed articulation of the elements. No pathology was observed.

A possible pit outline was observed during excavation; however, extensive rodent disturbance eliminated positive evidence. In addition to krotovina, other disturbances included insects, possible historical-period farming, and construction grading. No associated artifacts were recovered with this feature.

Feature 617

Feature 617 was less than 25 percent of an adult cranium; no postcranial remains were recovered. A wedge-shaped section of the left side of a cranium was recovered. This piece included part of the face and eye orbit, the left aspect of the frontal, and part of the left parietal. No dental remains were recovered. Bone appearance and density supported an adult age determination. The lack of well-preserved bone, however, prohibited estimation of sex. No pathology was observed.

The area was thoroughly explored, and there was no evidence of a pit or other indications of a formal burial. A buried red brick septic, sewer, or water tank, in disuse, was located in the general area. It is conceivable that construction of the tank and associated pipeline impacted the burial from which these remains originated. It is also possible, though not as likely, that the cranial remains were all that was left of a primary burial. Two human bone fragments were collected from nearby krotovina. No associated artifacts were recovered with Feature 617.

LAN-64

Feature 32

Feature 32 was initially thought to be a human burial. During excavation in the field, it was identified as probable faunal remains. Subsequent laboratory analysis determined that Feature 32 contained human remains. No pit or prepared area was identified during the excavation of Feature 32. As a result of the initial field determination that Feature 32 was not a human burial (but rather consisted of large mammal bone), data given to Walker and his students indicated that this was not a burial. Consequently, burial feature data in this report does not include Feature 32. Rather, the remains were treated as isolated human remains and those data are presented in Appendix L.

Feature 43

Feature 43 consisted of a primary adult burial in a formally prepared pit. The human remains were in a flexed position. The body was placed on the left side and oriented north; the face was turned to the east. The right arm was bent at the elbow and crossed over the abdominal area onto the elbow region of the left arm. The left arm was somewhat interlocked with the right arm, and was bent at the elbow with the left hand (represented by one phalanx) resting near or on the face (the facial region was disturbed and absent). The left leg was flexed at the knee and tightly bent up to the chest area. The right leg was also flexed at the knee, but the upper leg was extended at a right angle to the body's alignment. Two teeth were recovered and exhibited a flat plane of wear, with cupped dentin exposure. Based on the dental wear, an approximate age of 35 years or more was estimated for this individual. The absence of diagnostic bone prevented any sex determination. No pathology was observed.

Skeletal preservation for Feature 43 was fair to poor. Long-bone shafts remained; however, the proximal and distal ends were missing due to poor preservation. Identifiable elements included part of the cranial vault, a fragment of the left side of the mandible, shaft portions for the upper and lower arms and legs, a right innominate fragment, a carpal phalanx, two tarsals, and a metatarsal shaft piece. Aside from the mechanical means of discovery, disturbance included insect and rodent activities.

The pit was shallow, oval, and measured approximately 1.20 by 0.90 m by 0.14 m deep (the pit might have been deeper, but the feature was exposed by mechanical stripping). A few flaked stones were collected from the general feature fill. The size of the pit substantially exceeded that needed for the inhumation, which suggested mortuary accompaniments might have been present.

Feature 52

Feature 52 consisted of a primary adult burial. The individual was placed on the right side in a flexed position, the body oriented north, and the face directed west. Teeth recovered from beneath the skull (in an area of rodent disturbance) exhibited heavy wear. The dental wear, seen in conjunction with diploic thickening of the cranial vault, provided an age estimate ranging from 35 to 50 years old. A tentative sex determination was based on one aspect of cranial morphology, a relatively robust nuchal crest (more typically male). No additional sex information could be obtained from the cranial and pelvic remains. No pathology was observed.

The skeletal remains were fair to poorly preserved and incompletely represented (less than 50 percent complete). Initial mechanical action revealed the cranial outline and a portion of a femoral shaft. A phalanx, rib fragment, and indeterminate human bone fragments had been displaced prior to excavation and were collected from the general feature fill. Identifiable in situ elements included part of the cranium and left side of the mandible; innominate and sacral fragments; rib fragments; and shaft portions of the left and right humeri, left radius and ulna, and both femora.

There was no evidence of a pit outline or of formal pit preparation. Krotovina was seen throughout the feature, which contained an active rodent at the time of excavation. A stone bowl was the only associated mortuary item for Feature 52. A fragment of this bowl was located on the left side of the face, with the rim edge facing down. If this represents the original placement of the bowl, then it had been inverted over the top of the head or face. Additional stone bowl fragments were recovered from the windrow and might have been from the same vessel. Two flaked stones were collected from the general feature fill.

Feature 56

Feature 56 was the relatively incomplete remains of an adult primary inhumation. The body was placed prone, or on the stomach, and was oriented to the southwest. The cranial remains were too incomplete to determine which direction the head actually faced. The pelvis, left femur, and right humerus and scapula were positioned with the posterior aspect up. The right humerus was extended and parallel with the body axis. Shaft portions of a tibia and fibula were located above the pelvic region. These two shaft pieces and another belonging to a femur, all of indeterminate side, were perpendicular to the alignment of the pelvis. Their arrangement and the absence of much of the skeleton are suggestive of postdepositional disturbance. The inhumation was determined to be an adult based on the general appearance of the bone present and a fully fused left acetabulum. Both sciatic notches were visible, although the left was slightly altered by ground pressure. The sciatic notches exhibited an intermediate expression, yielding an indeterminate sex estimation. No pathology was observed.

Overall, the human remains represented less than 25 percent of a complete skeleton. Aside from miscellaneous unidentifiable bone fragments and a tooth recovered from general fill, Feature 56 consisted of a portion of a cranial vault, part of a right scapula and shaft of the corresponding right humerus, the majority of both innominates and sacrum, and parts of femoral, tibial, and fibular shafts.

No pit or other formal ground preparation was observed. Rodent disturbance was noted, particularly in the northeast portion of the excavated area. The incomplete nature of the body and movement of shaft fragments from the legs suggested mechanical disturbance, possibly due to discing or plowing for agricultural-field preparation. It has been noted that the general site area was known to be under cultivation in historical and modern times. The feature fill was consistent with the surrounding matrix. Shells, flaked stones, and a worked stone bowl fragment were collected from the general feature fill. It is uncertain whether these artifacts were intended as burial inclusions or were part of the surrounding midden material.

Feature 61

Feature 61 consisted of the poorly preserved remains of a child, aged approximately one to three years at time of death. The position of a femoral shaft suggests a flexed position, with the body oriented north-west. The body was probably on the right side, facing south. Two long-bone shafts (humerus and femur) were recovered; however, no epiphyseal ends were preserved. The cranial vault was visible in cross section, and exhibited a unilaminar structure, allowing an age estimate of no more than three years. The dental remains were encased in the matrix in the skull. Due to the fragmentary condition of the cranium, the teeth and alveolar bone were left in situ and removed together. Later examination of the teeth may permit a more precise age estimate.

Less than 25 percent of a complete skeleton was represented. Identifiable bones included a portion of the cranial vault, teeth and teeth fragments, a fragment of possibly the left scapula and humeral shaft, and a shaft section of the right femur. Indeterminate bone fragments were also collected from the surrounding fill. No sex determination was possible for these remains, and no pathology was observed.

It was not possible to define a pit for this mortuary feature. Rodent, root, and insect activity were observed in the excavated area. One flaked stone was recovered from the general fill. No mortuary accompaniments were present with this inhumation.

Feature 62

Feature 62, a possible primary burial, included the disturbed and incomplete human remains of a probable adult. Preservation was considered poor, as the bone condition was fragmentary and incomplete. The few elements that were present indicated a body orientation towards the north. There were no cranial remains, and it was not possible to determine whether the body was flexed and lying on the right or left side, or in a supine position. The age estimate of adult for this individual was based on the appearance and density of the bone. A sex determination was not possible.

Less than 25 percent of the skeleton was present, and only part of that was identifiable. Identifiable elements included a scapula fragment, two humeral shafts, two shaft fragments from the lower arm (radii or ulnae), rib fragments, and a lumbar vertebra. Many tiny fragments of indeterminate unburnt bone were also collected from the feature fill and krotovina.

No pit or prepared area was seen in this highly disturbed feature. Prior mechanical agricultural field preparation, along with much rodent activity, had relocated, fragmented, and removed the skeletal elements belonging with this feature. No artifacts were collected with Feature 62.

Feature 64

Feature 64 represented the primary inhumation of an adult. The individual was tightly flexed and oriented north. The body position at discovery appeared to be on the right side; however, this might have been the result of postdepositional slumping from a more supine posture. The position of the skull, resting on its "base" and facing south, might have reflected a pit edge close to the back of the head, which supported the skull at the time of burial. Bone preservation was fair. Rodent disturbance had removed the facial region, and no mandible was present. The inhumation was determined a "possible" male based on the robusticity of the right supraorbital ridge, more suggestive of a male than female. No other cranial or postcranial attributes were preserved for observation, which would have permitted a more positive sex determination.

The identifiable elements represented less than 50 percent of a complete skeleton. The elements present included a portion of the cranial vault; rib fragments; shaft portions of both arms, both upper and lower elements; a small fragment of the left innominate and left femoral shaft; and much of the right upper and lower leg.

Vague pit boundaries were observed while excavating this feature, yet it was not possible to define the pit with certainty. Heavy rodent disturbance was noted during excavation, and redeposited, gnawed bone fragments were present throughout the feature fill. No associated artifacts were found with this burial feature.

Feature 65

Feature 65 consisted of a disturbed and incomplete primary inhumation. The body was interred either supine or on the right side, in a tightly flexed position and oriented to the west. The left arm was lying across the chest, and the right arm was articulated at the elbow and bent at a 90-degree angle, so that the hand (if it had been present) would have been placed below the right femur. The proximal portion of the left femur was articulated, with the left innominate tightly flexed, exposing the posterior aspect up. A shaft portion of the right femur was nearly parallel with the left femur, but had no corresponding innominate (likely missing because of rodent disturbance). A portion of the tibia shaft, of indeterminate side and with the posterior aspect facing up, was positioned between the right and left femora and somewhat under the left innominate. The placement of this element was probably the result of postdepositional settling or relocation. The cranial remains were too incomplete to indicate in which direction the head had faced. Due to the paucity of preserved bone, sex and age were indeterminate. The gracile nature of the bone, however, as well as a relatively thin cranial vault structure, suggested a possible young or subadult. No evidence of pathology was observed.

Overall, the remains represented less than 25 percent of a complete skeleton. Identifiable elements of the burial included a portion of the cranium, the left humerus, radius and ulna, the right arm, left femur and innominate, the right femur, a tibia, and two fragmentary lumbar vertebrae. The feature and the surrounding area contained numerous krotovina. In addition to rodent disturbance, prior mechanical activity had taken place. Below the modern ground surface and the plane of the latest grading activities, some elements had been moved and others removed. The cranium, which was beneath the level of recent discovery, appeared to have been previously sheared off, with only the posterior aspect of the vault remaining. The left humerus and the one tibia present appeared to have shifted also. Smaller elements, such as ribs, vertebrae, and the bones of the hand and feet were absent, possibly due to rodent activity.

No pit was identified during the excavation of Feature 65. Indeterminate bone fragments were collected from the disturbed feature fill. No associated burial inclusions were observed during recovery.

Feature 66

Feature 66 was identified as the partial remains of the primary burial of an adult female. The few elements present indicated the individual was placed in a supine position and oriented to the northwest, with the legs tightly flexed over the body, and the upper right arm extended parallel with the body. No cranial remains were present to indicate where the head had faced.

The postcranial remains consisted of less than 25 percent of a complete individual. Skeletal elements for this individual included the shaft of the right humerus, shaft portions of the right and left femora (posterior aspect facing up), fragments from lumbar vertebrae and the sacrum, and a portion of the right innominate (anterior facing up). The ilium exhibited a wide sciatic notch, allowing for a female sex determination. No pathology was observed for these few elements.

There was no evidence of a formal pit preparation. As with features already discussed, previous mechanical activity (perhaps for agricultural field preparation) removed much of this burial. Rodent burrowing had also considerably impacted the feature's integrity. Indeterminate unburnt bone fragments were recovered from nearby krotovina. A rectangular, undisturbed area remained, preserving the lower portion of the body and one associated artifact. An inverted abalone shell was located on the outer (west) side of the right innominate or hip area. Nearby mechanical activity exposed some abalone shell fragments and a piece of a broken stone bowl. It was uncertain whether these artifacts were directly associated with Feature 66 or were part of the general midden fill.

LAN-206A

Feature 100

Feature 100 consisted of a partial adult cranium; only the vault portion was retained. There was no facial region, dentition, mastoids, or associated mandible to provide additional information for age and sex determinations. One large vault piece was recovered along with other fragments that were located northeast in a linear fashion, as if dragged.

Overall, less than 25 percent of a human cranium was recovered. The density and general appearance of the bone were consistent with an adult age estimate. No pathology or trauma was observed.

No pit or formal burial preparation was identified. The human remains were discovered in an approximately 0.12-m deep, 0.80-by-0.20-m area, where old plow furrows were observed in the recently bladed surface. Following the removal of the cranial fragments, the surrounding area was intensively explored. No additional human remains were recovered. Whether this feature represented a heavily disturbed burial or evidence of relocation of part of a skull uncovered during plowing or other mechanical activities is unknown.

Summary

Overall, the preservation of the human remains was fair to poor. Bioturbation and historical-period or modern agricultural mechanical activities (such as plowing and disking) left little ground undisturbed at West Bluffs. Soil condition, combined with length of time in such an environment, also deteriorated the bone. Rodent disturbance was noted for all features, and some exhibited significant bone movement and gnawing. Features 475 and 480 were particularly affected by rodent activity; several small skeletal elements and fragments likely associated with those burials were recovered from nearby krotovina.

Osteological observations for the burials were understandably limited due to taphonomic factors. For some features, it was possible to determine age and sex. Preserved adult teeth exhibited heavy wear. Some evidence of pathology was preserved on Feature 480. Additional data may become available after laboratory cleaning and analysis. Of the 15 features thought to represent burials, 14 contained human remains. SRI recovered 10 adults, 1 possible adult, 1 sub- or young adult, and 2 children from the three sites. One of the child burials (Feature 492) included an adult clavicle fragment in the rodent-disturbed feature fill. Sex determination was possible for 4 burials. We identified 1 male, 1 possible male, and 2 possible females; 10 burials were indeterminate.

Information about mortuary behavior was limited. Body position was identifiable for 10 features: 8 burials were in a flexed position, 1 was prone, and 1 appeared to be a secondary burial. Another burial might have been a secondary deposit, but rodent disturbance had obliterated identification of body placement. One feature retained no identifiable body position, and two features consisted only of cranial remains. Mortuary accompaniments were limited, likely due to preservation and taphonomic factors. Shells and flaked stone were present in the general fill for several of the features. Five features contained clearly associated mortuary items. Abalone shells had been placed with two individuals (Features 66 and 492), and asphaltum nodules with one (also Feature 492). A piece of a stone bowl covered part of the facial area of Feature 52. A carved steatite object was in proximity to the disturbed remains of Feature 475. Feature 480 included a small piece of red ochre. No organic remains or impressions, such as textiles or baskets, were observed. Only one feature, Feature 43, was located in a clearly discernable pit. No other features retained any identifiable subsurface preparation.

Isolated Human Remains

Small quantities of bone were also collected from nonburial features, test pits, and other isolated contexts. This material was identified in the laboratory as human or nonhuman, and analyzed for any information about age and sex, pathology, or cultural modifications such as burning.

LAN-63

The majority of bone from LAN-63 that was not associated with primary burial features came from Feature 587. Most of this bone had been burnt. Bone fragments from isolated contexts are listed in Appendix L. Due to the absence of diagnostic features on any of the isolated small bone fragments, however, no demographic characteristics or pathological conditions could be gleaned from these isolated remains. In Feature 587, a minimum of three individuals could be identified, based on sex or age determinations. All three of these individuals were identified based on single elements, rather than more extensive remains.

LAN-64

Several burial features from LAN-64 also contained bone that displayed evidence of burning. Small quantities of calcined bone were recovered from fill from Features 52, 62, and 64–66. These bone fragments were primarily white or mottled brown and white.

As none of the primary burials displayed any evidence of burning, the calcined bone fragments identified from the burial feature fill from Features 52, 62, and 64–66 appear to be from a different individual or individuals. All bone fragments appeared to be from adult individuals. As the assemblage contained no whole bones or distinctive elements such as articular surfaces, and no obvious age or size differences were apparent, identification beyond bone or general skeletal element (long bone, cranial vault) was generally not feasible. Given these constraints, there was no evidence of any repetitive elements that would indicate more than one individual present. Therefore, the additional MNI for the burial cluster is calculated at one for each of the features (assuming the calcined bone fragments represents a different individual from the primary burials).

Likewise, none of the isolated human bone fragments from nonfeature contexts (listed in Appendix L) contained any diagnostic age or sex information, nor was there any indication of repetitive skeletal elements which could aid in determining the MNI in the assemblage. All bone fragments appeared to be from adult individuals.

LAN-206A

A small amount of human bone from isolated (point-provenienced) contexts was found at this site. This material was identified as being human (based on long-bone fragments) or probably human in origin.

Summary

In conclusion, the small amounts of bone fragments from isolated contexts could provide little additional information about demography or pathological conditions for the West Bluffs population. Although the skeletal element of fragments could often be identified, the lack of other diagnostic criteria made it impossible to assess the number of additional individuals (if any) present at any of the three sites. The preservation of burnt and unburnt bone fragments differed, however. The unburnt bone fragments displayed a highly friable texture, similar to the majority of the burial features at the three sites. Due to the cremation process, however, the burnt bone tended to occur in larger pieces, and its hard surface texture rendered it more easily observable.

Age Determination

Determination of each individual's age at death was made difficult by the incompleteness of the West Bluffs burials and the extensive fragmentation of the bone that was preserved. Often, only cortical bone thickness and other bone-size indices could classify the individual as an adult or subadult (see Table 13.1). No pubic symphyses or auricular surfaces were available for age estimations based on the age-related changes in these features. For several individuals (Features 61, 475, and 587), the presence of incompletely formed teeth allowed a precise age estimate based on tooth-development standards.

For a few additional individuals (burial features 480 and 600), the presence of worn molars adjacent to each other allowed us to calculate ages based on what is known about tooth wear rates among Native Americans from ancient southern California populations. Wear rates calculated for a large sample of human remains from Channel Island–area archaeological sites provided a basis for such estimates (Tables 13.5 and 13.6). The difference between the sum of the Scott (1979) wear scores for adjacent molars (M^1-M^2, M^2-M^3, M_1-M_2, M_2-M_3) provide an index of the amount of wear that occurred during the approximate six-year interval between the eruption of these adjacent molars. The averages of these values for individuals in Channel Island–area skeletal collections showing the expected wear gradient (M1>M2, and M2>M3) were used for wear-rate constants in equations with the following formula:

$$\text{Age in years} = ((\text{WS} - 4) / \text{K} \times 6) + \text{EA}$$

where *WS* is the sum of the Scott wear scores for the four quadrants of an individual's molar; *K* is the wear-rate constant (see Table 13.5), empirically derived by averaging the differences between wear-score sums of adjacent teeth (M1-M2 and M2-M3) for individuals in the Channel Island–area sample, in which M1 > M2, and M2 > M3; and *EA* is the age at which the appropriate tooth erupts (M1 = 6 years, M2 = 12 years, M3 = 18 years).

In the equation, 4 is subtracted from an individual's wear score because a person with an unworn tooth in the Scott system receives a total score of 4. In the equation, (WS – 4)/K is multiplied by 6 because (WS – 4)/K is the number of six-year wear increments estimated to be represented by an individual's WS value. EA is added to this value because the eruption age is the age at which the tooth in question begins to accumulate wear. The values of K calculated for M1-M2 were used in the equations employed to estimate ages for M1 and M2, and the values of K calculated for M2-M3 were used in the equations employed to estimate ages for M3. The results of these calculations are presented in Table 13.7.

Sex Determination

Highly diagnostic, sexually dimorphic structures such the pubic bones were not preserved in any of the West Bluffs burials. As a result, we were forced to use such less reliable sex-determination criteria as sexually dimorphic cranial traits (only a few individuals retained these) and long-bone dimensions. Logistic regression was used to develop equations that allowed long-bone measurements to assist in sex determination (Tables 13.8, 13.9, and 13.10). These equations were generated using data from the burials excavated at the Malibu cemetery (LAN-264), where the sexes could be determined based on pelvic morphology (Gamble et al. 2001; Walker et al. 1996). In the logistic regression analysis, the "pelvic sex" of these individuals was considered to be the "known sex," and various combinations of long-bone dimensions in the West Bluffs burials were then used as the independent variables for predicting the pelvic sex. These equations were then applied to the West Bluffs data set to obtain probability estimates that a specific individual was a female. Individuals with a probability of being female lower than 0.5 were considered to be likely males, and individuals with a probability estimate greater than 0.5 were considered to be likely females.

The Malibu collection used in this analysis consisted of individuals dating to the late Middle period component (A.D. 900–1100) and derived from an area historically occupied by Chumashan-speaking people who interacted with Uto-Aztecan–speaking people to the south. Owing to the uncertainty concerning the population affinities of the people buried at West Bluffs, it is possible that the pattern of sexual dimorphism in the West Bluffs population differed in some respects from that of the people buried at Malibu. We have reason to believe, however, that sexing errors stemming from this source are unlikely to be great. In our experience, the patterns of sexual dimorphism among the Native Americans who lived in southern California are similar to each other, regardless of their linguistic affinities.

Dental Data

Owing to the preservation problems mentioned above, the teeth provided some of the most useful information. Teeth are comparatively resistant to disintegration in the ground and often were preserved in the West Bluffs project burials when little else remained of the individual's skeleton. A total of 25 measurable teeth were recovered from five different features (Features 480 and 600 in LAN-63, and 43, 52, 64 in LAN-64) and additional general site proveniences. Additional unmeasurable tooth fragments were recovered from Features 475 and 587. Many of these teeth and tooth fragments were found in isolation because of the disintegration of the alveolar bone that once held them.

Tooth Wear

Differences between the wear scores of adjacent molars provide an index of the rate of tooth wear. This is because the first molar erupts and begins to wear at about the age of 6, whereas the second molar erupts six years later, at about 12, and the third molar erupts six years after that, at about 18. The differences in wear among the molars, therefore, provides information on the rapidity of wear. If wear rates are low, the average difference between the wear scores of the first and second molars and the second and third molars will also be small. If wear rates are high, the first molar will show much more wear than the second molar and the difference between their wear scores will be large (Walker 1996; Walker et al. 1991).

Because only two of the West Bluffs burials were well enough preserved to allow wear-rate calculations, meaningful statistical comparisons with other prehistoric Native American populations in southern California were impossible. The severity of wear seen in these two individuals, however, was consistent with that seen in a large sample of native Californians from the Santa Barbara Channel area sites: the wear-score difference between the first and second mandibular molars of the West Bluffs Feature 480 burial was 9, and the wear-score difference between the first and second maxillary molars of the West Bluffs Feature 600 burial was 7. These values were higher than the average values for maxillary (6.05, n = 569) and mandibular (5.35, n = 698) wear-score differences seen in individuals from other Santa Barbara Channel area sites with expected gradient of a M1 wear score greater than that of the M2 (see Table 13.5). When compared statistically using the Kruskal-Wallis one-way analysis of variance, the West Bluffs project values did not differ significantly from the Santa Barbara Channel area values as a whole (M^1-M^2: $\chi^2 = 0.55$, $p = .34$; M_1-M_2: $\chi^2 = 1.86$, $p = .17$).

Patterns of wear on the incisors and canines provided information on use of the anterior teeth in activities such as basket making, net making and other craft activities. Unfortunately, the only well-preserved anterior teeth were from the Feature 43 burial. Although this person had heavily worn anterior teeth, the absence of posterior teeth from this individual made any conclusions about a high wear rate of the anterior teeth relative to the posterior teeth impossible. No grooves or other unusual wear facets sometimes seen in the teeth of ancient Native Californians (Buzon et al. 2003; Schulz 1977) and associated with specialized activity patterns are present in this individual.

Dental Pathology

The heavy wear and poor preservation of the teeth in the West Bluffs sample reduced our ability to detect carious and hypoplastic lesions. One molar in the small West Bluffs dental sample, however, exhibited a carious lesion and is, perhaps, an indication that carious lesions were common in the West Bluffs area population.

Odontometrics

The 25 measurable teeth from the West Bluffs collection provided a limited basis for odontometric comparisons (Table 13.11). Odontometric analysis is useful for examining genetic variation between populations. Two measurable maxillary third molars were recovered during the archaeological work. For all other tooth types, only one measurable specimen was available for metrical analysis. Any statistical comparisons at the population level, therefore, were impossible.

The average molar diameters of these West Bluffs individuals tended to be larger than the averages found in a series of Middle and historical-period burials from Malibu (Table 13.12). One-sample *t*-tests showed that several of the dimensions of the molars of the Feature 43 burial and one dimension of the Feature 600 burial were significantly larger than would be expected by chance using the conventional probability of < .05 (Table 13.13). Finding several significant differences, based on comparisons of the Malibu samples with a single individual was not unexpected because molar dimensions are strongly correlated with each other. If one tooth in a dentition is large, the other teeth are likely to be proportional in size. The significance of these size differences was unclear; they could simply have been a sampling error relating to the sexual composition of the West Bluffs sample (male molars tend to be larger than those of females). Also, the probability of getting a significant result increases with the number of tests done. One out of 20 *t*-tests on samples from the same population can be expected to result in a significant result by chance using $p < .05$ as a significance level. Given the 18 *t*-tests performed, one of them could conceivably have been significant owing to this problem.

These statistical differences at least suggested that the teeth of some of the people in this population were comparatively large. This finding could conceivably have been related to the temporal provenience of the West Bluffs sample: in southern California, tooth size tends to decrease between the Early and Late periods (see the historical period vs. Middle period Malibu tooth dimensions in Table 13.12). Alternatively, the evidence for large tooth size could have been a population-specific characteristic related to the selective pressures experienced by a population experiencing high tooth-wear rates.

Mortuary Practices

Information on mortuary practices was compiled from field notes and burial forms. Owing to surface disturbance and poor preservation, it was not possible to determine the original burial position for every feature. Of the burials whose position could be determined with some certainty, all were buried in a flexed or semiflexed position (see Table 13.2). Two burials, both from LAN-63, displayed considerable disarticulation, suggestive of possible secondary burial. Because both of these burials occurred in highly disturbed contexts, however, the excavators noted that originally the burial could have been in a flexed position. Orientation of the head, when discernable, tended to be toward the north. At LAN-64, five burials had their heads oriented towards the north and the head of another was oriented to the west. At LAN-63, the head of one burial was oriented towards the north and another was oriented to the west (see Table 13.2). This tendency for burials to have a northern orientation is consistent with the pattern seen at the Dayton Canyon cemetery (LAN-254), which is also in the Gabrielino territory, as well as cemeteries in the Santa Barbara Channel area where northern and western burial orientations tend to dominate (Buzon et al. 2003; Walker and Lambert n.d.). Out of the 14 West Bluffs burial features, two burials (Features 43 and 64) were associated with evidence of burial pits, most clearly discernable around Feature 43. The other 12 individuals appeared to have been interred directly into the surrounding midden and this obscured the outline of any burial pit that might have been present.

Cremated Bone

A small proportion of the human bone analyzed showed evidence of burning (see Table 13.3; Appendix M). Almost all of the burnt human bone was recovered from Feature 587 at LAN-63. Feature 587 was an extremely large feature containing ground stone and large-mammal bones, as well as isolated pieces of burnt human bone. It is possible that some of this material was inadvertently burned by fires on the site after the interment of an uncremated body. Considering the archaeological context, however, and that at the time of European contact, cremation was widely practiced by Native Americans in southern

California, including the Gabrielino/Tongva (Gould 1963; Kroeber 1976), it seems likely that intentional cremation explains the condition of most, if not all, of these burnt human remains.

When recording burnt bones, in addition to making the usual observations made about unburnt skeletal remains, we recorded color variation on the external and internal surfaces of each fragment. Many specimens exhibited a variety of colors owing to uneven heat exposure. To facilitate comparisons with previous studies, a subjective assessment was made of the range of colors (black, white, and brown). Because recording the color of the specimens photographically was prohibited, the Pantone (2001) color standards were used to record color variation. Because the external and internal surface colors often differed, they were recorded separately. One or two Pantone colors and the percentage of the surface that the assigned color occupied were recorded for each surface (see Appendix M).

The burnt remains from LAN-63 identified as human with varying degrees of certainty (definitely human, probably human, and possibly human) consisted of 93 bone and tooth fragments weighing a total of 265 grams. The average weight of the highly calcined cremated remains of an adult produced by a modern crematorium is 2,430 grams (Warren and Maples 1997), so the material recovered from LAN-63 constituted only about one-tenth of the amount expected from the cremation of an adult. It was difficult to make many inferences from the distribution of body parts represented in the burnt-bone collection (see Table 13.3), because it was heavily weighted toward elements such as teeth and cranial fragments (83 percent of the total weight) that bear distinctive anatomical features characteristic of our species.

The cremated bones from Feature 587 included adult and subadult remains, so at least two individuals were represented in the collection. The adult remains consisted of many cranial vault and tooth fragments and phalanges from the hand and foot. It is likely that at least one male and one female were represented in these remains. A frontal bone fragment showed a gracile morphology suggesting a female, and another cranial vault fragment was notably thick, a condition more often seen in males. The lack of fusion of a small sutural segment preserved in this specimen suggested that these are the remains of a comparatively young adult. Subadult remains included a premolar with an incompletely formed root and a fragment of a humeral epiphysis. The development of the premolar suggests that the child was between 6 and 9 years old at the time of death. The only pathological condition in the cremated remains was a carious lesion in a fragmentary maxillary molar.

The color variation present in the human bone provided some clues to the method used for cremation (Table 13.14). The color of burnt bone depends on several cremation-environment variables. The most important of these are the availability of oxygen during cremation, the duration of cremation, and the temperature (Walker and Miller 2005). Burning at high temperatures for a prolonged period in the presence of ample oxygen produces a white "calcined" bone. Burning in a reducing environment where little oxygen is available can produce a black bone, even at fairly high temperatures. As the duration of cremation increases, however, the influence of oxygen availability on bone color gradually diminishes (Walker and Miller 2005). Dark brown bones result from shorter exposures to heat at lower temperatures. Bones with a mottled appearance have been exposed to an irregular cremation environment in which a variety of the above conditions existed.

The burnt human bones from LAN-63 exhibited a range of colors, which suggested cremation environments in which exposure to heat and oxygen, as well as the duration of the process, varied markedly (see Table 13.14). The largest proportion of bones—both by weight (37 percent) and count (40 percent)—were uniformly black. A similar pattern has been found elsewhere in southern California, at LAN-840, where a large proportion of the bones of individuals in what appeared to be a mass cremation were uniformly black (Walker and Wheeler 1988). This was interpreted as indication that the cremation took place in a reducing environment, perhaps analogous to an earth-covered oven. LAN-63 also contained a fairly large proportion of white calcined bone (21 percent by weight, 24 percent by count) so, at times, high temperatures and ample oxygen had been available during the cremation process. The remainder of the bones were either brown (14 percent by weight, 12 percent by count) or multicolored (30 percent by weight, 25 percent by count). One caveat regarding the interpretation of these relative frequencies of bones of different colors is that cremation markedly increases the resistance to the disintegration from bacterial activity. This is especially true of highly calcined bones because they are devoid of the collagen upon which bacteria thrive. Calcined bones would thus be expected to be over-represented in the collection in comparison to their relative frequency at the time of cremation.

Conclusions and Synthesis

In this report, we have provided bioarchaeological data on human skeletal remains from archaeological sites in the West Bluffs area. Our goal was to obtain as much data as possible for use in determining the population affinities, health status, and lifeways of the people whose remains were recovered from these sites. The small number of individuals represented in these collections (a minimum number of 17 individuals) and the poor preservation and incompleteness of the remains that were preserved limited the inferences that we could make. Nevertheless, a number of important findings are suggested by our research.

The information we have obtained on the mortuary practices of the people who interred their dead at these sites is of considerable archaeological interest. Three very different mortuary patterns were observed. The bodies of some deceased individuals were buried in the flexed position that was typical of many Native Californian societies. Other West Bluffs burials displayed considerable disarticulation, which is suggestive of another common Native Californian mortuary practice; often, especially in the period just before European contact, Native Californians disinterred the remains of deceased individuals after a period of time and reinterred the skeletonized remains in a smaller grave. Some tribes, such as the Pomo, customarily buried cremated remains of important individuals and children, disinterred them, and then reburied them as part of mourning rituals (Loeb 1926). Usually, however, disinterment and reburial was a practice reserved for inhumations. Although the motivations for this practice are unknown, it seems likely that the desire to bury related individuals at a specific burial area was often a decisive factor motivating the disinterment and reburial of inhumations. Through time, such desirable burial plots would become filled with earlier burials and, if expansion of the plot was impossible or considered culturally inappropriate, the only alternative would be to disturb the remains of people who had been buried at an earlier time.

If this hypothesis is true, then the remains of disturbed burials should predate those with articulated bones. An alternative interpretation is that the disturbed burials reflect looting, agricultural, or industrial activities that occurred at the sites during recent times. Burials at LAN-63 were generally deep and most likely were not disturbed by historical-period activity (save Feature 617, which was certainly in a disturbed context). The burials at LAN-64 generally were close to the surface, which might have allowed damage by mechanical plowing at the site. The same was true for the single locus of human remains at LAN-206A; there, excavators noted plow scars and assorted historical-period or modern trash associated with the burial.

A third mortuary pattern is suggested by the small proportion of the human bone from West Bluffs showing evidence of burning. Although human remains are sometimes burned inadvertently (for example, by campfires built in burials areas), the extent of the burning and archaeological context of the burning exhibited by the remains we examined provided clear evidence of intentional cremation. Almost all of this material was found in Feature 587, a very large concentration of ground stone artifacts. This archaeological context was very reminiscent of the pattern found by E. F. Walker (1952) at archaeological sites elsewhere in Los Angeles County. Cremation and inhumation both were practiced in the Gabrielino/Tongva territory (Gould 1963; Kerr et al. 2002; Kroeber 1976) and, at present, the exact chronological sequence and pattern of co-occurrence of these burial patterns is unclear. Cremation seems to be associated with the appearance of Uto-Aztecan speaking people in the area during the latter part of the Late period. The Southern Channel Islands are an exception; there, inhumation was the dominant mortuary practice during all periods (Bean and Smith 1978; Titus and Walker 2000).

Many of the bones were white, which suggested temperatures in excess of 500°C. A significant amount of fuel would have been needed, and a long duration of burning, to achieve this temperature (Shipman et al. 1984; Walker and Miller 2005).

The social significance of the presence of both inhumations and cremations in the West Bluffs area collections is unclear. In some California Indian societies, cremation of the dead seems to have been associated with wealth and high social standing (King 1970). This inference is based on the location of cremations in the central parts of cemeteries and their association with large amounts of grave goods in comparison to inhumations. In other California Indian groups inhumation was reserved for those who died close to home and cremation was used as an expedient measure to facilitate the transportation of relatives who died in a distant place (Essene 1942; Myers 1978). In other groups, such as the mainland Tongva/Gabrielino, cremation was the normal method used for disposal of the dead (Bean and Smith 1978). In the case of the West Bluffs cremations, the recovery of cremated bones from both adults and children suggested that this practice was not only for people who had acquired high social standing through their adult activities and is an indication that whatever status implications cremation might have had extended to all members of the social group.

Owing to the poor preservation of the West Bluffs skeletal remains, few metric and paleopathological observations were possible. This preservation problem limited our ability to explore the health status and genetic affinities of these people. Owing to their durability, the teeth provided some of the most useful information in this regard. The tooth-wear rates estimated for two individuals suggested a diet of highly abrasive food that produced wear similar to that seen in the Native Californians who lived in the Santa Barbara Channel area (Walker 1978; Walker and Erlandson 1986).

The heavy tooth wear tended to reduce the frequency of carious lesions (Meiklejohn et al. 1992). Nevertheless, the small West Bluffs dental sample included a molar with a carious lesion. It is unwise to make far-reaching conclusions based on a single pathological lesion. If this was an indication that dental caries were common among these people, however, then it suggests that they had a cariogenic, plant-based diet with a high carbohydrate content (Walker and Erlandson 1986; Walker and Hewlett 1990; Walker et al. 1995).

The teeth of the West Bluffs sample also provided some data on the population affinities of these people. The large molars of two individuals with measurable teeth contrasted with the smaller teeth of people living to the north at the Malibu site. These two populations were generally contemporary. Although making far-reaching conclusions based on this difference is unwise, it suggested the possibility of a genetic difference between the people buried in the West Bluffs area and the Chumashan speaking people to the north.

The postcranial remains provided additional evidence concerning the health status and lifeways of these people. Several of the joint surfaces showed evidence of osteoarthritic lipping, an age-related condition that, to some extent, reflected the wear and tear on joint surfaces from daily activities (Walker and Hollimon 1989). Given the small number of observations and the age-dependent nature of these lesions, it is difficult to determine the significance of these findings. The lesions at least suggested that arthritis was present in this population. One individual showed evidence of a mild inflammatory reaction in the tissues surrounding a long bone (osteoperiostitis). Such lesions can develop as a result of a variety of health problems, including systemic infection and local trauma (Lambert 1993; Walker et al. 2005). Again, we do not know how common such conditions were in the West Bluffs area population, but they were present.

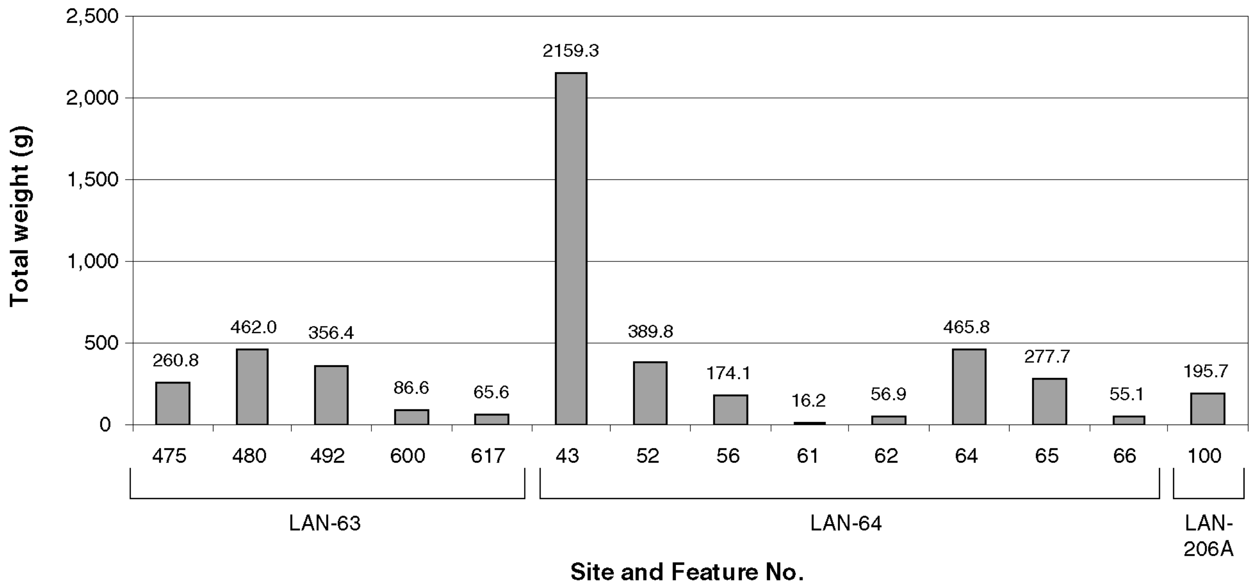


Figure 13.1. Total weight of unburnt human bone recovered from West Bluffs features.

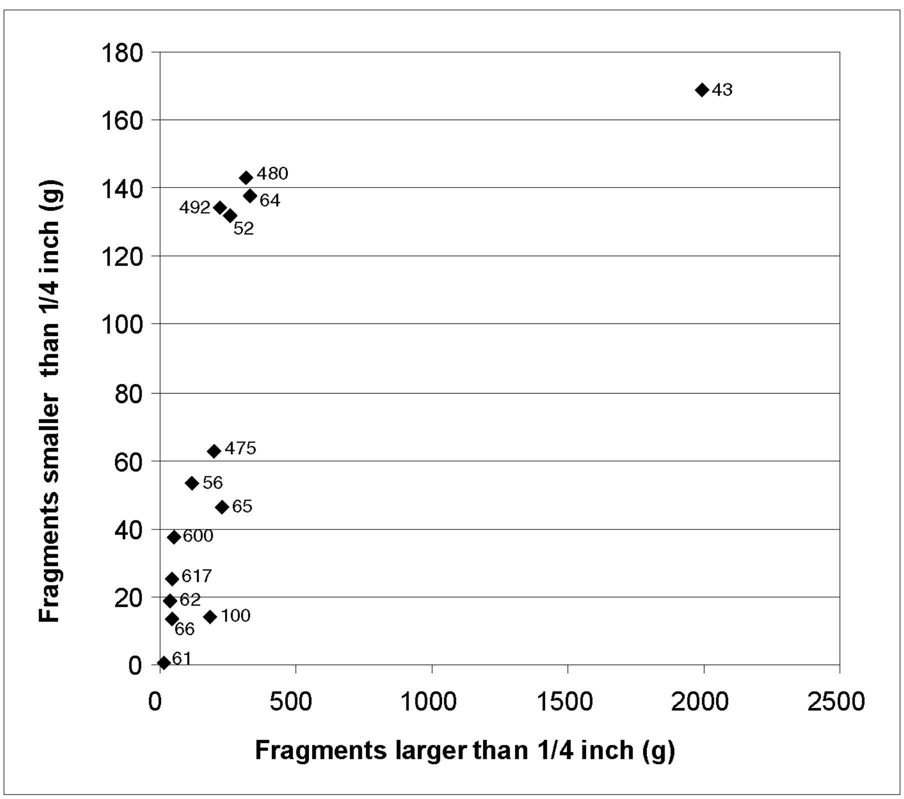


Figure 13.2. Distribution of weights of human bone from West Bluffs burial features captured by and passing through a ¼-inch screen.

Table 13.1. Summary of Age and Sex Determinations

Site Feature	Age	Sex	Aging Criteria	Sexing Criteria
LAN-63				
475	5-year-old child	unknown	upper 4th premolar crown was 90% complete	unknown due to immaturity
480	middle-aged to older adult	unknown	heavy tooth wear and arthritic lipping	—
492	adult	unknown	long bone dimensions	—
587	adult	female	Skeletal dimensions	frontal bone morphology
587	young adult	male?	open cranial suture	size of cranial fragment
587	5–7 year old	unknown	root is just beginning to form on premolar	—
600	adult ca. 29–35 years old	female?	tooth wear and long bone dimensions	long bone dimensions
617	adult	unknown	cranial morphology	—
LAN-64				
43	adult	female	tooth wear, suture closure	long bone dimensions
52	adult ca. 35 years old	probable male	tooth wear and skeletal dimensions	nuchal crest
56	adult	probable female	long bone dimensions	long bone dimensions
61	child 1–3 years old	unknown	tooth development	unknown due to immaturity
62	adult	possible female	skeletal dimensions	gracile ulnar fragment
64	adult older than 30	possible male	third molar wear	development of glabella and supra-orbital ridge
65	adult	unknown	long bone dimensions	somewhat gracile long bones, long bone dimensions ambiguous
66	adult	female	long bone dimensions	wide sciatic notch
LAN-206A				
100	middle-aged adult	probable male	partial sagittal suture closure	mastoid process and nuchal crest

Table 13.2. Summary Information in the Positions of the West Bluffs Burials from Burial Feature Contexts

Site Feature	PD No.	Bone	Burial Position	Head Orientation	Head Facing	Legs/ Arms	Burnt Bone
LAN-63							
475	4068	cranium	disarticulated	unknown	unknown	unknown	yes
480	4078	—	flexed	west		bent	yes
492	4106	pedal phalange	disarticulated	unknown	—	—	no
600	4466	miscellaneous unidentified	flexed	north	—	bent?	no
617	4475	cranium	head only	unknown	southwest	—	no
LAN-64							
43	1194	cranial	semiflexed?	north (24°mN)	east	bent	yes, faunal
52	1252	cranial	side flexed	north	forward	bent	yes
56	1260	cranial	prone	south-southwest	unknown	—	no
61	1350	cranial	semiflexed?	unknown	—	—	no
62	1447	long bone	indeterminate	possibly north	—	—	no
64	1478	cranial	flexed, on right side	north	west	bent	yes, small amount
65	1476	cranial	flexed?	west	unknown	—	yes
66	1503	long bone	flexed	possibly north (no head)	—	unknown	yes
LAN-206A							
100	2025	cranial	head only	?	—	—	no

PD = provenience designation

Table 13.3. Cremated Human Bone from LAN-63 and LAN-64

Site / Body Part	Identification	n	Weight (g) Mean	s	Minimum	Maximum
LAN-63						
Cranium	Human	28	4.2	5.5	0.1	21.6
	Probable Human	28	2.6	2.9	0.3	10.7
	Possibly Human	3	9.3	9.8	0.9	20.0
	Subtotal	59	3.7	4.8	0.1	21.6
Tooth	Human	7	0.6	0.3	0.2	0.9
	Subtotal	7	0.6	0.3	0.2	0.9
Hand/Foot	Human	6	0.7	0.7	0.1	1.8
	Subtotal	6	0.7	0.7	0.1	1.8
Long Bone	Human	4	3.8	3.4	0.3	8.4
	Probable Human	2	3.3	3.5	0.8	5.7
	Possibly Human	5	1.4	0.3	1.0	1.7
	Subtotal	11	2.6	2.5	0.3	8.4
Post-cranial	Probable Human	2	4.1	1.1	3.3	4.9
	Possibly Human	1	0.4		0.4	0.4
	Human	1	2.0		2.0	2.0
	Subtotal	4	2.7	1.9	0.4	4.9
Miscellaneous/ Unidentified	Human	3	0.2	0.2	0.0	0.4
	Probable Human	3	0.1	0.0	0.1	0.1
	Subtotal	6	0.1	0.1	0.0	0.4
LAN-64						
Cranial	Probable Human	1	—	—	—	—
Post-cranial	Human	17	—	—	—	—
Miscellaneous/ Unidentified	Human	4	—	—	—	—

Table 13.4. Weights of Non-Burned Human Skeletal Remains Recovered from West Bluffs Project Features

Site	Weight of Fragments (g)		Total Bone Weight (g)	Fragments > 1/4 inch		
Feature	> 1/4 inch	< 1/4 inch		Weight (%)	Count	Average Weight
LAN-63						
475	197.9	62.8	260.8	75.9	142	1.4
480	319.1	142.9	462.0	69.1	169	1.9
492	222.3	134.1	356.4	62.4	105	2.1
600	49.0	37.7	86.6	56.5	100	0.5
617	40.6	25.0	65.6	61.9	32	1.3
LAN-64						
43	1990.7	168.6	2159.3	92.2	86	23.1
52	257.8	132.0	389.8	66.1	98	2.6
56	121.0	53.1	174.1	69.5	102	1.2
61	15.7	0.5	16.2	96.9	17	0.9
62	38.3	18.6	56.9	67.3	55	0.7
64	328.0	137.8	465.8	70.4	213	1.5
65	231.2	46.5	277.7	83.3	170	1.4
66	41.3	13.7	55.1	75.0	20	2.1
LAN-206A						
100	181.8	14.0	195.7	92.9	88	2.1

Table 13.5. Mean Wear-Score Differences for Burials from the Santa Barbara Coast and Channel Island Area

Wear-Score Difference *(K)*	n	Mean	S.D.
Mandibular			
M_1-M_2	754	5.0	3.1
M_2-M_3	540	5.8	2.8
Maxillary			
M^1-M^2	555	5.9	4.1
M^2-M^3	338	5.5	4.2

Note: n = the total size of the sample from all sites.
These values are derived from observations made on skeletal material from the following sites: SBA-60, n = 264; SBA-52, n = 54; LAN-254, n = 5; SBA-17, n = 16; SBA-46, n = 100; SBA-46A, n = 46; SBA-7, n = 22; SBA-81, n = 38; SBA-142, n = 4; SBA-1C, n = 2; SBA-1D, n = 2; SBA-205, n = 2; SBA-28, n = 4; SBA-378, n = 2; SBA-46, n = 20; SBA-48, n = 4; SBA-485, n = 6; SBA-53, n = 6; SBA-71, n = 8; SBA-78, n = 6; SCRI-100, n = 144; SCRI-3, n = 66; SCRI-83, n = 90; SOL-357, n = 186; SRI-2B, n = 124; SRI-41A, n = 88; SRI-5A, n = 6; SRI-60, n = 14; SRI-9A, n = 6; SRI-3, n = 68.

Table 13.6. Tooth Wear Scores for West Bluffs Project Burials

Jaw	LAN-63 Features		LAN-64 Features			Nonfeature Contexts
Side, Tooth	600	480	52	64	43	
Maxilla						
R, C	—	—	—	—	7	—
R, P3	—	—	—	—	7	—
R, P4	—	—	—	—	7	—
L, P3	—	—	—	—	6	—
L, P4	—	—	—	—	7	—
L, M1	27	—	—	—	—	—
L, M2	20	—	—	—	—	—
L, M3	20	—	22	—	—	—
Mandible						
L, P4	6	—	—	—	—	3
R, M1	—	26	—	—	—	—
R, M2	—	17	—	—	—	—
L, M3	—	—	—	23	—	—

Note: The values for the anterior teeth follow Smith (1984). The values for the molars are the sums of the Scott (1979) scores for each quadrant of a molar.

Table 13.7. Age Estimates in Years Based on Individual Molar Wear Scores of West Bluffs Project Burials and the Wear Constants *(K)*

Jaw	LAN-63				LAN-64				Wear-Rate Constant *(K)*
	Feature 600		Feature 480		Feature 52		Feature 64		
Tooth	Wear Score	Age Estimate	Wear Score	Age Estimate	Wear Score	Age Estimate	Wear Score	Age Estimate	
Maxilla									
M^1	27	29.4	—	—	—	—	—	—	5.9
M^2	20	29.5	—	—	—	—	—	—	5.5
M^3	20	35.5	—	—	20	35.5	—	—	5.5
Mandible									
M_1	—	—	26	32.4	—	—	—	—	5.0
M_2	—	—	17	25.4	—	—	—	—	5.8
M_3	—	—	—	—	—	—	23	31.7	5.8
Mean Age Estimate	—	31.4	—	28.9	—	35.5	—	31.7	—

Note: The equations used in this table are described in the text.

Table 13.8. Definitions of Post-Cranial Measurements Made on the West Bluffs Project Skeletal Remains

Variable Name (No.)	Skeletal Element	Measurement	Measurement Definition
HMSAP	Humerus	Minimum Midshaft Anteroposterior Diameter	The distance between anterior and posterior surfaces measured at the midpoint of the diaphysis measured to the nearest whole millimeter. This is the sagittal diameter and should be measured perpendicular to the anterior surface of the elbow.
HMSML	Humerus	Minimum Midshaft Mediolateral Diameter	Instrument: Sliding caliper. Comment: Determine the midpoint of the diaphysis on the osteometric board and mark with a pencil. Record minimum diameter wherever it occurs.
HDELAP	Humerus	Deltoid Anteroposterior Diameter	Anteroposterior diameter of the humerus at the level of the deltoid insertion.
HDELML	Humerus	Deltoid Mediolateral Diameter	Mediolateral diameter of the humerus at the level of the deltoid insertion.
HDELCI	Humerus	Deltoid Circumference	Circumference of the humerus at the level of the deltoid insertion.
UMSAP (49)	Ulna	Anteroposterior Diameter	Maximum diameter of the diaphysis where the crest exhibits the greatest development in Anteroposterior plane. Instrument: Sliding caliper.
UMSML (50)	Ulna	Mediolateral Diameter	Distance between medial and lateral surfaces at the level of greatest crest development. Instrument: Sliding caliper. Comment: Taken perpendicular to Anteroposterior diameter.
FMAXLEN (60)	Femur	Maximum Length	Distance from the most superior point on the head of the femur to the most inferior point on the distal condyles. Instrument: Osteometric board. Comment: Place the medial condyle against the vertical end board while applying the movable upright to the femoral head.
FSTML (64)	Femur	Anteroposterior Subtrochanteric Diameter	Distance between anterior and posterior surfaces at the proximal end of the diaphysis, measured perpendicular to the Mediolateral diameter. Instrument: Sliding caliper. Comment: Be certain that the two subtrochanteric diameters are recorded perpendicular to one another. Gluteal lines and/or tuberosities should be avoided.
FSTAP (65)	Femur	Mediolateral Subtrochanteric Diameter	Distance between medial and lateral surfaces of the proximal end of the diaphysis at the point of its greatest lateral expansion below the base of the lesser trochanter. Instrument: Sliding caliper.
FMSAP (66)	Femur	Anteroposterior Midshaft Diameter	Distance between anterior and posterior surfaces measured approximately at the midpoint of the diaphysis, at the highest elevation of linea aspera. Instrument: Sliding caliper. Comment: The sagittal diameter should be measured perpendicular to the anterior bone surface.
FMSML (67)	Femur	Mediolateral Midshaft Diameter	Distance between the medial and lateral surfaces at midshaft, measured perpendicular to the Anteroposterior

Variable Name (No.)	Skeletal Element	Measurement	Measurement Definition
			diameter. Instrument: Sliding caliper.
FMSCI (87)	Femur	Midshaft Circumference	Circumference measured at the level of the midshaft diameters. If the linea aspera exhibits a strong projection which is not evenly expressed across a large portion of the diaphysis, then this measurement is recorded approximately 10 mm above the midshaft. Instrument: Metal tape.
TNFAP (72)	Tibia	Maximum Diameter at the Nutrient Foramen	Distance between the anterior crest and the posterior surface at the level of the nutrient foramen. Instrument: Sliding caliper.
TNFML (73)	Tibia	Mediolateral diameter at the Nutrient Foramen	Straight line distance of the medial margin from the interosseous crest at the level of the nutrient foramen. Instrument: Sliding caliper.
TNFCI (74)	Tibia	Circumference of tibia at the Nutrient Foramen	Transverse circumference of the tibia at the level of the nutrient foramen. Instrument: Tape measure.
FIMSAP	Fibula	Fibula Midshaft Anteroposterior	Anteroposterior diameter of the fibula at the midshaft. Instrument: Sliding caliper.
FIMSML	Fibula	Fibula Midshaft Mediolateral	Mediolateral diameter of the fibula at the at the midshaft. Instrument: Sliding caliper.

= Ubelaker and Buikstra (1994) measurement number

Table 13.9. Post-Cranial Osteometric Observations on West Bluffs Project Burials

Variable Name	Measurement	LAN-63	LAN-64				
		480	43	64	52	56	65
FMAXLEN	Femur maximum length	—	180.0[a]	—	—	—	—
FSTAP	Femur subtrochanteric diameter anteroposterior	—	33.12	—	—	—	—
FSTML	Femur subtrochanteric mediolateral	—	24.68	—	—	—	—
FMSAP	Femur midshaft anteroposterior	—	26.08	—	—	—	27.87
FMSML	Femur midshaft mediolateral	—	24.1	—	—	—	25.19
FMSCI	Femur midshaft circumference	—	82.0	—	—	—	83.0
TNFAP	Tibia shaft anteroposterior (nutrient foramen)	—	30.32	31.92	—	—	—
TNFML	Tibia shaft mediolateral (nutrient foramen)	—	22.32	19.95	—	—	—
TNFCI	Tibia circumference (nutrient foramen)	—	86.0	80.0	—	—	—
FIMSAP	Fibula midshaft anteroposterior	14.56	—	—	—	—	—
FIMSML	Fibula midshaft mediolateral	10.46	—	—	—	—	—
HDELAP	Humerus deltoid anteroposterior	—	—	—	—	20.09	—
HDELML	Humerus deltoid mediolateral	—	—	—	—	17.29	—
HDELCI	Humerus deltoid circumference	—	—	—	—	60.0	—
HMSAP	Humerus midshaft anteroposterior	—	—	—	—	20.2	—
HMSML	Humerus midshaft mediolateral	—	—	—	—	14.39	—
HMINCI	Humerus minimum circumference	—	—	—	—	62.0	—
UMSAP	Ulna midshaft anteroposterior	—	—	—	17.49	—	—
UMSML	Ulna midshaft mediolateral	—	—	—	11.06	—	—

[a] = estimated measurement

Table 13.10. Results of Logistic Regression Sex Determination Analysis

Independent Variables Used in Logistic Regression Equation	Feature 43		Feature 56		Feature 65	
	Pseudo R^2	Female P	Pseudo R^2	Female P	Pseudo R^2	Female P
64 + 65 + 66 + 67 + 60	0.35	0.99	—	—	—	—
HDELAP + HDELML + HMSML + HMSAP	—	—	0.60	0.99	—	—
66 + 67	0.17	0.67	—	—	0.17	0.46

Note: The values under the burial feature numbers are the probabilities of that individual being female based on the dimensions used in the logistic regression equations listed on the left. The logistic equations were generated using data from the Malibu cemetery (LAN-264) on individuals with sexes determined based on pelvic morphology (Walker et al. 1996).

Key to variables used in logistic regression equations (see Table 9 for definitions):
60 = Femur Maximum Length
64 = Femur Anteroposterior (Sagittal) Subtrochanteric Diameter
65 = Femur Medial Lateral (Transverse) Subtrochanteric Diameter
66 = Femur Anteroposterior (Sagittal) Midshaft Diameter
67 = Femur Mediolateral (Transverse) Midshaft Diameter
HDELAP = Humerus Deltoid Anteroposterior Diameter
HDELML = Humerus Deltoid Mediolateral Diameter
HMSAP = Humerus Midshaft Anteroposterior Diameter
HMSML= Humerus Midshaft Mediolateral Diameter

Table 13.11. Summary Odontometric Statistics for the West Bluffs Project

Jaw	Dimension	LAN-63 Features		LAN-64 Features	
Tooth		600	480	52	43
Mandible					
P4	Crown Height	4.27	—	—	—
M1	Crown Height	—	4.14	—	—
M2	Crown Height	—	4.51	—	—
M1	Buccolingual	—	11.29	—	—
M2	Buccolingual	—	11.84	—	—
M1	Mesiodistal	—	—	—	11.67
M2	Mesiodistal	—	—	—	10.64
Maxilla					
C	Crown Height	—	—	—	2.75
P3	Crown Height	—	—	—	3.26
P4	Crown Height	—	—	—	2.93
M1	Crown Height	4.41	—	—	—
M3	Crown Height	3.93	—	4.04	—
C	Buccolingual	—	—	—	7.19
P3	Buccolingual	—	—	—	8.58
P4	Buccolingual	—	—	—	8.64
M1	Buccolingual	11.26	—	—	—
M3	Buccolingual	10.49	—	10.94	—
C	Mesiodistal	—	—	—	6.03
P3	Mesiodistal	—	—	—	5.31
P4	Mesiodistal	—	—	—	6.03
M1	Mesiodistal	9.91	—	—	—
M3	Mesiodistal	7.61	—	9.77	—

Note: All measurements are in millimeters. For measurement definitions, see Buikstra and Ubelaker (1994).

Table 13.12. Means of the West Bluffs Project Maxillary and Mandibular Molar-Dimension Populations Compared with Those of the Historical and Middle Period Malibu (CA-LAN-264) Burial Populations

Measurement by Molar	West Bluffs Project			Malibu Middle Period			Malibu Historical Period		
	n	Mean	S.D.	n	Mean	S.D	n	Mean	S.D.
M^1									
Buccolingual Diameter	1	11.26	—	41	11.19	0.6	34	11.05	0.7
Mesiodistal Diameter	1	9.91	—	41	9.76	1.05	37	9.79	0.99
M^3									
Buccolingual Diameter	2	10.72	—	27	9.99	0.86	24	9.86	1.22
Mesiodistal Diameter	2	8.69	—	27	8.65	0.9	22	8.66	0.69
M_1									
Buccolingual Diameter	1	11.29	—	42	10.59	1.01	35	10.02	1.16
Mesiodistal Diameter	1	11.67	—	42	10.74	1.2	35	10.62	1.26
M_2									
Buccolingual Diameter	1	11.84	—	32	10.5	0.63	29	9.8	1.02
Mesiodistal Diameter	1	10.64	—	35	10.78	0.95	27	10.19	0.98

Table 13.13. Tests of One-Way Analyses of Variance of the West Bluffs Project Maxillary and Mandibular Molar-Dimensions Compared with Those of People Buried at the Middle and Historical Period Malibu (LAN-264) Cemeteries

Molar Measurement	Middle Period Malibu			Historical-Period Malibu		
	Size Difference (mm)	*t*	*p*	Size Difference (mm)	*t*	*p*
M^1						
Buccolingual Diameter	0.07	-0.75	.46	0.21	-1.75	.09
Mesiodistal Diameter	0.15	-0.91	.37	0.12	-0.74	.47
M^3						
Buccolingual Diameter	0.73	-4.41	.00	0.86	-3.45	.00
Mesiodistal Diameter	0.04	-0.23	.82	0.03	-0.20	.84
M_1						
Buccolingual Diameter	0.7	-4.49	.00	1.27	-6.48	.00
Mesiodistal Diameter	0.93	-5.02	.00	1.05	-4.93	.00
M_2						
Buccolingual Diameter	1.34	-12.03	.00	2.04	-10.77	.00
Mesiodistal Diameter	-0.14	0.87	.39	0.45	-2.39	.02

Table 13.14. Color Variation in Cremated Human Bone from LAN-63

Color	Weight (g)	Weight (%)	Count (n)	Count (%)
Brown	37	14	11	11.8
White	54	20.5	22	23.7
Multicolored	77	28.9	23	24.7
Black	97	36.5	37	39.8
Total	265	100.0	93	100.0

Chapter 14

Chronology

Kathleen L. Hull and John G. Douglass

Temporal data for the West Bluffs sites were available from a variety of sources, providing complementary data sets to assess the age of these sites. Radiocarbon assays provide absolute dates that are the most precise information on site chronology. Such data focus on features in which organic remains are preserved, however; depending on the variety of features available for such dating, the data could elucidate only limited aspects of use at these sites. Obsidian hydration data, on the other hand, derived from a variety of feature and nonfeature contexts and provided at least a relative site chronology that could clarify vertical and horizontal stratigraphy. The application of proposed source-specific rate formulas can provide absolute date estimates for contexts based on obsidian hydration analysis. Given the limited representation of obsidian in the lithic artifact sample at West Bluffs, however, this technique also had restricted application at these sites. In addition, the small size of many obsidian artifacts precluded geochemical sourcing that was necessary to correctly interpret both relative and absolute applications of this technique. Therefore, only relatively large obsidian artifacts could be included in this analysis, potentially excluding components that might have only been represented in small debitage.

A third source of chronological information is temporally diagnostic artifacts and features. The latter include mortuary features, since mortuary practices changed through time in this area of coastal southern California. Temporally diagnostic artifacts include projectile points, cogged stones, discoids, and shell beads, with beads providing the most precise data in this region. Artifact and feature cross-dating is based on extant regional chronologies, however, and is therefore not an independent dating method. In addition, some of the artifacts produced or practices represented by features prevailed for hundreds or even thousands of years. Therefore, for some categories of data, temporal information was much more coarse-grained than that available from radiocarbon dating or even obsidian hydration dating.

This chapter begins with a brief review of the analytical methods and limitations of radiocarbon and obsidian hydration dating. This overview is followed by a summary of the multiple sources of temporal data for each of the three sites subject to study. For each site, the specific sampling goals and methods are indicated for each technique, as appropriate. In addition, results from previous studies at these sites are incorporated to provide the fullest possible picture of site chronology. The chapter concludes with a synthesis of the temporal data from these three sites and a consideration of the West Bluffs site chronology in the wider context of the Ballona.

Analytical Methods

As noted above, both radiocarbon analysis and obsidian hydration dating were used to derive absolute dates for the West Bluffs sites. Although these techniques have a long history of use in archaeology, ongoing research has recognized various factors that can affect the accuracy of both methods. Therefore, this section provides some background on the techniques and factors that were considered in the current applications.

Radiocarbon Assays

Radiocarbon dating is based on measurement of the decay of radioactive carbon (^{14}C) to stable nitrogen (^{14}N) in organic material such as shell, wood, and bone. Such carbon is created in the atmosphere by the bombardment of stable nitrogen by cosmic rays, and organisms take in both stable (^{12}C) and radioactive carbon from the environment during their life. Upon death of the organism, carbon is no longer taken in and the ^{14}C already present begins to decay to ^{14}N at a fairly constant rate. Thus, radiocarbon dating measures the ^{14}C remaining in the organic material to determine the amount of time that has elapsed since death of the organism. The rate of beta-particle emissions that reflect the amount of ^{14}C present is an estimate, however, so radiocarbon dates are always presented with statistical uncertainty (i.e., a "±" statement of the probability of the actual age falling within the given range) that varies based on factors such as sample size. Small samples require extended counting times, or even analysis by accelerator mass spectrometry (AMS) rather than standard radiometric techniques.

It has also been recognized that various other factors may alter the abundance or decay rate of radioactive carbon within ancient organic materials. For example, the concentration of radioactive carbon in the ocean is lower than that of the atmosphere. Thus, radiocarbon dates based on analysis of marine organisms must be adjusted for the "reservoir effect"(ΔR)—that is, the availability of radioactive carbon in the particular aquatic environment in which these organisms are found. The reservoir effect will vary based on factors such as coastal upwelling (i.e., influx of deep sea waters to the surface) and the mixture of saltwater and freshwater in estuaries, both of which can deplete ^{14}C in aquatic settings (see Ingram 1998). In the West Bluffs area, there have likely been significant shifts in ^{14}C activity in prehistory, including varying inputs of freshwater into the Ballona through time. In the San Francisco Bay, Ingram (1998) has documented ΔR values ranging from 870 to -170 ^{14}C years over the last 5,000 years, related in part to El Niño events. There have also been changes in atmospheric ^{14}C through time due to the burning of fossil fuels, nuclear explosions, and additional unknown cosmic or environmental events in prehistory. Therefore, radiocarbon dates for both terrestrial and marine samples are generally "calibrated" using tree-ring data for radiocarbon-dated material. Through these methods, radiocarbon dates can be converted to calendric dates with a corresponding statistical uncertainty factor.

Existing regional archaeological chronologies rely on uncalibrated dates for charcoal and shell, and the reservoir effect has often been taken into account for dates based on shell. Therefore, the current analysis focuses on conventional (uncalibrated) rather than calibrated radiocarbon dates. Studies of ^{14}C activity in modern surface waters of the Pacific Ocean along the southern California coast indicate a 220 ± 40 ^{14}C year (ΔR) adjustment for radiocarbon dates derived from shell in this area (Ingram and Southon 1996), although Beta Analytic, Inc., applied a correction of 225 ± 35 ^{14}C years for the California coast in general to the current radiocarbon results (see Appendix N). For the purposes of discussion, tree-ring calibration of all radiocarbon dates is also provided, because these dates are the most accurate indication of when the site was used.

Obsidian Hydration Analysis

Obsidian hydration dating is based on the observation that a freshly exposed surface of obsidian adsorbs water from the surrounding environment, creating a visually distinct "rim" on the outermost surface of the piece (Friedman and Smith 1960). The thickness of this rim increases through time as more water is absorbed, so removing a thin section from the artifact and measuring the thickness of the hydration band can provide an indication of the length of time that has elapsed since the surface was exposed. If the surface was created during manufacture of an artifact, the hydration rim provides an estimate of the age of the tool or flake. Similarly, sampling the hydration rim on a break or in a reworked area can indicate the age of the damage or reuse. Hydration is measured in microns, and a ± 0.2-μ error is generally accepted for the optical measurement techniques employed. Multiple measurements are usually taken along both faces of the artifact to derive a mean thickness of the hydration rim.

Laboratory and empirical studies have demonstrated that hydration generally progresses in a logarithmic fashion (see Hull 2001), with hydration developing relatively rapidly at first, then slowing over time as the rim becomes thicker (cf. Anovitz et al. 1999). Several factors can influence the rate at which the hydration rim develops, however, including obsidian geochemistry, temperature, and relative humidity (see Stevenson et al. 1998). The relationship between trace element geochemistry and rate of hydration has not been thoroughly explored, but the effect of environmental variables on hydration is well understood. Higher temperatures speed up the hydration process (Jones et al. 1997), and low relative humidity results in slower hydration. In many areas, subsurface relative humidity is nearly 100 percent within less than 25 cm of the ground surface (e.g., Mundy 1993), however, so relative humidity often is not taken into account in interpretation of hydration results (see also Stevenson et al. 1998:193). Rather, effective hydration temperature (EHT) has been the primary factor considered in archaeological applications. Other recent research (e.g., Stevenson et al. 1996, 1998) has suggested that intrinsic water within obsidian—which varies from piece to piece or even within a piece—is also significant to the rate of hydration. Methods based on this conclusion have yet to be widely applied in archaeology, however, in part because hydration analysis provides sufficiently accurate dates for most interpretations without taking intrinsic water into account.

When one geochemical source of artifactual obsidian is represented and specimens are recovered from sites or deposits in relatively similar environments, raw obsidian hydration measurements can be used “as-is” to establish a relative chronology. This often includes establishing hydration measurement ranges for various projectile point series that can serve as a framework for determining the relative age of other tools or debitage that have hydration rims of similar thickness. If hydration measurements are compared in different environmental contexts, however, relative applications become more problematic since EHT may differ significantly between sites. For example, artifacts of the same geochemical source and age recovered from high versus low elevation zones will likely exhibit very disparate hydration rims (e.g., Hull and Roper 1999; Onken 1990; Stevens 2002), and the same may be true for surface versus deeply buried artifacts at any one site since EHT declines with depth (see Mundy 1993). For the most part, archaeologists have tended to ignore potential intrasite EHT differences in use of obsidian hydration as a relative dating technique, probably because subsurface temperature data are not readily available. Instead, EHT has been considered more often in intersite comparisons of obsidian hydration measurements, with archaeologists relying on air temperature data to compute EHT based on Lee’s (1969) temperature integration formula. This same method of EHT estimation is also applied to some absolute dating approaches with obsidian hydration (see below).

Researchers have invoked two different methods for conversion of obsidian hydration measurements to absolute dates. The first is based on induced hydration of obsidian at relatively high temperatures in a laboratory setting. High temperatures—far exceeding those typical to archaeological deposits—allow the hydration process to proceed fast enough for the rim to develop in a matter of days or weeks rather than centuries or millennia. Resulting data can be applied to the Arrhenius equation—which defines the relationship between time, temperature, and hydration based on diffusion theory—to establish the rate of hydration for any given geochemical source material. In some cases, “comparison constants” that allow a rim measurement of one geochemical source material to be “converted” to that of another, better-understood source have also been developed based on induced hydration (e.g., Tremaine 1993). Such constants can be used in either relative or absolute dating with obsidian hydration.

Although induced hydration studies have a long history in archaeological research, these methods often produce results that are significantly at odds with other archaeological data. For example, hydration dates are often much too old given what is known of regional archaeology. Therefore, the second method of absolute dating with obsidian hydration relies on empirical derivation of hydration rates based on archaeological, rather than laboratory, data. For example, obsidian hydration measurement and radiocarbon pairs or hydration ranges for projectile point types that have known chronological spans based on association with radiocarbon dates elsewhere in a region can be used for such rate derivation. For the most part, a best-fit curve is derived from these data, and such curves often approximate the logarithmic relationship recognized by diffusion theory (see Hull 2001).

In some cases, empirical rate formulas are "corrected" for temperature for application from one region to another based on air temperature data (see above). Such corrections are usually posited as a percent per degree adjustment, despite the fact that diffusion theory indicates that the relationship between hydration rate and temperature is not linear (see King 2004). One recent study of Casa Diablo obsidian (Hull 2001), however, integrated subsurface temperature data into rate derivation based on the Arrhenius equation. The resulting temperature-dependent empirical formula can be adjusted for EHT within different deposits without relying on linear air-temperature "corrections" (see also Stevens 2002). This method appears very promising, although subsurface EHT data must be available, and resulting rate formulas are specific to the geographic area in which they were developed. Despite the methods used, empirically derived rates—even those that rely on linear, air temperature EHT corrections—have proven to be much more accurate than induced hydration rates, particularly for more ancient specimens.

The current analysis relied primarily on the empirically derived rate formula for Coso obsidian proposed by Basgall (1990) in which years B.P. = 31.62 $\text{microns}^{2.32}$. This rate is based on mean hydration and uncalibrated radiocarbon pairs from 10 features at INY-30, a site located near Lone Pine in eastern California. It is the most commonly applied rate for this source material in both interior and coastal southern California (cf. King 2004), although problems with applications on the central California coast have been recognized (Jones and Waugh 1995) and continue to be a source of consternation among regional archaeologists. Based on application of air temperature data to Lee's (1969) EHT formula, Basgall (1990) also proposed various "correction" constants to adjust his formula for use in regions other than the Owens Valley, including the southern California coast. For example, he noted a 0.09°C higher EHT on the Malibu coast than in the Lone Pine area, indicating that the rate should be multiplied by 0.9946 (i.e., 6 percent per 1°C) to produce a date for southern California coastal sites such as those at West Bluffs. As noted above, the use of standard EHT "corrections" such as this is somewhat problematic given what we know about the logarithmic progression of hydration process and it's relationship to temperature. In this case, however, the apparent EHT difference between Lone Pine and Malibu was so small that results were probably not substantially distorted by these methods given the general accuracy of obsidian hydration analysis. This approach served as the starting point for consideration of the obsidian hydration data from the West Bluffs sites, including a reanalysis of raw hydration data presented by Van Horn and his colleagues (DiGregorio and Linscheid 1987a, 1987b; Freeman 1987), who relied on a linear rate formula inconsistent with diffusion theory.

A potentially more significant problem with Basgall's (1990) rate formula for Coso obsidian was his use of uncalibrated radiocarbon dates in rate construction, since such dates do not represent a consistent scale, and thus, the relationship between time and hydration is inaccurate. Given this source of error, the INY-30 data were reevaluated for the current analysis using calibrated radiocarbon ages and regression consistent with diffusion theory (i.e., microns squared versus time in thousands of years). This resulted in the following Coso rate formula: years B.P. = $1{,}000 \times \text{microns}^2 \div 19.1927$. Using this method, the Coso obsidian hydration measurements available from the West Bluffs sites were converted to calibrated radiocarbon dates to augment data derived using Basgall's (1990) formula. No temperature correction was used in the application of this tentatively proposed formula, since the EHT of Malibu and Lone Pine are so similar and subsurface EHT data are not available.

In addition, it should be noted that neither this tentative formula nor Basgall's (1990) original equation addressed the issue of intersource geochemical variability. Hughes (1988) demonstrated that at least four geochemically distinct "sources" are represented within the Coso Volcanic Field, but the primary data from INY-30 did not distinguish between these flows. Hull's (2001) temperature-dependent rate for Casa Diablo obsidian was used to date the single Casa Diablo artifact from the West Bluffs sites examined for hydration. In this case, the EHT estimate provided by Basgall (1990) for Malibu was used in the absence of subsurface temperature data specific to this area.

Temporal Data for LAN-63

The current study and previous research by Van Horn and his colleagues (Van Horn 1987) have provided multiple lines of chronological data for LAN-63. These include radiocarbon assays, obsidian hydration data, and temporally diagnostic artifacts and features.

Radiocarbon Assays

Radiocarbon dates were derived from Venus clam (*Chione* sp.) shell samples recovered from 12 different proveniences at LAN-63 (Figure 14.1; Table 14.1). These proveniences, which sampled a variety of areas across the site, included seven features and five levels in control column or excavation units not associated with cultural features. Conventional radiocarbon dates corrected for the reservoir effect ranged from 1700 ± 90 B.P. to 2190 ± 70 B.P. The oldest date was from shell in the uppermost level of Unit 36, and the youngest date was associated with Feature 475. As detailed in Appendix N, five of the dates were derived using AMS, and the remainder were derived using standard radiometric dating.

The radiocarbon dates for five of the seven dated features represented a relatively tight cluster (see Figure 14.1). When Features 11 and 475 were excluded, chi-square analysis of these data using OxCal (v. 3.10) radiocarbon analysis software provided confidence that the five remaining features represented a population that had a combined date of 1919 ± 25 B.P. Because they were all within the 95 percent confidence interval, we could be fairly certain they were all from the same population. In other words, these dates were sufficiently close to represent a single component dating to this time. Since these five features included both burials and thermal features distributed across the entire site area, this result suggested that many of the activities carried out at LAN-63 were roughly coeval and that this use was relatively widespread. Because the date from Feature 11 was outside the 95 percent confidence interval that the other dates were clustered within, we could not be as certain it was from the same population (or, alternatively, component) as the rest of the sample dates. The date for Feature 475, on the other hand, was distinct from those of the other dated features. Feature 475 was a burial within the apparent disposal area between the two knolls at LAN-63, and thus, the somewhat later interment of this individual indicated by radiocarbon results was consistent with activity postdating the predominant use of this site, when much of the discard of shell likely occurred. This date may have suggested, then, that the burial was dug into the base of the disposal area after much of the trash had been deposited.

The radiocarbon dates for the two nonfeature contexts sampled multiple excavation levels within the A horizon. The three levels sampled from Control Column 1 (CC 1) provided a picture of sediments between approximately 10–120 cm below ground surface in the western site area. The youngest radiocarbon date was derived from the lowest of the three levels, whereas the sample from the 50–60-cm level rendered the oldest date (see Figure 14.1). Chi-square analysis indicated that these dates were not significantly different, however, with a combined age of 1880 ± 29 B.P. calculated for this deposit. That is, we can be fairly certain that these dates were from the same population and were thus contemporaneous to one another. The two levels sampled from Unit 36 located on the eastern margin of the western knoll also exhibited date "reversal," but statistical analysis again demonstrated that these dates were not significantly different. The combined date of 2112 ± 53 B.P. for this portion of the deposit was sufficiently different from the dates for CC 1, however, to indicate that at least a 230-year span of use was likely represented at this site. As noted above, features other than Feature 475 also dated within this 230-year range (see Figure 14.1). The radiocarbon date for Feature 475 suggested that major use of the site, including activities associated with features, might have persisted for as much as 410 radiocarbon years. Regardless, all of these dates indicated use during the Intermediate period (3000–1000 B.P.) as defined for this portion of the southern California coast or, more specifically, for the period ca. 1775–1235 cal B.P.

These radiocarbon results were also consistent with those reported by DiGregorio and Linscheid (1987a) for five shell samples from various areas of LAN-63. This previous study indicated conventional radiocarbon dates ranging from ca. 2020 to 2530 B.P., although these dates were not adjusted for the reservoir effect. Calibrating these previous dates and adjusting for the reservoir effect (Table 14.2) using the Calib software (v. 5.0.1) indicated that four of the five dates spanned from ca. 1400 to 1190 cal B.P. The one remaining date of ca. 1925 cal B.P. suggested potential earlier use, although this sample was recovered from the 40–50-cm level of Unit 8 in Trench D on the eastern knoll, and another sample from greater depth in the same unit returned a younger date. DiGregorio and Linscheid (1987a) attributed this date reversal to bioturbation, which was supported by the presence of historical-period artifacts as deep as 90 cm in the deposit. Statistical analysis of the two dates from this unit conducted for the current analysis were disparate enough to indicate that two different events had indeed been dated, and thus, that bioturbation was likely.

DiGregorio and Linscheid (1987a) also concluded that the dates overall were too old, however, because arrow points were observed at the site, and they suggested a reservoir correction of nearly 700 years that would make the dates more acceptable. This correction was much greater than that currently recognized for this area, however, and given the spatial distribution of such points (see below), it seems more likely that horizontal stratigraphy could account for the later component recognized by DiGregorio and Linscheid, without resorting to manipulation of the radiocarbon data. The radiocarbon dates were derived from deposits underlying the strata in which the late points were recovered, further supporting our conclusion.

Obsidian Hydration Analysis

Twelve artifacts from LAN-63 were submitted for obsidian hydration analysis from the current project sample. These pieces represented all items in the lithic collection of sufficient size for X-ray fluorescence analysis, which was required for adequate interpretation of the obsidian hydration results. Therefore, this sample did not provide dates across the entire site area, nor was it certain that these samples represented all of the components present at this site.

As noted in the flaked and ground stone analysis (Chapter 8), geochemical study indicated that 10 artifacts were of West Sugarloaf obsidian of the Coso Volcanic Field, one biface was of Casa Diablo glass, and another biface was of Mono Glass Mountain obsidian (Appendix O). The West Sugarloaf (Coso) samples included seven pieces of debitage and three bifaces. Thin sections for debitage were sampled in just one location on each flake, but each tool was sampled in two locations to examine reworking that might have been related to scavenging (Appendix P).

Table 14.3 provides the hydration measurements and accompanying age estimates for the Coso and Casa Diablo specimens from LAN-63. As noted above, two different rate formulas were applied to the Coso specimens to assess different methods of age estimation, whereas the age of the Casa Diablo artifact was based on Hull (2001). No rate formula was available for Mono Glass Mountain obsidian.

Uncalibrated data for the Coso specimens indicated dates ranging from approximately 290 to 2580 B.P., although the youngest date was from a secondary rim on a biface (catalog no. 1687) that had a somewhat earlier age for the primary rim that sampled a relict flake scar. In fact, the biface sample in general indicated ages that tended to be younger than the debitage, which suggested different patterns of use or re-use might have been represented. For example, another biface (catalog no. 1684) in the Coso collection exhibited the second youngest age (ca. 870 B.P.), although there was no temporal difference between the original working and the broken and reworked portion of this tool. The third Coso biface (catalog no. 1686) was approximately 400 years older still, although it possibly dated slightly older than at least one piece of debitage. Given the accuracy of hydration dating, the discrepancy between hydration rims on the worked and reworked areas of this tool was not substantial enough to indicate a time lag between production and reworking. In addition, the thinner rim was observed on the "older" surface. No uncalibrated date is available for the Casa Diablo biface, but the calibrated dates for the original and reworked surfaces were older than those indicated for the bifaces of Coso glass. The younger surface was similar to the oldest date for the site indicated by radiocarbon dating from the current collection (see above).

Given the potential curation of Coso bifaces or association of such tools with a late component at this site (see below), the debitage sample may be a better indicator of primary obsidian tool manufacturing activity at this site. These data suggest such production occurred between ca. 1190 and 2577 B.P., although activity before ca. 1920 B.P. was especially evident. It is interesting to note that two of the age estimates for Feature 587 provided a mean date of 2030 B.P., which was very close to the ΔR-adjusted radiocarbon age of 1920 ± 80 B.P. for this feature. Another flake from sediment overlying this feature, however, provided an age estimate of just 1190 B.P. Overall, the obsidian hydration age estimates for Coso tools and debitage derived using a temperature correction of Basgall's (1990) formula suggested a broader span of use than that indicated by the radiocarbon dates, but a range also encompassing that span represented by radiocarbon dates.

The calibrated date estimates for the Coso samples based on a recalculation of the INY-30 data suggested a somewhat narrower date range than that apparent in the uncalibrated data. Still, the age range was not sufficiently tight to suggest that a single component was represented. In addition, this method seemed to provide dates that were often older than those indicated by calibration of the radiocarbon dates from LAN-63. This is readily apparent in comparison of the data for Feature 587, as the calibrated obsidian hydration method provided dates that are at least 300 years too old, if the ΔR correction applied to the radiocarbon dates is correct. Such discrepancy may be due to differences in EHT between the coast and the interior locale on which the Coso rate formula is based—since no temperature correction was applied—although application of Basgall's (1990) proposed linear temperature correction would only decrease the age estimates slightly. Given these observations, the recalculated formula for Coso obsidian hypothesized herein may not be an improvement over that posited by Basgall (1990) based on uncalibrated radiocarbon dates, and establishment of a temperature-dependent rate formula based on hydration and radiocarbon pairs from Ballona sites would provide a much-needed aid to temporal interpretation in this region.

Table 14.4 provides uncalibrated and calibrated age estimates for the obsidian hydration sampling undertaken by DiGregorio and Linscheid (1987a), replacing the ages they derived based on a linear rate formula. Although the sampling criteria were not specified, it appeared that obsidian was selected to examine both vertical and horizontal stratigraphy. Three of the hydration rims dating from ca. 14,480 to 32,580 B.P. clearly reflected hydration unrelated to cultural activity (cf. DiGregorio and Linscheid 1987a:237). The remaining age estimates ranged from ca. 610 to 5375 B.P., with all but six samples dating to later than 3700 B.P. Five of the six dates that were older than this were from various depths and areas within Trench A, suggesting these items might have represented spatially discrete use of either scavenged material or obsidian from a source other than the Coso Volcanic Field. In fact, the lack of geochemical data for any of these specimens suggested caution in using or interpreting these results, as the current study clearly indicated non-Coso artifacts were used (if not manufactured) at this site (cf. DiGregorio and Linscheid 1987a:237). There was no apparent pattern in the distribution of temporal data with depth.

DiGregorio and Linscheid (1987a) relied on mean hydration values for trench samples to discuss horizontal stratigraphy at LAN-63. As a result, they concluded that Trench A represented the oldest portion of the deposit, since the five dates greater than 4000 B.P. from this provenience substantially increased the mean hydration value for this sample. Excluding these outliers from the current reanalysis, however, indicated a mean hydration age of ca. 2090 B.P. for this trench. This was very similar to the mean date of ca. 1805 B.P. for Trench B, 2120 B.P. for Trench C, and 1960 B.P. for Trench D. In addition, these dates were consistent with the conventional radiocarbon dates derived for LAN-63 from both the current and previous studies at this site.

Temporally Diagnostic Artifacts

Potentially temporally diagnostic artifacts observed at LAN-63 included projectile points, cogged stones, discoids, and shell, stone, bone, and glass beads. Bone and glass beads were only noted in previous investigations, and this earlier work also revealed a greater variety of temporally diagnostic flaked stone tools than the current study. Conversely, cogged stones and discoids were not observed in earlier work.

Projectile Points

Six projectile points were recovered from LAN-63 during the current project, and at least five of these tools were temporally diagnostic. Unfortunately, all were of non-obsidian lithic materials, precluding obsidian hydration analysis of these specimens. In addition, dating of many of these types relies on information from the Great Basin or interior California rather than the coast.

The oldest specimen was a Great Basin Stemmed point, which is associated with the Western Pluvial Lakes Tradition dating to ca. 11,000–7000 B.P. (see Moratto 1984). Two Gypsum Cave points were also recovered, and this type dates to ca. 4450–1450 B.P. (2500 B.C.–A.D. 500) in the Great Basin (Holmer 1986:105). Elko Eared points such as the single specimen in the current collection also date to ca. 3300–1350 B.P. (1350 B.C.–A.D. 700) in the western Great Basin and adjoining areas of California (Justice 2002:304; see also Holmer 1986:101; Thomas 1981:20). The Humboldt Concave Base point from LAN-63 could date as early as 3000 B.C., based on data from the Great Basin (Thomas 1981:17), but Justice (2002:156) indicated this type persisted as late as 1350–650 B.P. (A.D. 600–1300) in the western Great Basin. The final point was a medium-size, side-notched specimen with a convex base that likely was a reworked corner-notched dart point, perhaps of the Elko series. Together, these data suggested primary use of the site some time between ca. 3300 and 1350 B.P., although the Great Basin Stemmed point is clearly older than this range. Thus, this artifact might have been a scavenged item.

Previous excavation at LAN-63 resulted in the recovery of a greater diversity of projectile points, including some dating much later than those collected during the current project. These specimens included 31 Canaliño, 8 Marymount, 9 Gypsum Cave, 1 Pinto, and 1 Cottonwood Triangular point, as well as 28 leaf-shaped dart points, 19 side-notched dart or arrow points, 12 foliate dart points, 9 “miscellaneous tanged” points, and 1 triangular dart-size point (Freeman and Van Horn 1987). Although no Elko series points were identified in the previous excavation collection, some of the large “side-notched” points had metric attributes consistent with points in this series. The presence of Gypsum Cave points was also consistent with the current projectile point sample from LAN-63, and the prevalence of dart-size points in general in previous samples is also in keeping with the current results. In addition, a bone atlatl spur was identified in the previous collection (DiGregorio 1987:168). The obsidian hydration result for the Pinto point of ca. 4850 B.P. may suggest somewhat earlier use, although this item was recovered in the upper 20 cm of Trench A. This portion of the deposit (see below) seemed to relate primarily to a later component; therefore, this tool may have been scavenged.

The presence of Canaliño, Marymount, and Cottonwood Triangular points in the previous collection contrasts sharply with the current projectile point sample. In addition, many of these points were manufactured of fused shale, which was also lacking in the current tool and debitage collection. Significantly, Freeman and Van Horn (1987) observed that the Canaliño points were found below the blow sand deposit between 20 and 50 cm in the western site area and in the upper 40 cm of the eastern half of Trench A in the northeasternmost portion of the site. Marymount points were similarly limited to the upper 50 cm in the same two areas. These data indicated two relatively small, spatially discrete, Late period (post-1000 B.P.) use areas near the bluff edge that post-dated the predominant use of the site indicated by the early projectile points, radiocarbon dates, and obsidian hydration results (see also Freeman and Van Horn 1987:90, 92). For example, such later activity did not appear to have included the use of thermal features or interment of individuals on-site, suggesting the mode of use was very different than that of the preceding Intermediate period. In addition, the prevalence of bifacial tools—particularly projectile points—and incorporation of fused shale into the lithic technology was very distinct, and pointed bone tools from the previous excavation were also associated with bluff-edge areas (DiGregorio 1987:171) reflecting such late use. The lithic artifact data suggest this component reflected hunting camps or task-specific locales primarily related to hunting, rather than long-term occupation, although the bone tools may indicate somewhat broader site function. The obsidian hydration results for the bifaces noted above suggest that this late use may have included scavenging or manufacture of obsidian bifacial tools and dating of this component to ca. 900–300 B.P.

Cogged Stones

Two land-and-groove cogged stones (Eberhart 1961) were recovered from LAN-63. Regional chronological information suggest such artifacts relate to the Millingstone period (ca. 8500–3000 B.P.), although association of cogged stones with radiocarbon-dated contexts is rare (Donn Grenda, personal communication 2005). The only other temporal data that suggested such early use were six obsidian hydration age estimates from the sample examined by DiGregorio and Linscheid (1987a), and as noted above, these dates may reflect non-Coso obsidian or scavenged material. This ambiguity, coupled with the fact that the cogged stones were recovered from nonfeature contexts, suggested that any Millingstone period use was ephemeral. Rather, as noted in Chapter 8, these items may have been scavenged from earlier deposits located nearby, such as LAN-64.

Discoids

Five discoids were also recovered from nonfeature contexts at LAN-63. As discussed by Moratto (1984:150), discoids have often been found in caches with cogged stones elsewhere in southern California, suggesting these two artifact types are contemporaneous. Therefore, Millingstone period use might also have been indicated by these artifacts, although this component appeared relatively ephemeral.

Beads

Stone and shell beads were recovered during the current and previous excavations, whereas bone and glass beads had been found only during the previous investigations at this site. Eleven of the 13 stone beads recovered during the current study were small disk beads similar to specimens identified by Rigby (1987) during previous excavation at this site. Ten of these beads had metric traits consistent with Type 1A1c defined by Rigby (1987:10), and the remaining bead was Type 1A1b (Rigby 1987:9). Most of these beads were recovered from Feature 587, but one, Type 1A1c, was from Feature 475. Rigby (1987:10) noted that similar beads have been found in contexts at other southern California sites dating between 2750 and 2150 B.P, suggesting a time slightly younger than that indicated by radiocarbon dating of these two features. Rigby (1987) reported that other types of stone beads identified in the previous excavation at this site were common to periods including 2150–1650 B.P., 1250–1050 B.P., and 900–800 B.P.

Olivella shell beads and bead fragments were recovered from Features 475 and 587 at LAN-63. Beads from the latter feature included two type A1a, one type B2, four type G1, three type G2, two type G5, and two wall bead fragments of undetermined type. As discussed by Bennyhoff and Hughes (1987; see also King 1990), types G2 and G5 dated to the Intermediate period (3000–1000 B.P.), with type G2 most common in deposits dating to 2600–1300 B.P. Types A1a, B2, and G1, on the other hand, are found in all time periods, although B2 beads tend to be most common in Early and Late period contexts, and G1 beads are most prevalent after ca. 1250 B.P. Together, these data are consistent with the radiocarbon and obsidian hydration results for this burial, which indicated interment during the Intermediate period.

The two *Olivella* beads in Feature 475 were Type G2 and Type J. As noted above, G2 beads date to the Intermediate period, but Type J beads are tentatively dated from the early Late period to historical times. Although radiocarbon dating indicated that Feature 475 slightly post-dates much of the activity at LAN-63, these data and the recovery of the G2 bead both underscore Intermediate period affiliation for this feature. Therefore, Type J beads, such as the one associated with Feature 475, might be somewhat earlier than previously recognized in southern California.

Seven shell beads were identified in previous excavations at LAN-63, although different typology was used to classify these specimens. The descriptions, however, suggested that at least simple spire-lopped (Type A1), drilled whole (Type A3), and oval saucer (G5) *Olivella* beads were present. Two of these types were observed in the current collections, whereas Type A3 was not and is most common in the Early period and during Phase 1 of the Late period (Bennyhoff and Hughes 1987:119).

Finally, as noted above, bone and glass beads were found during previous excavations at LAN-63. The latter indicate the historical period, whereas Rigby (1987:20) observed that the bone beads are of types indicative of periods including 2750–1050 B.P., 1650–1050 B.P., 1250–1050 B.P., and 900–168 B.P.

Mortuary Practices

Regional archaeological research along the southern California coast suggests burial was the common mortuary practice until at least ca. 500 B.C., with replacement by cremation thereafter (see Moratto 1984:154). Subsequent influence of the Catholic missionaries prompted a shift back to burial once more during the historical period, although Kroeber (1925:633) noted that burial may have been more common than cremation in the coastal and island area from Topanga to San Pedro even prior to historical changes. As summarized by Moratto (1984:154), the shift from burial to cremation coincided with other changes in subsistence and settlement, and may have related to the immigration of Shoshonean peoples to the coast from the deserts at this time.

Mortuary features at LAN-63 included burials, as well as possible cremation or mourning features. Five burials were recognized around the periphery of the site, and burned human bone was identified in several features in the central portion of the site. The radiocarbon dates available for three of the burials (Features 475, 480, and 492) indicated interment between ca. 1700 and 1900 B.P., just slightly later than the general pattern for southern California sites, although the youngest date was from the burial of a child. As discussed elsewhere in this report, two of these features were likely secondary burials, whereas Feature 480 (perhaps pre-dating the other two) was a flexed primary inhumation. The remaining undated burials included another primary flexed interment (Feature 600) and a disturbed primary or secondary burial (Feature 617). The presence of cremation or mourning features incorporating cremated remains such as Feature 587, however, also indicated the concurrent practice of cremation, since this feature dated to ca. 1900 B.P. as well. Thus, these observations are consistent with either the transition from interment to cremation after ca. 2000 B.P., or the persistence of burial coinciding with less-common cremation, as recognized by Kroeber (1925) for this portion of the coast.

Summary

Three periods of use were represented at LAN-63. The earliest, during the Millingstone period, was indicated only by a few obsidian hydration dates and the presence of cogged stones and discoids. As noted, however, dating of cogged stones and discoids remains problematic, as few have been recovered in radiocarbon-dated contexts. Obsidian hydration dates indicative of the Millingstone period at LAN-63 were equally problematic, as these specimens were recovered in an area of the site that otherwise demonstrated much later use (i.e., Late and some Intermediate period occupation). Therefore, the obsidian artifacts that potentially dated to the Millingstone period may have been scavenged from elsewhere, or the visual ascription of these flakes to the Coso source may be in error. In any case, the Millingstone period component, if present, is very ephemeral.

Dominant use of this site occurred during the Intermediate period, as indicated by all of the radiocarbon dates, the bulk of the obsidian hydration dates, stone beads, some shell beads, mortuary practices, and dart points from the current sample. This component appears to have dated primarily to an approximate 230–410-year period, from ca. 2110 to 1700 B.P., and was found throughout the site area. Thermal and ritual features, burials, and lithic production activities were all associated with this component, and use of non-obsidian bifaces, core tools, and flake tools was highlighted. Some of the stone beads identified in the current and previous excavations also dated to this period, and some of the bone beads might have related to this component as well.

The final component dated to the Late period and was indicated by two small, spatially discrete loci near the bluff edge identified by Van Horn (1987). This component was represented by small arrow points, some bone beads, and the glass beads from the previous site collection (which may date to the Mission period), as well as some obsidian hydration dates from both the current and previous sample. Significantly, the hydration dates were primarily from finished bifacial tools rather than debitage, highlighting the association of bifacial implements with this component. In addition, use of fused shale was limited to the Late period.

Temporal Data for LAN-64

Temporal information for the current study of LAN-64 was limited to radiocarbon dates, cogged stones, discoids, and mortuary practices. Previous excavation at this site, however, has also produced additional radiocarbon and obsidian hydration data, as well as other types of temporally diagnostic artifacts.

Radiocarbon Assays

Twelve shells and one charcoal sample were submitted for radiocarbon dating from LAN-64 (Table 14.5). The latter was from Control Column 1 within a depression adjacent to the site, and the remaining samples were all from features within the site area. Organic remains were absent from many of the features on this site, so features were selected based on the presence of materials suitable for radiocarbon dating rather than in an attempt to examine all site areas. Seven features were radiocarbon dated, with paired Venus clam (*Chione* sp.) and scallop (*Argopecten* sp.) shells sampling Features 45, 49, 50, 55, and 60. Paired dates were used for these features to test initial radiocarbon dates on clam shell, which suggested substantial antiquity for these features. The remaining two features were much younger, and therefore, were dated with only one sample each. Nine of the radiocarbon assays were determined by AMS, and three were rendered through standard radiometric techniques.

Examination of the paired samples from Features 45, 49, 50, 55, and 60 revealed that dates based on clam and scallop differed by approximately 100–700 years for any given feature. In some cases, the date for the clam sample was older (Features 50, 55, and 60); in other cases, the scallop shells rendered older dates (Features 45 and 49). In three cases, however, chi-square analysis indicated that dates were sufficiently close to conclude that the clam and scallop shells were deposited at approximately the same time. Using OxCal software, the calculated combined date for Feature 45 was 7210 ± 35 B.P., Feature 49 dated to ca. 7034 ± 45 B.P., and the combined date for Feature 55 was 7101 ± 54 B.P. (see Figure 14.1) All of these features were located within 25 m of each other in the central site area.

The radiocarbon date for the clam sample from Feature 50 was very similar to the dates for clam shell from Features 45, 49, and 55. The dates for each shell pair from Feature 50 and 60 were sufficiently different, however, that we could not have confidence that these date pairs related to the same depositional event (see Table 14.5). Both of these features may represent deposition over time rather than during a single event, or one of the dates for each feature may be in error. The dates for these two features bracketed those of the other three features, however, so there was no evident explanation for date disparity such as early or late disposal practices that might have accounted for these observations. Feature 60 was located near the southwestern site boundary, but Feature 50 was within the same areas as Features 45, 49, and 55. Together, the radiocarbon results for these five features indicated use during the early Millingstone period (older than 6500 B.P.).

The radiocarbon results for Features 17 and 56 indicated deposition during the Intermediate period. Feature 56, a burial, dated to ca. 1930 ± 50 B.P.; whereas Feature 17 dated to 1560 ± 50 B.P. Thus, although both of these features are were associated with the Intermediate period, the dates were sufficiently different from each other to indicate more than one component of this age or a relatively long span of use, somewhat younger than that recognized at LAN-63 (see Figure 14.1). The charcoal sample from the low-lying depression adjacent to LAN-64 provided a conventional date of 220 ± 40 B.P., much younger than any other radiocarbon dates from the site, but similar to one obsidian hydration date (see below). Given that this radiocarbon date was from a nonsite context, there was no reason to believe that this date related to cultural activity at LAN-64.

DiGregorio and Linscheid (1987b) reported one radiocarbon date for the previous excavations at LAN-64, 2300 ± 90 B.P. (uncorrected for the reservoir effect). Using the ΔR correction applied for the current study resulted in a conventional radiocarbon age of ca. 2080 B.P., whereas correction for the reservoir effect and calibration of the date using Calib software provided a 1-sigma range of cal A.D. 177–411 (ca. 1773–1539 cal B.P.) and a 2-sigma range of cal A.D. 74–538 (1876–1412 cal B.P.). This radiocarbon result was consistent with Intermediate period use, although the date was older than that recognized for Feature 17, and more consistent with that noted for Feature 56 (see Figure 14.1).

Obsidian Hydration Analysis

No obsidian tools or debitage were recovered in the current archaeological investigations at LAN-64, but DiGregorio and Linscheid (1987b) analyzed 10 flakes in the previous collection for obsidian hydration. The criteria for selection of these specimens was not stated, and all were assumed by the authors to be Coso obsidian, although geochemical sourcing was not employed. Application of Basgall's (1990) Coso rate formula with the Malibu temperature correction indicated dates ranging from ca. 260–3245 B.P. (Table 14.6). The latest date was a distinct outlier, however, with at least two components dating to the Intermediate period suggested by the data. Five dates ranged from ca. 1845 to 1130 B.P., spanning a period that encompasses Features 17 and 56. Four other obsidian specimens from four different excavation units dated to 3245 B.P., a date that is not otherwise indicated in temporal data from the site. Therefore, these samples may have been from obsidian other than the Coso glass. Significantly, no obsidian hydration dates indicated a component dating to the early Millingstone period, revealed by radiocarbon dates for several of the features. This may have simply been due to the small size of the obsidian sample, or the fact that obsidian may not be associated with this early use.

Temporally Diagnostic Artifacts

Temporally diagnostic artifacts were rare in the current sample from LAN-64, but common in the previous collection from this site. Temporally diagnostic objects include a variety of projectile points, cogged stones, discoids, and stone beads.

Projectile Points

No projectile points were recovered during the current excavation, but more than 35 such specimens were found in previous archaeological work at this site. This collection included 23 Canaliño, 1 Cottonwood Triangular, 1 Gypsum Cave, 5 side-notched, 2 bipointed foliate, 1 convex-based, and 3 aberrant points. Freeman (1987:248) noted that the arrow (i.e., Canaliño and Cottonwood) points indicative of Late period (post-1000 B.P.) use were recovered from the upper 40 cm of the deposit, but the dart-sized points such as Gypsum Cave, bipointed, and convex-based, were located below 60 cm in depth. These latter types date to the Intermediate period (3000–1000 B.P.).

Cogged Stones and Discoids

Three land-and-groove cogged stones and one discoid were recovered as point-provenienced objects not associated with features. As noted above, regional chronological information suggests that cogged stones and discoids date to the Millingstone period (ca. 8500–3000 B.P.), and association of these artifacts with early southern California occupation may be supported in this case by the suite of radiocarbon dates indicating use during the early Millingstone period at LAN-64. Multiple components are represented at this site, however, so association of cogged stones or discoids with early use at this site remains equivocal.

Beads

The 33 stone beads recovered from LAN-64 include one Type IA1a, 26 Type IA1b, and five Type IA1c, as defined by Rigby (1987). Regional chronological data suggest that such beads date to ca. 2750–2150 B.P. Types co-occur in some features, which also suggests contemporaneity of these three types. Features containing beads included Features 52, 62, 64, 65, and 66, none of which have radiocarbon-datable material that could be used to confirm the age suggested by cross-dating.

Mortuary Practices

As noted above, both burial and cremation were practiced at different times along the southern California coast, with the latter introduced ca. 500 B.C. Mortuary features at LAN-64 consisted of nine burials. A radiocarbon date of ca. 1930 B.P. available for one of these features (Feature 56) was consistent with the burial data for nearby LAN-63 and the broader chronology of mortuary practices emerging for this portion of the southern California coast. That is, burial appears to have persisted here at least until ca. 1700 B.P., if not later. The presence of cremated human bone scattered throughout the cluster of burials on the west edge of the site suggested these burials may date later in time than Feature 56. The fact that this cluster of burials contained burials with cremated human bone in the fill, however, is difficult to state with certainty if the cremated remains are a different depositional episode entirely from the burials or not.

The radiocarbon-dated burial was a primary inhumation, oriented southwest and placed on its stomach. All of the remaining burials at this site were also primary interments, but all were flexed, all were either placed on a side or back, and most were oriented north or, to a lesser extent, northwest or west. It is interesting to note that Feature 56 was also distinct in terms of location, as this burial was placed in the southeastern site area at some distance from the other interments. This might have suggested temporal or social difference of this particular individual.

Summary

Three periods of use were indicated by the temporal data for LAN-64. An early Millingstone component (older than 6500 B.P.) component was indicated by radiocarbon-dated shell-dump features dating to ca. 7000 B.P. Even earlier use during this time may have been indicated by the radiocarbon dates for Feature 60, whereas Feature 50 suggested somewhat later deposition. Millingstone period use may also have been indicated by cogged stones and discoids, although the dating of such specimens remains problematic.

Radiocarbon dates for Features 17 and 56, as well as most of the obsidian hydration dates and practice of burial, indicated use during the Intermediate period. Unlike the similar component at LAN-63, however, dates for features span a longer and somewhat later time in the period. Obsidian hydration dates of Intermediate period age suggested an even broader span of use. Given that early use during the Intermediate period was only indicated by obsidian hydration dates for objects lacking geochemical information, however, caution is warranted in inferring prolonged use based on these data.

Late period use is indicated by the Cottonwood Triangular and Canaliño points recovered in the previous study at this site. The stratigraphic position of these tools indicated this occupation is restricted to the upper 40 cm of the deposit. One obsidian hydration date for a sample from the previous collection may also indicate this late use.

Temporal Data for LAN-206A

Very little temporal data are available for the current sample from LAN-206A, and previous excavations also failed to provide much temporal data from this deposit. No organic material suitable for radiocarbon dates was available, and only one temporally diagnostic artifact was recovered. Radiocarbon dates, obsidian hydration dates, and temporally diagnostic artifacts were recovered, however, from adjacent LAN-206 during previous excavations (Van Horn and White 1997c), and these results were considered in the temporal analysis of this site, since LAN-206A was a component of the primary site, LAN-206.

Temporally Diagnostic Artifacts

The only temporally diagnostic artifact recovered from LAN-206 was a cogged stone.

Cogged Stones and Discoids

One land-and-groove cogged stone was recovered during SRI's investigations. As noted above, regional chronological information suggests that cogged stones date to the Millingstone period (ca. 6500–3000 B.P.), although few have been found in direct association with radiocarbon-dated material.

Mortuary Practices

One burial (Feature 108) was observed at LAN-206A. This interment was too disturbed to determine posture or orientation. Given its position within the plow zone of the site, as well as the fragmentary nature of the burial, it was unclear if the human remains were in situ or not. We were assuming in terms of chronology that it was, indeed, in situ. As noted in "Mortuary Practices," above, the results for nearby sites LAN-63 and LAN-64, and ethnographic data (Kroeber 1925), indicated that burial was the common aboriginal mortuary practice until at least ca. 1700 B.P. Therefore, the presence of a burial at this site suggests deposition prior to this time, a conclusion that does not contradict the other, limited temporal information available for this site.

Summary

The equivocal dating for cogged stones in southern California undermined confidence in this artifact in recognizing a Millingstone period component at this site. In the absence of other temporally diagnostic artifacts or chronometric dates, the burial feature provided the only other chronological information for this site, although this only suggested likely deposition prior to ca. 1700 B.P.

Temporal data derived from previous study of nearby LAN-206 did little to clarify the situation, as no consistent period of use was indicated. A reservoir-corrected radiocarbon date of 6450 B.P. was reported by Van Horn and White (1997c:19), and an obsidian hydration rim of 7.785 μ on one flake suggested an age of ca. 3650 B.P. using Basgall's (1990) rate with a Malibu temperature correction (3158 cal B.P. using the calibrated rate formula presented here). One cogged stone and one discoid were also found at LAN-206, and Van Horn and White (1997c:10) noted a projectile point base that was too fragmentary to determine type size but appeared to be a dart point. The radiocarbon date, cogged stone, and discoids suggested a Millingstone period occupation, which may also be present at LAN-206A. The hydration age estimate and possible dart point base, however, suggested later use during the Intermediate period as well. There is no evidence of a contemporary component at LAN-206A.

Conclusions

In sum then, what could be said about the chronology of the West Bluffs sites? It is clear that the radiocarbon assays and obsidian hydration dates from the primary components of LAN-63 and LAN-64 from both the Van Horn and SRI excavations are generally similar. The primary component of occupation from both sites appears to be during the Intermediate period, although the time span at LAN-64 appeared to be sufficiently different from LAN-63 to indicate either more than one component of this age or a relatively longer span of time, somewhat younger than that has been recognized at LAN-63. Both the SRI and Van Horn excavations at LAN-206A uncovered only a single example of an artifact that could be dated typologically (a cogged stone), and nothing that could be physically dated (e.g., radiocarbon or obsidian hydration). The cogged stone from LAN-206A suggested a Millingstone period component, which complemented radiocarbon dates and other cogged stone artifacts from LAN-206. However, as was pointed out, few cogged stone artifacts have been found in a dateable context in southern California, which leads to equivocal dating for the site.

Perhaps one of the most striking aspects of the chronology of the West Bluffs sites was that both SRI and Van Horn's excavations identified components that the other investigators did not. In the case of LAN-63, Van Horn identified a Late period component, based primarily on projectile points, which SRI did not identify. Van Horn also recovered three Mission period glass trade beads, whereas the SRI excavations did not identify anything dating to that period, beyond a radiocarbon date from the low-lying depression immediately west of LAN-63, which does not appear to be related to occupation of any of the sites on the property. Alternatively, SRI identified a very early Millingstone period component to LAN-64, which Van Horn did not find. Although these dates at LAN-64 were not entirely unexpected, given its proximity to LAN-206, these radiocarbon dates were much older than those found by Van Horn at LAN-206. The type of shell found in these old features at LAN-64, primarily scallop, as Van Galder and her colleagues discussed in the invertebrate analysis (Chapter 11), coincides well with the reconstructed paleoenvironment for the Ballona Lagoon area as described by Wigand for this time period.

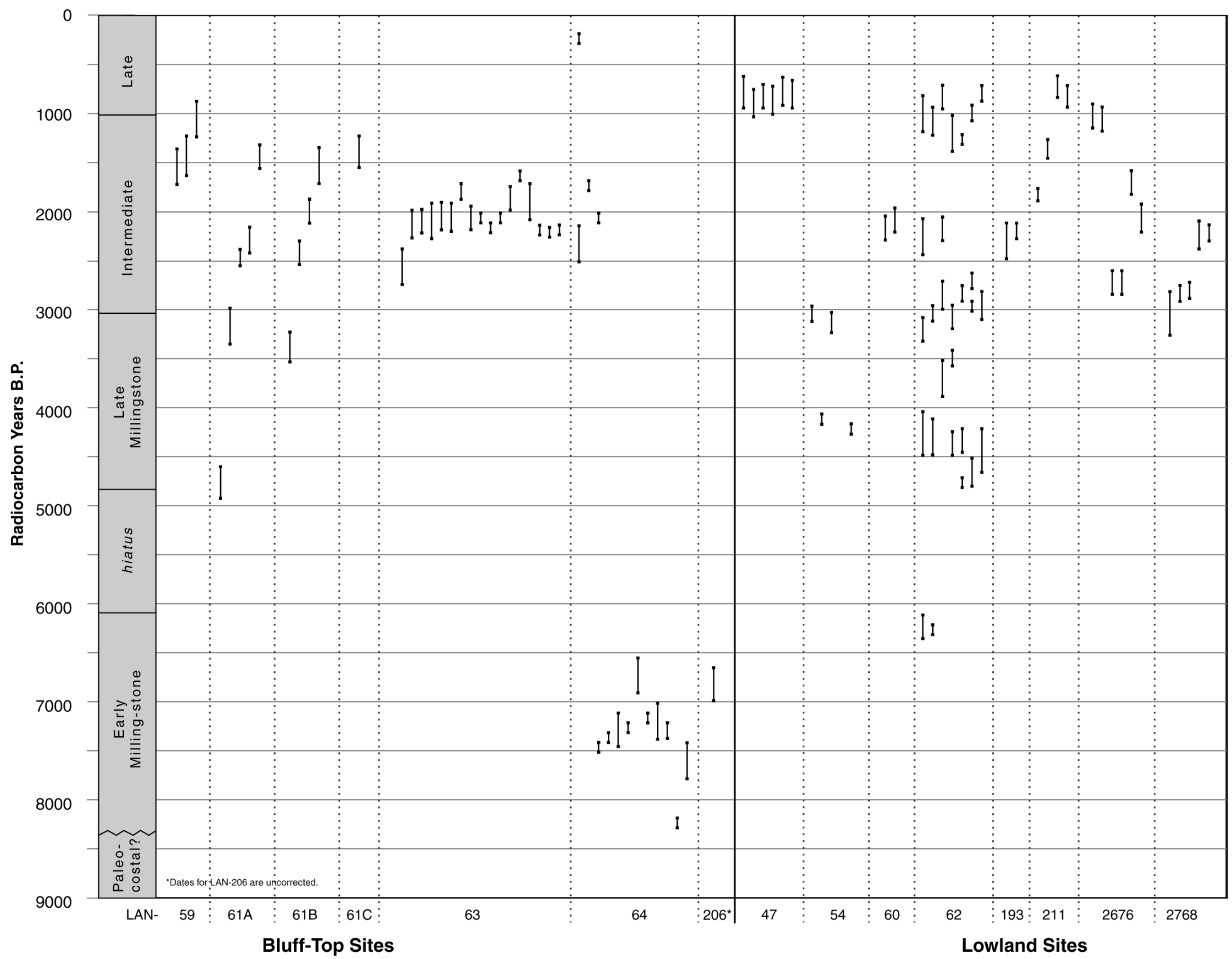


Figure 14.1. Radiocarbon dates for sites in the Ballona region, including new data from sites on the West Bluffs property.

Table 14.1. LAN-63 Radiocarbon Assays

PD	Context	Soil	Depth (m)	Sample No.	Radiocarbon Age	$^{13/12}C$ ratio	Conventional ^{14}C age	Calibrated Age		
								Intercept	68% Confidence	95% Confidence
133	U 36, L 1	A	0.10	197362	1990 ± 70	0.4	2410 ± 70 2190 ± 80[b]	A.D. 150	A.D. 80–260	B.C. 10–A.D. 360
159	U 36, L 9	A	0.90	197363	1860 ± 50	0	2270 ± 60 2050 ± 70[b]	A.D. 340	A.D. 250–420	A.D. 150–490
301	F 11	A	0.30	197364	1980 ± 60	-1.1	2370 ± 60 2150 ± 70[b]	A.D. 220	A.D. 130–280	A.D. 60–390
367	CC 1, L 2	A	0.20	195172	1690 ± 40	0.5	2110 ± 40 1890 ± 50[b]	A.D. 530	A.D. 450–580	A.D. 420–630
371	CC 1, L 6	A	0.60	195173	1720 ± 40	0.8	2140 ± 40 1920 ± 50[b]	A.D. 470	A.D. 430–550	A.D. 380–600
377	CC 1, L 12	A	1.20	195174	1660 ± 40	-1.0	2050 ± 40 1830 ± 50[b]	A.D. 590	A.D. 540–640	A.D. 460–670
3383	F 337	A	0.638	197365	1800 ± 60	-0.3	2210 ± 60 1990 ± 70[b]	A.D. 420	A.D. 330–470	A.D. 240–570
3403	F 340	A	0.624	197366	1720 ± 40	-0.5	2120 ± 40 1900 ± 50[b]	A.D. 510	A.D. 440–570	A.D. 400–620
4068	F 475 (burial)	A/B	2.052	195175	1510 ± 70	-0.4	1920 ± 80 1700 ± 90	A.D. 690	A.D. 630–780	A.D. 540–890
4078	F 480 (burial)	A/B	0.527	195176	1730 ± 40	0.3	2140 ± 40 1920 ± 50[b]	A.D. 470	A.D. 430–550	A.D. 380–600
4106	F 492 (burial)	A/B	0.317	195177	1710 ± 40	-0.3	2120 ± 40 1900 ± 50[b]	A.D. 510	A.D. 440–570	A.D. 400–620
4824	F 587	A	[a]ca. 2.40	195178	1720 ± 60	0.5	2140 ± 40 1920 ± 80[b]	A.D. 470	A.D. 400–580	A.D. 280–660

Note: All materials sampled were *Chione* and analyzed by Beta Analytic. PD = provenience designation; U = unit; L = level; F = feature; C = control column.

[a]The depth and elevation of F 587 is given for the *Chione* sample taken from it (U 210, L 5). The top of the feature (and the initial discovery depth) is 1.87 m below surface, 148.996.

[b]Adjusted for local reservoir correction.

Table 14.2. Radiocarbon Dates from Van Horn's (1987) Excavation at LAN-63

Provenience	Conventional Age[1]	Calibrated 1-Sigma Ranges	Calibrated 2-Sigma Ranges
U31, 190–200 cm	2020 ± 70 B.P.	A.D. 531–688	A.D. 431–753 A.D. 757–761
U26, 20–30 cm	2070 ± 60 B.P.	A.D. 484–637	A.D. 409–687
D8, 80–90 cm	2070 ± 90 B.P.	A.D. 457–654	A.D. 328–740
U26, 110–120 cm	2100 ± 70 B.P.	A.D. 444–612	A.D. 350–679
D8, 40–50 cm	2530 ± 90 B.P.	97 B.C.–A.D. 143	222 B.C.–A.D. 270

[1] Not adjusted for ΔR

Table 14.3. Obsidian Hydration Age Estimates for LAN-63

Catalog No.	Location	Source	Object	Hydration (μ)	Uncalibrated Age B.P. [a]	Calibrated Age B.P.[b]
1574	PP	WS	debitage	5.3	1496	1464
1575	F587/TP207/L5	WS	debitage	6.2	2152	2003
1576	F587/TP207/L5	WS	debitage	5.9	1918	1814
1623	F587/TP222/L2	WS	debitage	4.8	1189	1200
1624	PP	WS	debitage	6.5	2402	2201
1625	TP3/L5	WS	debitage	6.7	2577	2339
1626	PP	WS	debitage	6.6	2488	2270
1684	PP	WS	biface	4.2/4.2	872/872	919/919
1685	PP	MGM	biface	4/4		
1686	PP	WS	biface	4.9/5	1247/1307	1251/1303
1687	PP	WS	biface	2.6/3.8	287/691	352/752
1688	PP	CD	biface	4.1/4.7		1805/2371

[a]Based on Basgall (1990) with the temperature correction for Malibu.

[b]Based on the recalculation of the INY-30 data presented here.

Key: WS = Coso (West Sugarloaf); MGM = Mono Glass Mountain CD = Casa Diablo.

Table 14.4. Obsidian Hydration Age Estimates for the Previous Study at LAN-63

Object	Trench, Unit	Hydration (μ)	Uncalibrated Age B.P.[a]	Calibrated Age B.P.[b]
Debitage	A, 1	4.7	1132	1151
Debitage	A, 1	9.2	5377	4410
Debitage	A, 1	9.2	5377	4410
Debitage	A, 3	8.3	4235	3589
Debitage	A, 5	6.5	2402	2201
Debitage	A, 5	8.3	4235	3589
Debitage	A, 5	20.0	32,579	20,841
Debitage	A, 6	7.3	3144	2777
Debitage	A, 7	6.0	1995	1876
Debitage	A, 7	7.0	2852	2553
Debitage	A, 8	6.0	1995	1876
Debitage	A, 9	5.6	1700	1634
Debitage	A, 9	6.3	2234	2068
Debitage	A, 12	6.5	2402	2201
Debitage	A, 14	4.7	1132	1151
Debitage	A, 14	5.3	1496	1464
Debitage	A, 14	5.4	1562	1519
Point	A, 14	8.8[d]	4850	4035
Debitage	A, 15	6.6	2488	2270
Debitage	A, 15	7.0	2852	2553
Debitage	A, 16	6.6	2488	2270
Debitage	A, 19	5.6/6.3	1700/2234	1634/2068
Debitage	A, 21	6.3	2234	2068
Debitage	A, 21	6.5	2402	2201
Debitage	A, 22	4.7	1132	1151
Debitage	A, 25	6.0	1995	1876
Debitage	A, 26	6.5	2402	2201
Debitage	B, 6	4.2/4.7	872/1132	919/1151
Debitage	B, 6	6.0	1995	1876
Debitage	B, 7	7.2	3045	2701
Debitage	B, 15	5.5/6.2	1630/2152	1576/2003
Debitage	B, 15	6.9	2759	2481

Object	**Trench, Unit**	**Hydration (μ)**	**Uncalibrated Age B.P.**[a]	**Calibrated Age B.P.**[b]
Debitage	B, 18	6.0	1995	1876
Debitage	B, 18	6.8	2667	2409
Point	B, 26	4.42[c]	982	1018
Debitage	B, 27	3.6	610	675
Debitage	C, 5	7.4	3245	2853
Debitage	C, 8	5.1	1368	1355
Debitage	C, 8	6.3	2234	2068
Debitage	C, 8	14.1	14479	10359
Debitage	C, 27	4.2	872	919
Debitage	C, 27	5.4	1562	1519
Debitage	C, 27	7.3	3144	2777
Debitage	C, 28	5.0	1307	1303
Debitage	C, 28	6.1	2073	1939
Debitage	C, 28	6.1	2073	1939
Debitage	C, 28	7.5	3347	2931
Debitage	D, 5	5.1	1368	1355
Debitage	D, 5	6.6	2488	2270
Debitage	D, 6	5.45	1596	1548
Debitage	D, 6	6.25	2193	2035
Debitage	D, 6	6.5	2402	2201
Debitage	D, 6	7.07	2919	2604
Debitage	D, 7	4.3	921	963
Debitage	D, 7	5.6	1700	1634
Debitage	D, 8	5.3	1496	1464
Debitage	D, 8	6.85	2712	2445
Debitage	D, 8	18.4	26,849	17,640
Debitage	D, 9	5.7	1771	1693
Debitage	D, 9	5.9	1918	1814
Debitage	D, 9	6.2	2152	2003
Debitage	D, 10	5.0	1307	1303
Debitage	D, 10	5.9	1918	1814
Debitage	D, 11	6.6	2488	2270
Debitage	—, 33	6.7	2577	2339

Object	Trench, Unit	Hydration (μ)	Uncalibrated Age B.P.[a]	Calibrated Age B.P.[b]
Debitage	—, 34	4.5	1023	1055
Debitage	—, 34	5.2	1431	1409
Debitage	—, 34	7.8/9.2	3666/5377	3170/4410
Debitage	—, 37	5.5	1630	1576
Debitage	—, 48	6.3	2234	2068

[a]Based on Basgall's (1990) rate, with the temperature correction for Malibu.

[b]Based on the recalculation of the INY-30 data presented here.

[c] This result was reported as 4.75μ by Freeman and Van Horn (1987:99), which results in an age estimate of ca. 1160 B.P. using Basgall's (1990) rate and 1175 cal B.P.

[d] This result was reported as 8.7μ by Freeman and Van Horn (1987:104), which results in an age estimate of 4723 B.P. using Basgall's (1990) rate and 3944 cal B.P.

Table 14.5. LAN-64 Radiocarbon Assays

PD	Context	Material	Soil	Depth (m)	Sample No.	Radiocarbon Age	$^{13/12}C$ ratio	Conventional ^{14}C age	Calibrated Age		
									Intercept	68% Confidence	95% Confidence
62	CC 1, L 9 (depression)	charcoal	A	0.90	195169	210 ± 40	24.3	220 ± 40	A.D. 1660	A.D. 1650–1670 A.D 1770–1800 A.D. 1940–1950	A.D. 1640–1680 A.D. 1730–1810 A.D. 1930–1950
1065	F 17	*Chione*	A	0.157	197367	1370 ± 40	-0.2	1780 ± 40 1560 ± 50[b]	A.D. 830	A.D. 780–900	A.D. 720–960
1197	F 45	*Argopecten*	[a]B	0.73	197368	7070 ± 40	-0.2	7480 ± 40 7260 ± 50[b]	B.C. 5750	B.C. 5800–5710	B.C. 5860–5670
1197	F 45	*Chione*	[a]B	0.73	197369	6970 ± 40	-0.2	7380 ± 40 7160 ± 50[b]	B.C. 5670	B.C. 5710–5630	B.C. 5750–5600
1236	F 49	*Chione*	[a]B	1.052	195170	6780 ± 90	0	7190 ± 90 6970 ± 100[b]	B.C. 5510	B.C. 5610–5450	B.C. 5680–5340
1236	F 49	*Argopecten*	[a]B	1.052	197370	6840 ± 40	1.5	7270 ± 40 7050 ± 50[b]	B.C. 5600	B.C. 5620–5540	B.C. 5660–5480
1241	F 50	*Argopecten*	[a]B	0.625	197371	6360 ± 120	0	6770 ± 130 6550 ± 130[b]	B.C. 5100	B.C. 5270–4940	B.C. 5370–4780
1241	F 50	*Chione*	[a]B	0.625	197372	6770 ± 40	0.5	7180 ± 40 6960 ± 50[b]	B.C. 5500	B.C. 5550–5470	B.C. 5600–5440
1249	F 55	*Argopecten*	[a]B	1.323	197373	6750 ± 100	0.5	7150 ± 110 6930 ± 120[b]	B.C. 5480	B.C. 5600–5370	B.C. 5680–5280
1259	F 55	*Chione*	[a]B	1.323	197374	6830 ± 50	0.8	7250 ± 50 7030 ± 60[b]	B.C. 5560	B.C. 5620–5510	B.C. 5660–5470
1260	F 56 (burial)	*Chione*	A/B	1.312	195171	1740 ± 40	0.1	2150 ± 40 1930 ± 50[b]	A.D. 460	A.D. 420–540	A.D. 360–590
1343	F 60	*Chione*	[a]B	0.955	197375	7910 ± 40	-3.5	8260 ± 40 8040 ± 50[b]	B.C. 6520	B.C. 6590–6460	B.C. 6640–6430
1343	F 60	*Argopecten*	[a]B	0.955	199066	7170 ± 110	-3.4	7530 ± 110 7310 ± 120[b]	B.C. 5800	B.C. 5960–5940 B.C. 5920–5700	B.C. 6030–5610

Note: All materials sampled were analyzed by Beta Analytic. PD = provenience designation; L = level; F = feature; CC = control column.

[a]All shell dump features (Features 45, 49, 50, 55, 60) were identified in the B horizon. It is assumed all of these features were intrusive into the B from the A horizon, although no pits were identified.

[b]Adjusted for local reservoir correction

Table 14.6. Obsidian Hydration Age Estimates for Previous Study at LAN-64

Object	Trench	Unit	Depth (cm)	Hydration (µ)	Uncalibrated Age B.P.[a]	Calibrated Age B.P.[b]
Debitage	E	28		2.5	262	326
Debitage	E	28		4.7	1132	1151
Debitage	E	16		5.0	1307	1303
Debitage	E	21		5.2	1431	1409
Debitage	E	7		5.6	1700	1634
Debitage	E	24		5.8	1844	1753
Debitage	E	32		7.4	3245	2853
Debitage	E	16		7.4	3245	2853
Debitage	E	30		7.4	3245	2853
Debitage	E	24		7.4	3245	2853

Chapter 15

Subsistence and Settlement

Sarah J. Van Galder and Richard Ciolek-Torrello

Fifteen years ago, SRI researchers identified two major themes to guide archaeological research in the Ballona region (Altschul et al. 1991). The first concerned prehistoric human-land relationships. Specifically, SRI researchers were interested in the evolution of the Ballona lagoon and its effect on subsistence-and-settlement patterns over time. The second theme concerned cultural history and cultural dynamics of prehistoric settlement in the Ballona region. These two broad research goals are also the main themes that have guided our research in the West Bluffs area.

In this chapter, we bring together a variety of data to address these two themes at West Bluffs and in the Ballona area. Subsistence data were derived primarily from several types of archaeological remains that people used to procure, process, and consume food. These data included recovered vertebrate and invertebrate faunal remains, botanical remains, and tools and facilities—such as flaked and ground stone tools and cooking features. Nondestructive analysis of human remains also provided data on diet and disease. The collections obtained during the 2000 and 2003 field seasons are the primary data we use in this chapter, although the results of Van Horn's 1980s excavations are considered here as well. Where appropriate, we also present the results from recent excavations at other sites throughout the Ballona. These data provide a comparative framework that places the West Bluffs sites into a broader regional context and help us to better understand the subsistence-and-settlement patterns evident in the prehistoric record of the West Bluffs area.

In 1990, Altschul and Ciolek-Torrello (1990; see also Altschul et al. 1993) presented SRI's initial model of subsistence and settlement in the Ballona wetlands. We argued that changes in human use of the area were tied directly to the evolution of the wetlands. When humans first ventured into the region, the Ballona was part of Santa Monica Bay. These early visitors were transitory and confined their stays to the only stable landforms, which at this early date in the evolution of the Ballona we believed were restricted to the tops of the Westchester Bluffs. As the open bay gradually became a closed lagoon and floral and faunal resources of the Ballona became more attractive to humans, we argued that seasonal settlements were established along the length of the bluff tops. As sediments gradually filled the lagoon, marshes formed along the edges of the lagoon. Eventually these marshes developed into a resource-rich estuarine environment, and the inhabitants of the Ballona forsook their scattered bluff-top settlements for larger settlements along the edges of the lagoon, where they had direct access to the food resources of the lagoon.

In the course of our work at West Bluffs, we have demonstrated that the broad outlines of this model are correct. We found, however, that the timing and nature of environmental and cultural events were quite different from what we expected. At the onset of the West Bluffs project, two of these events had emerged as central to our research in the Ballona and are of special significance to the West Bluffs area. The first event occurred between 3000 and 1000 B.P., a time defined as the Intermediate period, when people first established what we believed were semipermanent settlements in the Ballona. We originally suspected that the Intermediate period was characterized by an open lagoon and a settlement pattern restricted to the bluff tops. We envisaged that population grew in step with the increasing diversity and density of wetland resources (Altschul and Ciolek-Torrello 1990).

Our initial research in the Ballona revealed problems with this concept; the lagoon formed several thousand years earlier than the onset of the Intermediate period and the population influx during this period was sudden and widespread, encompassing the banks of Centinela Creek as well as the bluff tops (Altschul et al. 2005; Ciolek-Torrello 2000). More problematic was the discovery that the faunal collections recovered from our initial excavations along Centinela Creek were quite distinct from those Van Horn collected from contemporaneous bluff-top sites, reflecting subsistence patterns that were counterintuitive to the environmental locations from which the collections were obtained. Van Horn's collections from the bluff tops revealed a subsistence focus on lagoonal resources, with an emphasis on fish that could be caught in shallow lagoon waters, especially cartilaginous varieties, and invertebrates. In contrast, our collections from Centinela Creek revealed a more terrestrial focus, with a high incidence of terrestrial fauna and much lower frequencies of piscine and invertebrate species (Becker 2003; Maxwell 2003). Three hypotheses emerged to account for this archaeological record: (1) desert peoples migrated to the Ballona and established an enclave along Centinela Creek, while indigenous coastal residents occupied the bluff tops; (2) two different social groups from the same general population occupied the Ballona during the Intermediate period, occupying different site locations and following different subsistence practices; or (3) bluff-top and creek-side occupations were not actually contemporaneous, occurring either at different times in the Intermediate period or representing different seasons of occupation. We also suspected that the radically different collections from creek-side and bluff-top sites might be the product of different sampling methods and analytical approaches. Thus, one of the major research objectives of our West Bluffs investigations was to determine whether we could replicate Van Horn's results, and, if so, address these three alternative hypotheses.

The second important event that emerged from our initial investigations in the Ballona related to the abandonment of the bluff tops and the upper portion of Centinela Creek edge around 1000 B.P., a time when the wetlands had reached maturity and remained attractive to humans. This abandonment, then, did not seem to have an environmental cause. We initially suspected that during the Late period, or between 1000 B.P. and the arrival of Europeans, the previously dispersed population of the Ballona aggregated into a village situated closer to the edge of the lagoon (Altschul and Ciolek-Torrello 1990). This development is certainly in accordance with ethnohistorical accounts of settlement trends in the greater Los Angeles Basin region (see Bean and Smith 1978). Another hypothesis is that the population remained dispersed as it had been during the Intermediate period, but that it rearranged itself into relatively small camps along the edge of the lagoon. Finally, it is possible that the Ballona was largely abandoned at this time and was used only periodically by small groups. Our recent research, however, revealed a substantial occupation from the lower reaches of Centinela Creek to the edge of the lagoon that persisted from the beginning of the Late period to the early historical period (Altschul et al. 2003; Vargas et al. 2005). Preliminary results of subsistence studies suggest that inhabitants of this late occupation of the Ballona practiced a much more diversified subsistence pattern than that which characterized the Intermediate period (Altschul et al. 2005).

We address the various research issues and hypotheses relating to these two major events in more detail in the remainder of this chapter. In the first section, we review the reconstruction of the Ballona's physical development from an open bay to the wetlands of today and look at the types of habitats and resources that may have been available to the prehistoric residents of the area. Next, we address the types of subsistence remains found at West Bluffs sites and inferred resource utilization by the residents of these sites. We then discuss the procurement and processing methods used by the prehistoric West Bluffs inhabitants. Next, we compare the remains from the West Bluffs sites to that of other sites within the Ballona. Specifically, we compare the subsistence patterns between the bluff-top and lowland sites. Also discussed is the changing subsistence patterns in relation to the Ballona lagoon development. The last section discusses the implications of these data on our interpretations of the nature and intensity of prehistoric settlement at West Bluffs and in the Ballona.

Environmental Reconstruction

The reconstruction of the evolution of the lagoon is largely complete after a 10-year study, the results of which are presented by Homburg and Palacios-Fest (2005). This reconstruction presents a context for the discussions that follow. The resources available for prehistoric subsistence were directly related to the environmental parameters at any given point in time. Subsistence changes inferred from the archaeological record may be a direct reflection of a changing environment. Over the past 10 years the SRI paleoenvironmental team, led by Jeffrey Homburg, has conducted extensive research to reconstruct the past Holocene environments of the Ballona estuary and the surrounding area. Homburg and his team's primary research goals include identifying and interpreting natural earth processes associated with the formation and alteration of the archaeological record and reconstructing how the landscape evolved over time during different occupations (Homburg and Ferraro 1998:47; Shelley et al. 2003:77). Below is a description of the changing lagoon environment and the terrestrial environment surrounding West Bluffs.

Estuary Development

Shelley et al. (2003) discussed the Ballona lagoon in detail. Researchers have reconstructed the environmental history of the Ballona lagoon based on diatoms, foraminifera, ostracode, algae, and aquatic plants collected from a series of cores (see Chapter 12). The Ballona Lagoon changed dramatically throughout the Holocene: Salinity levels rose and fell; habitable landforms emerged, subsided, and were inundated; and plant and animal species appeared, flourished, and disappeared (Shelley et al. 2003).

The sea level in the Ballona 7,000 years ago was 10 m below present levels and the shoreline was at least 500 m seaward of its present location (Shelley et al. 2003:Figure 33). At this time, the Ballona was an open bay into which the Ballona Creek and Los Angeles River drained. Over the last 7,000 years, the bay has continued to fill in, changing its entire character as well as the habitats for plants and animals. Around 5,000 years ago, Ballona Bay collected runoff from the Los Angeles River and Ballona Creek drainage systems. As sediment from these large drainage areas accumulated in the bay, bars and spits began to develop, dividing it into an outer and inner bay. By 4,000 years ago, fluvial sediment input continued to cause alluviation of the inner bay, a saltwater marsh expanded to both sides of the bay, a beach spit barrier formed across the mouth of the outer bay, and sediment began to fill the outer bay. The amount of fresh water increased in the bay as the beach spit barrier blocked its outflow as well as the influx of ocean water. By 3,000 years ago, the inner bay had filled in beneath intertidal deposits of sand and mud, restricting open water to the outer bay. The salt marshes continued to expand during this time. By 2,000 years ago, the salt marsh began to cover much of the bay, while the coastal plain began to encroach on the salt marsh along the northern margin of the bay. An extensive intertidal, unvegetated mudflat developed in the remaining part of the bay. By 1,000 years ago, the salt-marsh islands and intertidal mudflats had increased. About this time, a double barrier formed between the ocean and the bay.

Plant Community Development

Terrestrial plant communities within the Ballona area also fluctuated throughout the Holocene in response to changing temperatures and precipitation levels. Wigand discusses the plant community variability in detail in Chapter 12. At the end of the Pleistocene, the Ballona area was dominated by a sagebrush steppe habitat with few grasses. During the early Holocene, precipitation increased, particularly during the winter months. By 8,000 years ago, during a period of increased precipitation and warmer temperatures, mixed chaparral vegetation established itself in the Ballona, replacing the sagebrush steppe habitat that previously occupied the area. By 6,000 years ago, when we find the first evidence of human occupation, precipitation began to decrease, as did the chaparral species. Precipitation continued to decrease until about 2,500 B.P., a time that corresponds with the early part of the Intermediate period. At this time, there was an expansion of pine and sagebrush. Between 2200 and 2000 B.P., there was a brief increase of sagebrush triggered by a pulse of winter rainfall. About this time, the vernal pools located in the Los Angeles Prairie south of the West Bluffs reached their maximum, providing a vast freshwater environment (see Chapter 12). Wigand notes three shifts in vegetation in the last 500 years of prehistory. Between 500 and 300 years ago, during a period known as the Little Ice Age, plants from the mint family were dominant. During the peak of the Little Ice Age, ceanothus became most common. During the last 200 years, sagebrush increased throughout the region at the expense of both mint and ceanothus (see Chapter 12).

Available Environments and Resources

The West Bluffs sites were located in an ecotone between the Los Angeles Prairie, the Ballona Lagoon, and the riparian woodlands along Ballona Creek and the Los Angeles River. Thus, the occupants of the West Bluffs had access to a wide variety of resources from these environments. Resources collected ethnographically by the Gabrielino included a wide variety of fish and invertebrate animals, small and large mammals (both terrestrial and marine), aquatic and terrestrial birds, and reptiles (Harrington 1934, 1942; Heizer 1968; Koerper 1981; McCawley 1996; Reid 1926). Depending on the varying environment, some resources were more convenient to collect at certain periods during prehistory.

A wide variety of plants was available to West Bluffs occupants, particularly during the Intermediate period, 2,000 years ago, when the coastal prairie extended 95 km^2 to the south and southeast of the site. This habitat consisted of a wide variety of grasses and herbaceous species from pond-edge and vernal pool habitats.

Hordeum pusillum (little barley) and *Leptochola* sp. (strangletop), both of which were found in the seed collection from West Bluffs, grow only around vernal pools in open prairies. Ethnographic accounts suggest that the Gabrielino hunted pronghorn, which typically prefer open prairie or desert environments. Three Ballona sites contained the remains of pronghorn. However, although pronghorn are most common in the Great Basin and eastern Sierra Nevada (Jameson and Peeters 1988; Lubinski 1999), it is unclear whether these animals were available along the California coast during the Holocene. Mule deer, which were also found at several of the Ballona sites, prefer more open, rugged habitats, but also may have been attracted to the riparian habitat along the creeks (Verts and Carraway 1988). Rabbits and rodents, which were identified in the West Bluffs vertebrate collection, can be found in a variety of habitats.

Wigand (see Chapter 12) reports remains from both the aster and chenopod plant families in the West Bluffs collection. Plants from the aster family, particularly *Baccharis* sp., were found in the riparian areas below the West Bluffs sites, in the coastal chaparral on the bluffs, and in the Los Angeles Prairie south of the sites. Chenopods grow both in the Ballona estuary and on the bluffs. People may have exploited these resources; however, Wigand notes that these plants could have occurred in the windfall naturally.

The majority of the fish from the West Bluffs collections could be found in the Ballona Bay. A few species, such as gulf grunion, were most likely found along sandy beaches; others, such as yellowtail, salema, and Pacific-chub mackerel, were found in deep-water habitats. Almost all of the shellfish species identified from the West Bluffs sites also could be found in Ballona Bay or the lagoon. However, abalone would have been most abundant along rocky shores in intertidal or moderately deep water.

Subsistence at the West Bluffs Sites

The remains from the three West Bluffs sites reflect different subsistence strategies, suggesting that these sites may have been used for slightly different reasons. Remains from LAN-63 indicate that the occupants had a generalized subsistence strategy during the Intermediate period. Whereas 67 percent of the vertebrate remains recovered were from mammals, these included remains from all sizes of mammal. An abundance of shellfish remains from the site indicates that these were a popular food item as well. Although botanical remains were poorly preserved, the high number of ground stone tools recovered from the site—including mortars, pestles, manos, and metates—indicate that these inhabitants were likely processing seeds, roots, and tubers. Van Horn (1987) also reported an abundance of vertebrate, invertebrate remains, and ground stone. Of the animal remains, mammals likely provided the majority of calories for the LAN-63 occupants. Although shellfish and fish remains were abundant, a single shellfish or fish did not provide nearly the amount of meat as even a small to medium-sized mammal. Because of preservation issues, it is unknown how much plants contributed to the diet.

The remains from LAN-64 reveal a slightly different pattern. Mammal remains represented 94 percent of the vertebrate fauna. Fifty-seven percent of these were large-mammal remains, and another 14 percent were from medium-sized to large mammals. The site also contained shellfish remains and ground stone, but not nearly as much as were recovered from LAN-63. Very little shell was recovered from the Intermediate period deposits. Van Horn (1987) also reported few shellfish remains during the 1980s excavations. As with LAN-63, the Intermediate period deposits were dominated by Venus clam remains whereas scallop dominated the Millingstone period deposits at LAN-64.

Only 20 vertebrate faunal bones were recovered from LAN-206A, all of which were large-mammal remains from surface deposits. One identifiable horse bone was recovered from the site. It is possible, if not likely, that all of these large-mammal remains belonged to a single horse and were probably not related to prehistoric subsistence activities at the site. No shellfish or fish remains were recovered from LAN-206A during SRI's 2000 and 2003 excavations. Recovered manos and metates indicate that the processing of plants, shellfish, or small mammals occurred at the site, however. Although we obtained no radiocarbon dates from LAN-206A, the ground stone tools were recovered in subsurface deposits that likely dated to the late Intermediate period (Van Horn 1987), and they were probably older than the large-mammal bone. Van Horn believed LAN-206A related to the later components of the Berger Street site (LAN-206) based on the lack of marine shell, which was abundant in earlier deposits at the Berger Street site, and the presence of an obsidian flake and three red ochre pieces. Dating a site based entirely on the lack of shell is a difficult is difficult to justify, however. Certainly, as discussed in Chapter 14, the locations of features at LAN-206A along Hastings Canyon may suggest a contemporaneous occupation with the Intermediate component of LAN-64, located on the other side of the canyon. At the same time, as also pointed out in Chapter 14, arguably there were Millingstone period artifacts found during the controlled grading of LAN-206A. As a result, it is unclear to which time period LAN-206A dates.

The resources recovered from the West Bluffs sites could have been and likely were procured within a localized area. As discussed earlier, the sites were located in an ecotone that provided an abundance of resources. A great variety of marine resources was available in the Ballona Lagoon, on nearby beaches, and in offshore waters. Terrestrial and riparian resources would also have been abundant in the salt marshes along the edge of the lagoon, along Ballona and Centinela Creeks, and around the vernal pools of the coastal prairie. Occupants need not have traveled more than 15-25 km to gather or hunt their food. The exploitation of resources seems to have been opportunistic rather than planned. Although ethnographic accounts indicate that the Gabrielino often scheduled deer and rabbit drives and took wood plank canoes on deep-water fishing trips (Koerper 1981), there was no evidence of this in the West Bluffs collections even though remains of fish, rabbits, and deer were abundant in our West Bluffs faunal collection. No nets for fishing or rabbit drives were recovered, although nets were made of fibrous material and likely would not have preserved well when compared to other types of archaeological remains. The presence of steatite artifacts, presumably from the Channel Islands, suggests either ocean voyages by the inhabitants (and thus availability of deep-water canoes for fishing) or trading by the occupants of the West Bluffs sites for these items. Similarly, no evidence of prehistoric boats has been recovered so far from within the Ballona, except for possible fragmentary remains of a *tomol* from the Mission period burial area at LAN-62. It is probably safe to say, however, that boats would have been left close to the lagoon or ocean shore rather than been hauled up to the top of the bluffs. Finally, we found no evidence of large refuse deposits of one particular resource type that might reflect intensive resource exploitation.

Procurement and Processing

Detailed descriptions of the various methods the Gabrielino used to procure and process food are given in ethnographic accounts (Harrington 1934, 1942; Heizer 1968; Koerper 1981; McCawley 1996; Reid 1926). Prehistoric populations likely did not use all of the same methods that were used by the Gabrielino. Over time, the Ballona area has been subject to population shifts (Altschul et al. 1998; Ciolek-Torrello et al. 2000) and likely evolving procurement and processing methods; however, we expect some similarities between populations exploiting similar resources in similar environments. The remains of many of the same resources discussed in these ethnographic accounts were recovered at the West Bluffs sites.

The relative amount of each resource type used by coastal Luiseño has been estimated by several authors and synthesized by Koerper (1981) (Table 15.1). Based on the recovered archaeological remains from sampled contexts, it appears that mammals were the most sought-after food type. Plant resources do not preserve as well as vertebrate and invertebrate remains, however. Wigand (see Chapter 12) notes that botanical remains, particularly pollen, are not well preserved in the West Bluffs sediments. Beals and Hester (1974) estimated that botanical resources comprised as little as 15 percent of Gabrielino subsistence. However, Bean and Shipek (1978) estimated that botanical resources possibly composed between 50 and 90 percent of Gabrielino subsistence. In any case, plant resources likely comprised more of the diet than what is represented in the archaeological record at West Bluffs.

Although botanical remains were not well preserved at West Bluffs, Wigand (see Chapter 12) does mention a few plant types recovered from the West Bluffs sediments that were used ethnographically, including plants from the Onagraceae and Asteraceae families, sagebrush, devil's claw or devil's horn, and a variety of grasses. In addition, many ground stone types were recovered from LAN-63 and LAN-64, as was one digging-stick weight from LAN-63. The quantity of these tool types suggests that people relied heavily on plants as a food source. Generally, roots, tubers, and acorns were processed using a mortar and pestle, and seeds were ground with a mano and metate (Koerper 1981). Koerper (1981) reported that the Gabrielino utilized a variety of greens, bulbs, roots, fruits, and seeds. Acorns were particularly sought after and were gathered from scrub oak along the creeks (Reid 1926). Reid (1926) also reported that the Gabrielino targeted fruit from the mountain cherry trees, seeds from pepper grass, stalks of wild sage, and several kinds of berries and roots. The Gabrielino stored seeds in granaries consisting of interlaced brush and twigs that ranged in size between 2 and 6 feet in diameter or in caves or rock recesses (Koerper 1981).

Shellfish remains were recovered from both LAN-63 and LAN-64; however, none was found at LAN-206A during Van Horn's excavations in the 1980s or during SRI's excavations in 2000 and 2003. Venus clam made up the majority of the shellfish at LAN-63 during the Intermediate period. Venus clam and scallop were both important invertebrate resources at LAN-64 during different periods—scallops during the Millingstone period and Venus clams during the Intermediate period. Reid reported that, ethnographically, shellfish constituted part of the principal diet for the Gabrielino of the coast and islands

(Heizer 1968:33). Few ethnographic sources discuss shellfish-procurement and -processing methods (Koerper 1981). However, Venus clams burrow just under the mud or sand on tidal flats. They are easily collected by digging at low tide when tidal flats are exposed. The two species of scallop present at LAN-64 typically are found 1–60 m beneath the bottom of the ocean or bay floor (Morris et al. 1981) and therefore are not as easy to collect as Venus clams are.

SRI recovered a large number of fish bone from LAN-63 and only a few fish bones from LAN-64 during the 2000 and 2003 field seasons. Van Horn's team recovered more fish bones than SRI at both LAN-63 and LAN-64; however, they also found much less fish bone at LAN-64 relative to LAN-63. One possible gorge was recovered from LAN-63. The Gabrielino used a variety of tools for fishing, including fish nets of raw nettle hemp, stitched gill nets, hooks with lines made from agave fiber, harpoons, and *Haliotis* fishhooks (Koerper 1981). They also had plank canoes with paddles, which they used for fishing. There are little ethnographic data on the processing methods used to prepare fish.

Very few remains of amphibians, reptiles, and birds were recovered from the West Bluffs sites. The Gabrielino did eat a variety of reptiles and birds. Koerper (1981) reported that the Gabrielino exploited a variety of wild fowl. These were caught with many of the same tools used to catch small mammals, such as nets, bows and arrows, and sticks (Koerper 1981). Reid (1926) and Engelhardt (1973) both reported that the Gabrielino ate snakes. However, according to Reid, they did not eat rattlesnakes. Maxwell (2003) reported that burnt rattlesnake vertebrae were recovered from LAN-211; he suspected that these snakes were used ritually at the site.

A variety of large- and small-mammal remains was recovered from LAN-63 and LAN-64. In addition, several projectile points were recovered from both LAN-63 and LAN-64, which also indicates that West Bluffs inhabitants hunted animals. Koerper (1981) reported that ethnographically the Gabrielino used bows and arrows and spears for hunting mammals. Stone projectile points were usually used for killing larger mammals (Koerper 1981). The Gabrielino also used harpoons, spear throwers, and clubs for hunting marine mammals (Bean and Smith 1978). Small mammals were hunted with throwing clubs or sticks, nets, pole snares, slings, deadfall traps; by game calls and wearing down the animal by a foot pursuit; or by communal drives (Koerper 1981). Burrowing animals were smoked from their holes and clubbed to death (Bean and Smith 1978).

Ethnographically the Gabrielino processed small and large mammals in a variety of ways, depending on the size of the animal. Small mammals were broiled on hot coals, cooked in earth ovens, or roasted over open fires. Often, small mammals, including mice, squirrels, and even rabbit-sized animals, were pounded, bones and all, with a mortar and pestle (Koerper 1981). Archaeological evidence supports this activity. Yohe et al. (1991) reported that ground stone from two Southern California sites, Las Montañas in San Diego County and SBR-6179 in San Bernardino County, had traces of rodent immunoglobins on their surfaces. After the whole animal was cooked, they might have been pounded in a mortar and eaten or stored until needed (Koerper 1981). Sometimes the pulverized bones were made into soup. Venison was cooked like smaller game: sun dried or boiled in water (Koerper 1981). After cooking in an earth oven, the meat might be finely pounded in a mortar and stored. The Gabrielino also extracted marrow and rendered grease from large animal bones, particularly long bones.

The bone collections from the West Bluffs sites are highly fragmented. Some of the processing techniques mentioned above likely contributed to this fragmentation. Marrow was extracted using one of two methods—by fracturing off the two epiphyses and poking marrow out of the remaining diaphysis cylinder or breaking the long bones mid-shaft to extract the marrow (Outram 2001). Grease rendering required further fragmentation of the articular ends and axial elements (Outram 2001). These elements were smashed into small pieces and then boiled in water. The grease floated to the top, where it could be solidified and extracted by cooling (Binford 1978). If neither bone marrow nor bone grease had been exploited, the only human-caused damage to the bones would result from killing the animal, butchering it, and possibly processing some elements for craft purposes (Outram 2001). A grease rendered assemblage will consist of many small pieces of unburnt animal bone (Vehik 1977). Secondary evidence included grooved mauls, hammer stones, anvil stones, firepits, burnt or unburnt boiling-sized stones. However, the more permanent a settlement or the more frequently used a settlement area was, the more likely it was that the equipment and bone fragments would become disassociated, not only from each other but also from the area of the activity in which they were being used (Vehik 1977).

It has been argued that bone marrow and grease were processed during times of cross-cultural stress (Binford 1978). However, ethnographic sources report that the Gabrielino used bone marrow and grease throughout the year for a variety of purposes, not only as food but also for animal-skin dressings and hair grease (Koerper 1981).

Bluff-Top and Lowland Sites

Based on his work at West Bluffs during the 1980s, Van Horn (1987) hypothesized that the bluff-top sites were small temporary camps used primarily for resource procurement. However, we found a wide range of resources at both LAN-63 and LAN-64, large numbers of food-processing facilities and extensive refuse deposits, a number of burials, and several areas used for ceremonial activities. Taken together, this evidence indicates a much more intensive and permanent occupation than Van Horn originally theorized. In fact, based on the density of features, artifacts, faunal remains, and midden deposits, it appears that the bluff-top sites were actually more intensively used than contemporaneous sites along Centinela Creek.

Comparison of our collections from Intermediate period deposits along Centinela Creek and the lagoon edge (lowland sites) with Van Horn's bluff top excavations initially suggested that bluff-top sites were used as processing areas for marine, primarily lagoonal, resources. There appeared to be a much higher percentage of fish remains, especially cartilaginous fish, compared to other animal types at the bluff top sites, whereas terrestrial-mammal remains dominated collections from lowland sites. Based on these differences, we suggested that lowland settlements were characterized by a largely terrestrial subsistence pattern, whereas bluff-top sites where characterized by a marine pattern (Altschul et al. 2003, 2005). Analysis of collections from our 2000 and 2003 excavations at West Bluffs, however, did not support this difference between bluff-top and lowland sites. Instead, terrestrial-mammal remains dominated all of the collections from Ballona sites, except that from LAN-59. It now appears that the apparent differences between SRI's and Van Horn's collections can be attributed largely to different sampling procedures. Van Horn's analysts focused on identifiable fish bone in their analyses and largely ignored the vast amount of terrestrial-mammal bone, which was largely unidentifiable.

Although the marine focus of bluff-top sites and terrestrial focus of lowland sites is not supported by our analyses, some important subsistence differences are evident between bluff-top and lowland sites. Botanical data are less informative because of the poor preservation of botanical remains at West Bluffs and the fact that the remains from various Ballona sites have been differentially collected and analyzed.

With respect to the lithic collections, Hull (see Chapter 8) reports that LAN-63 and LAN-64 and perhaps other bluff-top sites contained more expedient tools than bifacial tools. Hull also reports that few ground stone or milling implements were found at Late and protohistoric period lowland sites, yet these artifacts are plentiful at Intermediate period bluff-top sites (see also Rosenthal and Hintzman 2003; Van Horn 1987; Van Horn and Murray 1985). This pattern suggests that Intermediate period bluff-top inhabitants processed a larger number of seeds, roots, tubers, and small animals than did the Late and protohistoric period inhabitants of the lowlands.

The same six shellfish species—Venus clam, speckled scallop, native Pacific oyster, littleneck clam, Pismo clam, and abalone—were present in varying degrees at most of the Ballona sites. The Veneridae (Venus and littleneck clams), however, were the most abundant shellfish collected from most Ballona sites, regardless of location or time. Although there was considerable variation from site to site (Table 15.2), this pattern is clearly evident when sites are grouped by time period and location

(Figure 15.1). Venus clam was dominant at the lagoon-edge site of LAN-62, and it was the most common species at LAN-47, another lagoon-edge site, it was not in the majority, and oyster was also common. The collections from sites along Centinela Creek were most variable. Veneridae dominated the collection from LAN-60, but scallop was equally abundant at LAN-2768. Although we did not distinguish between Venus and littleneck clams in this summary because the latter were not consistently identified by various analysts, Venus clams greatly outnumbered littleneck clams in most of the collections in which these species were distinguished (see Becker 2003:Table 23). At LAN-2768, however, littleneck clams outnumbered Venus clams. Littleneck clam as well as abalone were also very common at LAN-211/H, although the sample from this site was extremely small. Pismo clam outnumbered Venus clam at LAN-194, an early-historical-period lowland site. The pattern for the bluff-top sites was much simpler—Venus clam clearly represented the majority of shellfish at four of the five bluff-top sites: LAN-61, LAN-63, LAN-206A, and the Van Horn collections from LAN-64. Scallop, however, was the most common invertebrate in the SRI collections from LAN-64, and Pismo clam dominated the invertebrate collection from LAN-59. The difference in shell species between the Van Horn and SRI collections from LAN-64 may be attributed to temporal factors, as Van Horn targeted the midden at the site, which appeared to date largely to the Intermediate period, whereas most of the shell recovered by SRI derived from older Millingstone period deposits at the base of the midden.

The pattern of dominance of Venus clam in Ballona sites is not surprising given the estuarine environment of the Ballona during much of prehistory and the ease with which this species can be gathered. The prevalence of Pismo clam at LAN-59 was explained by Van Horn (1984:44) as being a result of environmental factors that existed during the occupation of this site—namely, the presence of a sandy bayshore at the foot of the bluffs northwest of the site. Similarly, Keller (1999:98) argued that the abundance of scallop at LAN-2768 reflected a changing estuarine environment during the occupation of this Intermediate period site. Becker (2003:193–194) took a more complex approach, arguing that apparent differences in species diversity can result from several factors, including availability, shell taphonomy, excavation sample size, and human behavior. Whereas other explanations for the dominance of a particular shellfish at Ballona sites have assumed that shellfish were collected in proportion to their abundance in the estuary, Becker emphasized that the proportions of different shellfish species found in archaeological collections may reflect different subsistence strategies. Focusing on the Late period collections from LAN-211/H and LAN-47, Becker (2003:196) suggested that most Early and Intermediate period inhabitants of the Ballona employed a focused subsistence strategy that relied on the abundant and easily procured Venus clam, whereas Late period inhabitants employed a more generalized strategy that relied on a broader range or diversity of food types, particularly shellfish with higher meat yields. Becker (2003:196–197) also suggested that although environmental change may have been a factor in this shift, decreasing residential mobility may have led to increased pressure on existing shellfish populations and the need to target species that were more difficult to procure but that provided higher meat yields.

Becker's hypothesis may be useful in accounting for the subsistence shift between the Intermediate and Late periods, as the diversification in procurement of shellfish corresponds with other faunal evidence suggesting an increasing diversification of resource use through time coupled with decreasing residential mobility. His hypothesis, however, does not account for the prevalence of scallop in the Millingstone period deposits at LAN-64.

Terrestrial-mammal remains dominated the collections at all but one (LAN-59) of the Ballona sites. Overall, the bluff-top sites tended to have slightly higher percentages (about 4 percent higher) of fish remains than did Intermediate period lowland sites. The lowland sites tended to have slightly higher percentages of reptiles and birds than did the bluff-top sites during all periods. Bony fish were also more common than cartilaginous fish in the vertebrate collections at all of the lowland sites, which was not the case at bluff-top sites. Cartilaginous fish were more common at three of the five bluff-top sites—LAN-59, LAN-61A, and LAN-61B. However, cartilaginous fish also dominated the fish collection from the 1986 excavations at LAN-63 and LAN-64. In contrast, frequencies of cartilaginous fish in SRI's collections from LAN-63 and LAN-64 were much more similar to those from lowland sites. As discussed in the vertebrate faunal analysis chapter (see Chapter 10), we suspect that the abundance of cartilaginous fish in Van Horn's collections from these five collections may have been the result of the different sampling strategies and analytic approaches used by Salls (Van Horn 1984), who analyzed all five of these distinct collections.

Excluding these anomalies, overall, Ballona residents relied most heavily on terrestrial mammals at both the bluff-top and lowland sites. Bluff-top sites generally contained slightly higher percentages of fish and many more ground stone tools. Lowland sites contained slightly higher frequencies of bird and reptile remains. The same species of shellfish were present at most of the sites. Venus clam and other Veneridae were either the dominant shellfish species or were abundant at almost all the bluff-top and lowland sites. Variations in these frequencies may reflect temporal changes in the local environment or shifting subsistence strategies.

Changing Subsistence Strategies and Lagoon Development

As the discussion above suggests, there is little significant spatial variation in the use of resources in the Ballona. During the Intermediate period, the only time when sites were widely distributed in different settings of the Ballona, Venus clam and other Veneridae were the dominant or most common shell taxa at most sites along the bluff top, lagoon edge, and creek sides. Similarly, previous hypotheses regarding a marine adaptation for bluff-top sites and a terrestrial adaptation for lowland sites are not supported by the vertebrate faunal data from SRI's investigations at LAN-63 and LAN-64.

Instead, subsistence data from the various Ballona sites suggest subsistence strategies may have changed over the course of time. These changes may have been related to changing climatic conditions, the evolution of the lagoon, and changing settlement patterns. The late prehistoric and protohistoric period site collections showed a wider variety of resources than did those of earlier periods. These patterns were most evident in the invertebrate collections. Data from LAN-64 and LAN-206, sites which have substantial Millingstone period components, indicate a pattern where scallop and Venus clam were equally targeted during the Millingstone period. Scallop and Venus clam constituted about 30–60 percent of the collections from LAN-206 and SRI's excavations at LAN-64 (an average of 43 percent [scallop] and 47 percent [Venus clam]), whereas other species comprised, on average, about 10 percent (see Figure 15.1; see Table 15.2). These admittedly limited results are supported by preliminary data from LAN-62 data recovery excavations that also showed a substantial Millingstone component containing a high frequency of scallop (Wegener and Shelley 2004).

During the Intermediate period, the importance of Venus clam increased dramatically, largely at the expense of scallop. Venus clams comprised 80–95 percent of the collections from Van Horn's excavations at LAN-63 and LAN-64, SRI's collections from LAN-63, and SRI's collections from LAN-60. Only LAN-59, with its extremely high frequencies of Pismo clam, was anomalous among Intermediate period sites. In contrast to the Millingstone period, collections from Intermediate period sites saw frequencies of scallop drop to well under 10 percent. The only exception was LAN-2768, where scallop comprised 34 percent of the collection, suggesting the possibility that an undiscovered Millingstone period component may have been present at this site. Although data recovery has been completed at LAN-2768, analyses have not, and the data presented in this report are based on testing results.

In contrast to the other key species, oyster collection appears to have remained relatively stable throughout the occupation of the Ballona. Oysters comprised as much as 29 percent of the collection from Intermediate period site LAN-61 and 32 percent of the collection from Late period site LAN-47, but on average oysters comprised 8–14 percent of the collections. Overall, the invertebrate data from the bluff tops and other sites in the Ballona suggest that the Millingstone period was characterized by a strategy that targeted diverse lagoon and bay species, whereas the Intermediate period was characterized by a collection strategy that focused, almost to the exclusion of all others, on a single species, Venus clam, which was most easily procured and most abundant during this time.

As discussed in the invertebrate faunal analysis chapter (see Chapter 11), this shift from the collection of scallops and Venus clams to a focus on Venus clam may have been the product of the evolution of the lagoon environment, as this shift corresponded with a change from a relatively open bay to one with extensive mudflats. Thus, the inhabitants of the Ballona may have focused on Venus clams and scallops during the Intermediate period because these taxa were most abundant and widespread at this time. Alternatively, the Intermediate period shellfish-collecting pattern reflects the type of focused subsistence pattern proposed by Becker (2003). It is probably not coincidental that the Intermediate period occupation of the Ballona was probably the first time that the area was settled on a relatively permanent basis and settlements were widely distributed. Targeting the most easily procured species may have been the most efficient strategy, especially if population densities remained relatively low.

The Late and protohistoric periods where characterized by a more generalized strategy that emphasized a greater proportion of other species, particularly oyster, littleneck clam, scallop, Pismo clam, and possibly *Haliotis* sp. The occurrence of *Haliotis* and Pismo clam are of particular importance, as they suggest not only a diversification of species targeted, but the targeting of a nonlagoon environment. Despite this pattern of diversification, Venus clams remained the most common species targeted in the Late and protohistoric periods. Diversification can be seen as a product of the lagoon's continued evolution. By the Late period, the Ballona had become a sediment-choked estuary, and the extensive mudflats of the previous millennia were probably greatly diminished, forcing residents of the area to extend their foraging strategies to the sandy shoreline and rocky coast. Another way of looking at this changing pattern is from the perspective of settlement. In contrast to the Intermediate period, Late period settlement was concentrated at the base of the bluffs near the mouth of Centinela Creek. From this single location, the Ballona's residents probably employed a logistical foraging strategy to exploit the lagoon and its surrounding areas.

The vertebrate faunal collections also appear to indicate a shift in subsistence strategies through time, although this pattern is obfuscated by differences in analytical approaches among the various analysts who studied the Ballona collections (Figure 15.2). The Millingstone period is poorly represented in the archaeological record with respect to the vertebrate fauna. A small collection from SRI's excavations at LAN-64 provided our only insights into this time period. Taken on face value, this collection suggests an almost complete dependence of terrestrial mammals during the earliest occupation of the Ballona. This view will undoubtedly change as more data become available from early contexts at LAN-62. The Intermediate period is much better represented, but it is here that analytical inconsistencies shroud the patterning. Our initial review of the data from Van Horn's excavations at LAN-59; LAN-61A, B, and C; LAN-63; and LAN-64 suggested an unusual pattern in which subsistence was focused largely on fish, especially bats, rays, and other cartilaginous species that would have inhabited the lagoon (Maxwell 2003). Terrestrial fauna received relatively little attention. Reevaluation of the data from Van Horn's excavations does not support this interpretation. If the large number of unidentifiable mammal bones are included, the faunal collections from Van Horn's excavations at LAN-63 and LAN-64 are not that dissimilar from SRI's collections from these two sites (Table 15.3). Mammals make up 68 and 86 percent of Van Horn's collections from LAN-63 and LAN-64, respectively, and 74 and 97 percent of the collections from SRI's excavations at these two sites. These proportions differ little from the proportion of mammalian fauna from contemporaneous lowland sites in the Ballona, thereby putting to rest the notion that lowland and bluff-top sites were characterized by different subsistence strategies.

The picture is not entirely that simple, however, as other differences are evident in the various sets of collections. Although comprising less than 1 percent of the overall faunal collections, sea mammal remains are nevertheless much more common in Van Horn's collections from LAN-63 and LAN-64. Colby (see 1987a, 1987b, also 1985) recognized 76 elements of Pinnepedia and other sea mammals in Van Horn's collection from LAN-63 and 4 elements of Pinnepedia and Cetacea in Van Horn's collection from LAN-64. In contrast, we identified only 10 elements of sea mammals in our LAN-63 excavations and none at LAN-64. Even more striking was the abundance of cartilaginous fish in the collections from Van Horn's excavations. In most of the collections studied by Salls (1987), Chondrichthyes were among the dominant vertebrate fauna, often outnumbering Osteichthyes by a factor of three to one. The contrast was especially striking in the collections from LAN-63. Although Osteichthyes (16.2 percent) slightly outnumbered Chondrichthyes (14.2 percent) in Salls analysis of Van Horn's LAN-63 collection, they constituted 24.2 percent in Gobalet's analysis of SRI's collection from this site, whereas the proportion of Chondrichthyes in SRI's collection was negligible (1.4 percent). Such significant differences cannot be explained by the same reasoning we used to explain the radically different proportions of mammalian fauna. Rather, such differences could represent a radically different approach to faunal analysis by the two primary fish analysts, Salls and Gobalet.

Because of such problems, the subsistence patterns of the Intermediate period are not entirely clear. Although there was much diversity in the exploitation of invertebrate fauna among the various sites of this time period, much greater diversity was evident in the presence of vertebrate fauna. How much of this diversity was the result of analytical problems is unknown at present. What we can conclude, however, is that there was an overall emphasis on terrestrial fauna, most likely the fauna that was common in the local area. Fish probably constituted a very important element in the subsistence pattern as well. If Salls (1987) was correct, bats, rays, and other cartilaginous fish of the lagoon may have represented a much more important element in the diet of the Ballona's residents. Birds and perhaps reptiles played a relatively minor role in their diet, although they appear to have been slightly more common in contemporaneous lowland sites.

Vertebrate faunal data from LAN-47 and LAN-62 suggest that subsistence changed little in the Late period. Preliminary data from LAN-211, however, suggest a marked change that, like the invertebrate data, indicate a pattern toward much greater diversification. Fish, reptiles, and birds were found in their highest frequencies at LAN-211, whereas mammalian fauna (largely terrestrial) made up less than 50 percent of the vertebrate fauna. Again, this pattern of diversification suggests a shift from a focus on lagoon resources to offshore resources.

A more complete picture of prehistoric subsistence in the West Bluffs area was provided by the paleobotanical record and other archaeological data. For a variety of reasons, Wigand (see Chapter 12) finds little correspondence between the pollen record and carbonized seeds found in samples from the West Bluffs sites. Some of this lack of correspondence may be the result of poor preservation or bias toward windblown pollen types in the archaeological record. In addition, Wigand points out that pollen and seeds are produced at different times of the year, and the absence of pollen may be the result of sites not being occupied during the season in which economic plants produced pollen or of plants being collected at some distance from the site area and the pollen not making it back to the sites. Regardless, Wigand concludes that the pollen data reveal little regarding the economic activities of the prehistoric residents of West Bluffs. Rather, the pollen represents what appears to be a record of the local environment. In contrast, Wigand observed that the carbonized seed collection was composed of a diverse mixture of very small seeds from a wide variety of local and regional habitats, including the Los Angeles Prairie to the south of the site and either the freshwater marshes in the Ballona below the bluffs or in the vernal pools that lie in the prairie. Furthermore, the seeds reflect harvesting of plant foods from early spring through midsummer.

The importance to the West Bluffs inhabitants of harvesting such plant foods is supported by other archaeological evidence. Large numbers of small-seed-type grinding stones were observed by Hull (see Chapter 8) in the lithic collection. Furthermore, the ubiquitous burnt rock features at the West Bluffs sites were probably used primarily for seed processing. An abundance of mollusk shells in some of these features suggests that they were used to cook mollusks. Most, however, lacked shell associations. Rather, Wigand points out that wood charcoal and carbonized seeds found in most of the paleobotanical samples from these features suggest that they were used to process these seeds.

The Nature of Settlement, Seasonality, and Subsistence at West Bluffs

Subsistence data are also relevant to other research issues at the West Bluff sites, as discussed in the chapter on previous and current research (see Chapter 3). For example, two competing models regarding the nature of settlement have emerged from investigations. After excavating the West Bluffs sites in the 1980s, Van Horn (1987) concluded that, in general, these sites and Ballona bluff-top sites functioned as temporary camps for one or two domestic groups. He theorized that these sites were primarily devoted to resource procurement. The sites contained no evidence of permanent structures, and the remains expressed a restricted set of activities (Van Horn 1987). Grenda and Altschul (1994; Altschul et al. 2000), on the other hand, hypothesized that the bluff-top occupations should be highly variable. There should be some temporary sites and some permanent sites on the bluff tops as well as in the lowlands. Some sites may reflect exploitation of specific resources or use that required only short stays, such as ritual use, whereas others may show evidence of long-term habitation.

If Van Horn's view of settlement on the bluffs is correct, features should be randomly distributed in space and time across the site. There should be a low diversity of cultural remains and few discrete activity areas. If Grenda and Altschul are correct, we would expect to find a variety of site types on the bluff tops. Larger, habitation sites should contain a wider diversity of cultural remains that are spatially complex, with a larger number of discrete activity areas representing a wider range of activities. We would also expect classes of contemporaneous features and their patterned distributions relative to refuse deposits. Grenda (1998) argued that although actual house remains may not be found, residential units may be indicated by the presence of hearths, roasting pits, refuse concentrations, and artifact clusters. Analysis of these features should reveal a more formal spatial structure with distinct areas defined by activity. For example, there should be separate areas for food preparation, tool manufacture, refuse disposal, and storage.

LAN-63 is the largest of the three West Bluffs sites. Hull, in Chapter 8, reports that four major activity types are represented in the lithic collection at LAN-63: procurement, processing, consumption, and manufacture. Lithic manufacture seems to be underrepresented as reported by Hull. The site, however, contained many ground stone tools that were likely used for processing food. The abundance of tools and food remains at LAN-63 suggests the site was a habitation site used on a more or less permanent basis where all types of activities were performed. LAN-63 also exhibited a much stronger site structure than that proposed by Van Horn's model. It contained a large midden deposit in a depression within the site. Most features were found on the periphery or outside of this midden area. The densest concentration of rock features and hearths, which made up the majority of the feature types, were to the west of the midden. Only 35 features were located within the midden, and most of these were on its western edge. Ritual areas that may have been associated with the mourning ritual were found in this area as well. In addition, four of the five burials were on the periphery of the site, mostly at the northern boundary along the edge of the bluffs. Thus, we can propose a site structure in which people resided and processed foods on the high areas surrounding this natural depression. Food remains were discarded within the depression. Mourning rituals may also have been carried out on the edge of the depression, whereas burials were placed on the northern margin of the living area.

Wigand (n.d.) provided a model for examining the seasonal availability of economic plant and animal species in the Ballona. This model provided a useful framework for viewing the evidence for the seasonality of occupation indicated by subsistence remains from the West Bluffs sites. Wigand suggested that winter rains would have brought cooler temperatures to the Ballona and would have dampened areas of the wetlands that had dried out during the summer and autumn. Increased rainfall also would have augmented the flow of Ballona and Centinela Creeks, lessening the salinity of the lagoon and other brackish areas. Lower salinity in the lagoon, in turn, would have attracted into the wetlands an increased variety of animal species, particularly small mammals with low salt-tolerance levels. The mild winters and proximity to the Pacific Flyway also make the Ballona wetlands a prime place to find migratory bird species, particularly winter visitors. Waterfowl would been abundant, particularly migratory duck species, which would have been attractive to humans as a food source and a source of feathers. During the winter, the local reptilian community, which would have been more of a competitor than a resource, would have been largely in hibernation, dug into the soft muds of the wetlands. Snakes may have occasionally been hunted, but with the variety of other foods available, this was probably uncommon. In addition, because of lower winter water temperatures, coastal areas would have hosted a variety of cool-water fish species, such as surfperch, that could be procured from the shore or in proximity to it. Lagoon and shallow-water fish species, such as guitarfish and bat rays, would also have been available as a reliable food source.

Wigand (n.d.) noted that although the coming of spring would have been marked by increasing air temperatures and decreasing rainfall, the Ballona wetlands would have remained attractive to waterfowl and other water-loving animals. Waterfowl, however, would have diminished in abundance, while migratory species and winter visitors would have begun returning to their summer residences. In contrast, snakes and other reptiles would have become more active and abundant. Also, coastal water temperatures would have remained cool and surfperch and other cool-water-preferring fish would still have been common. Wigand also pointed out that a springtime phenomenon, the mating season, would have made the lagoon- and shallow-water-loving guitarfish and other cartilaginous fish even more abundant than in winter. Guitarfish tend to congregate for breeding purposes in very shallow waters in the spring, particularly during the month of March. This activity would also have made them an especially easy target for fishers, and the species was probably harvested in considerable numbers in this season. Mammals would also have begun their breeding seasons, and juvenile animals would have been most abundant in the latter part of spring.

Wigand (n.d.) observed that the conditions in the Ballona would have been quite different in summer. Higher daytime temperatures would have resulted in the evaporation of much of the fresh water left standing from the winter rains, despite the sometimes tempered with dense fog cover during the morning and evenings. Salinity levels would have increased in many areas, driving out animal and plant species not adapted to high levels of salt. Rodents and other small mammals would have been found in large numbers, however, as the animals born in the spring would have left their nests. By contrast, most of the waterfowl would have left the area, and birds would have been restricted primarily to terrestrial species and those year-round residents of the shore, such as seagulls. Coastal water temperatures also would have increased considerably, beyond the preferred range of the surfperch but more amenable to species such as sardines and some larger game fish such as yellowfin tuna and even tiger shark. Following the end of mating season, guitarfish and other lagoonal cartilaginous fish would have been less abundant than in spring, but still an important food source. Thus, fishing would still have been productive, but with a very different catch.

Wigand (n.d.) maintained that autumn, with its Santa Ana winds and accompanying high temperatures, would probably have been the period of greatest resource stress for the people of the Ballona. Because winter rains had ended long before, the creeks probably experienced a dramatic reduction in flow, and the vernal pools may have dried out completely. The freshwater areas surrounding the lagoon were probably also dry to some degree, making them a less favorable habitat for small game. The open coast may have been the most attractive environment at this time. Coastal waters were probably still quite warm, although a shift to cooler water would have occurred in late autumn or early winter. This shift would have led to a change in the availability of different fish species. Wigand (n.d.) further suggested that a site occupied in autumn might be expected to be dominated by coastal-fish remains.

As Wigand's (n.d.) model suggests, Ballona residents had access to a variety of resources from marine, estuarine, freshwater, and terrestrial environments. The plant and animal data from the West Bluffs sites provide limited insight into the season of occupation. These data suggest that LAN-63 was likely occupied for several seasons, if not year-round—primarily from the winter to late summer or early fall. Colby (1987a) identified several bird species that are common in the Ballona only during the winter months, whereas Wigand (n.d.) reported remains from plants that were easily collected during the spring and early summer months. Colby (1987a) also identified one juvenile fur-seal bone, which came from an animal that must have been killed during the late summer or early fall months. The fish remains supported these conclusions. The abundance of bats and rays, especially in Salls's collection, suggest that these species could have been procured year-round, although they were probably most commonly taken in spring. Surfperch and sardines also were common in Salls's (1987) collections and Gobalet's (see Chapter 10), further indicating a multiseasonal occupation.

LAN-64 was occupied during both the Millingstone and Intermediate periods. This site was considerably smaller than LAN-63, and only procurement and processing activities were evident from sampled lithics and faunal remains. No seasonality data were available for this site. The site did contain a number of rock features, nine burial features, and a variety of vertebrate and invertebrate remains, suggesting that the site was used not only for a single purpose. It is likely, however, that this site fits Van Horn's model better than LAN-63 does and was used, at a minimum, seasonally for short periods of time during the Millingstone and Intermediate periods. However, it is clear, as well, that Van Horn's model may fit the Millingstone period component better than the Intermediate period one. That is, the sparse deposits of the Millingstone period, comprising small, discrete shell dumps, seem to be consistent with mobile, temporary occupation. During the Intermediate period, where there was little formal organization of rock cluster features, the presence of a cluster of burials and scattered cremated remains on the western edge of the site—away from cooking features—does suggest a certain degree of formal site structure that is inconsistent with Van Horn's model.

Very few vertebrate or invertebrate faunal remains were recovered from SRI's investigations at LAN-206A. The deposits at this site date to the Millingstone and Intermediate periods; however, the recovered faunal remains are from surface deposits and are likely more recent. All of the vertebrate faunal remains were from large mammals; the only identifiable fragment was a horse bone. It is possible, if not likely, that all of the vertebrate remains may be from this one horse, which obviously does not reflect prehistoric activities at this site.

Conclusions

People occupying the West Bluffs sites were opportunistic hunters and gatherers who relied most heavily on mammals. Fish and shellfish also provided a substantial part of their diet. Although botanical remains were not well preserved at West Bluffs, ethnographic information and the large number of ground stone tools recovered from the sites suggest it is likely that plants provided a large part of the diet, perhaps even the majority of the diet.

Based on the high density and variety of remains from LAN-63 and LAN-64, it does not appear that these were small procurement sites occupied by one or two family groups, as Van Horn initially hypothesized. LAN-63 is a large habitation site that was occupied during several seasons of the year, if not year-round. Likely this site was repeatedly used throughout the Intermediate period. Although LAN-64 was a much smaller site that was occupied during the Millingstone and Intermediate periods, it also contained a variety of remains that suggests it was used for more than the procurement of one or two resource types. The smaller size and density of cultural remains at this site suggests a much less intensive or year-round occupation than LAN-63.

Relatively little information is available concerning the Millingstone occupation of the West Bluffs area. According to Wigand (see Chapter 12), the earliest occupation of the West Bluffs corresponded with a period of climatic transition during the early Holocene when annual temperatures and precipitation reached their Holocene maxima. It was a time when coastal and montane chaparral were being established in the surrounding region. Within the Ballona, a cat-tail-rich and sedge-dominated freshwater marsh was well established just to the north of the West Bluffs. A saltbush salt marsh had also developed just to the west of this rich freshwater marsh, making a wide variety of resources available to the inhabitants of the area. This rich and diverse estuary appears to have been the focus of early Millingstone or Paleocoastal occupation at West Bluffs, as indicated by the vertebrate and invertebrate faunal data.

After this period, rapid infilling of the estuary would have eliminated the source of mollusks or moved it farther west. By the late Millingstone, increasingly unstable and drier conditions characterized the greater surrounding region. Significant changes in vegetation might have forced people from the Great Basin and Mojave Desert to look for alternative sources of food (Altschul et al. 2005; see Chapter 12). The Ballona and similar wetland areas along the Southern California coast might have become most attractive at this time. Only sparse evidence of occupation of the West Bluffs and Ballona was found for this period.

The high density and variety of features and artifacts found in sites dating to the Intermediate period at West Bluffs and throughout the Ballona suggests that population densities may have been at their highest during this period. Wigand (see Chapter 12) suggests that this intensive occupation corresponded with a brief period characterized by a dramatic increase in annual precipitation. He argues that the response of local plant resources to this climatic maxima would have been equally dramatic. Both annual and perennial grasses would have become abundant. The increase in fresh water input from both Ballona and Centinela Creeks would have greatly expanded the freshwater marsh. At the same time, the vernal pools in the prairie to the south of the bluffs would have become more extensive and of longer duration, perhaps lasting well into the summer. The resulting increase in local plant and animal resources offered by a diversity of terrestrial, freshwater marsh, saltwater marsh, and open coast would have made the area especially attractive and probably accounts for the large number and wide distribution of Intermediate period sites in the region.

Subsistence evidence from the West Bluffs sites indicates that the prehistoric residents of the area did indeed focus on the rich local resources of the Ballona and Los Angeles Prairie, exploiting the estuary's mollusks, lagoon fish, waterfowl, and the terrestrial plants and animals of the estuary and prairie. The concentration of sites along the top of the bluffs was ideal to take advantage of both the wetlands and prairie habitats. The focus of Intermediate period subsistence, however, appears to have been on the widespread and easily collected Venus clam and other intertidal mollusks and the terrestrial mammals and seed plants of the region. There is also evidence for exploitation of fish, sea mammals, and invertebrates of the open coast during the Intermediate period, although this evidence is limited and inconsistent. Generally, bluff-top sites have a larger number of ground stone tools and slightly more fish remains, especially cartilaginous fish, than do lowland sites, which suggests that those living in bluff-top sites exploited the coast more and processed more plants or that most of the fish and botanical remains were processed at bluff-top sites rather than at lowland sites.

Wigand (see Chapter 12) notes that the end of the Intermediate period was characterized by more unstable and increasingly drier conditions. These climatic changes would have significantly reduced terrestrial and freshwater marsh resources, although salt-marsh resources would have remained stable and may have expanded under these conditions. These changes appear to have dramatically affected settlement and subsistence in the Ballona. The West Bluffs sites were abandoned together with most of the sites along the bluff tops and upstream portions of Centinela and Ballona Creeks. By the Late period, settlement was concentrated in a few settlements along the edge of the salt marsh and lower Centinela Creek. Changes in subsistence were reflected in a diversification of subsistence remains found at the Late and protohistoric period sites. This diversification was reflected in a greater mix of resources exploited and an increased emphasis on bony fish and nonestuarine invertebrates at the expense of Venus clams, terrestrial resources, and possibly seed plants. Overall, residents of the Ballona appear to have responded to changing climatic conditions and the associated reduction of the freshwater estuarine habitat and the productivity of the vernal pools by shifting their focus from these habitats to a more even mix of coastal and estuarine resources.

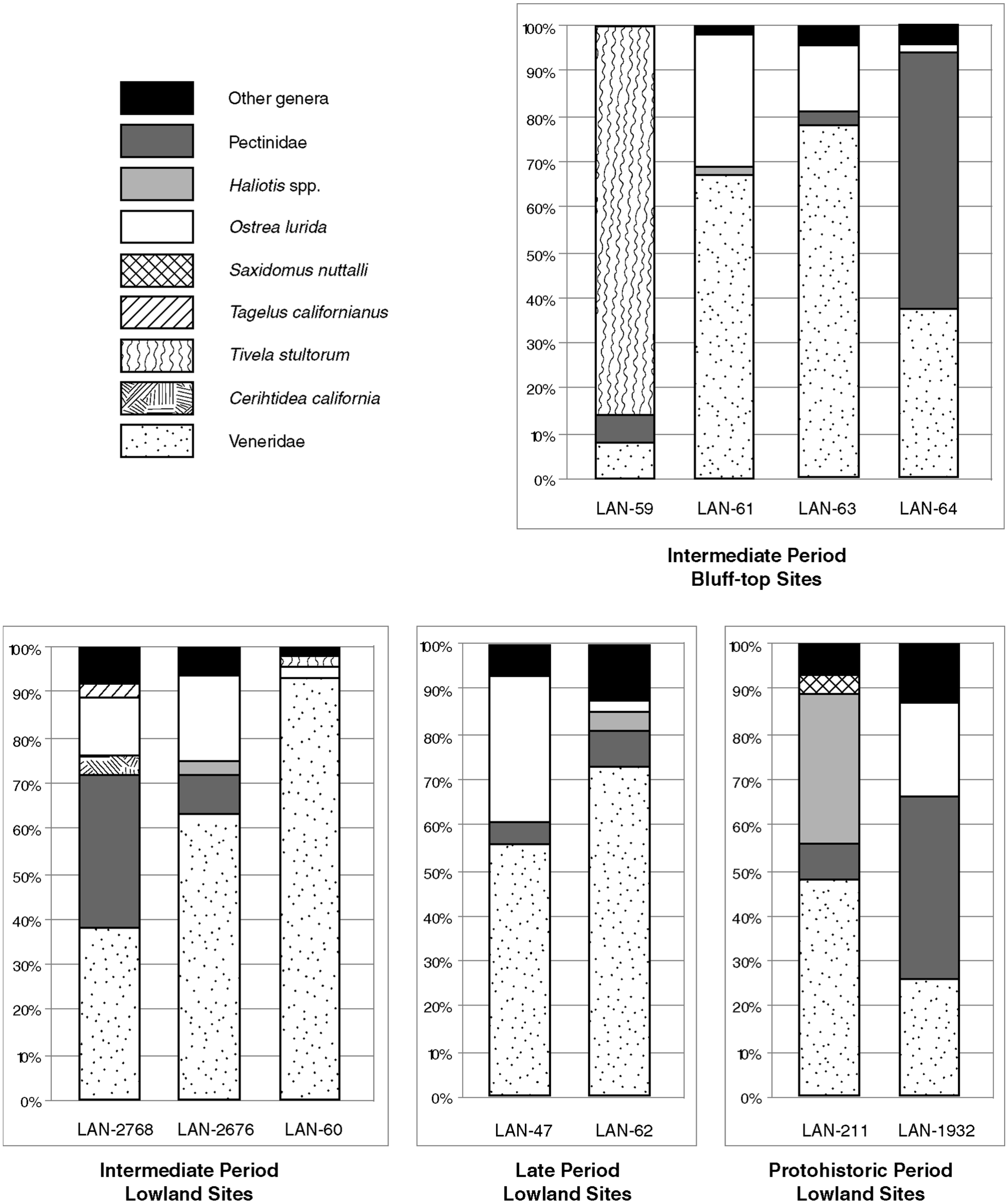


Figure 15.1. Relative abundance of invertebrate taxa in Ballona region sites.

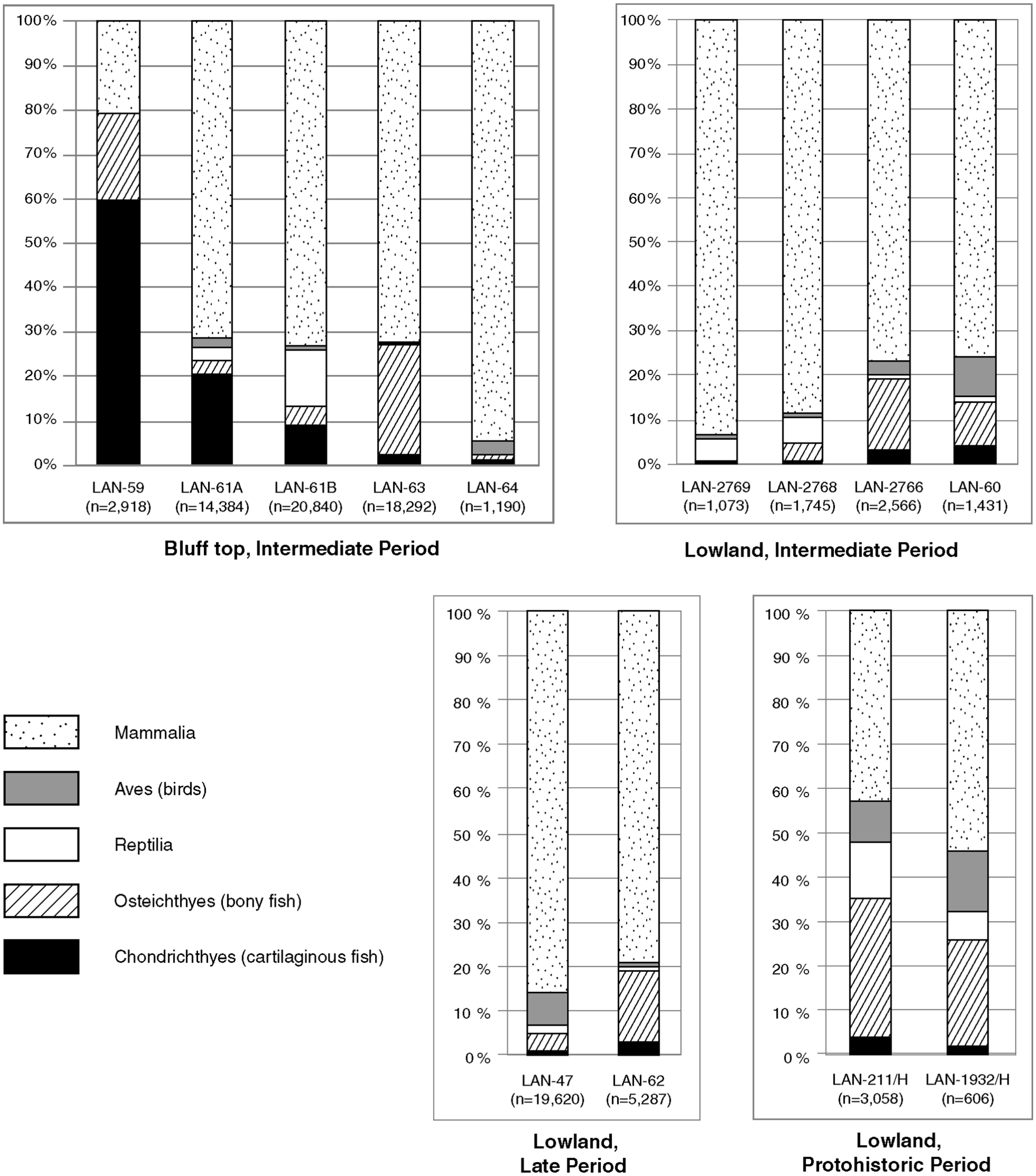


Figure 15.2. Relative abundance of vertebrate taxa in the Ballona region sites.

Table 15.1. Summary of Estimated Proportions of Classes of Food Eaten by Coastal Luiseño

Resource	White (1963)	Beals and Hester (1974)	Bean and Shipek (1978)
Acorns	10–25	10–25	15–25
Greens	5–10	0–5	5–10
Bulbs, roots, fruits	10–15	0–5	10–15
Seeds	5–10	5–10	20–40
Game	5–10	0–5	5–10
Fish and marine animals	50–60	50–60	20–35

Note: Table adapted from Koerper (1981).

Table 15.2. Percentages of Most Common Shell Taxa in Ballona Collections, by Site Location and Period

Shell Taxon	Bluff-Top Sites									Lowland Sites							
	Millingstone			Intermediate						Intermediate			Late/Protohistoric				
	LAN-64	LAN-206		LAN-59	LAN-61	LAN-63		LAN-64		LAN-60	LAN-2768		LAN-47	LAN-62	LAN-194	LAN-211	
	SRI	Van Horn	Avg.	Van Horn	Van Horn	SRI	Van Horn	Van Horn	Avg.	SRI	SRI	Avg.	SRI	SRI	King	SRI	Avg.
Veneridae	37	56	47	8	67	78	88	95	67	93	38	66	56	73	28	48	51
Pectinidae	57	28	43	6	—	3	5	—	3	1	34	18	5	8	7	8	7
Haliotis spp.	—	—	—	—	2	—	—	1	1	—	—	—	—	4	—	33	9
Ostrea lurida	2	16	9	—	29	15	7	4	11	3	13	8	32	3	19	—	14
Tivela stultorum	—	—	—	86	—	—	—	—	17	2	—	1	7	12	38	—	14
Other genera	4	—	2	—	2	4	—	—	1	1	15	8	—	—	8	11	5
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Key: Avg. = average

Table 15.3. Percentages of Major Classes of Vertebrate Fauna in Ballona Collections, by Site Location and Period

Vertebrate Taxon	Bluff-Top Sites							Lowland Sites							
	Millingstone	Intermediate						Intermediate				Late/Protohistoric			
	LAN-64	LAN-59	LAN-61	LAN-63		LAN-64	Avg.	LAN-60	LAN-193	LAN-2768	Avg.	LAN-47	LAN-62	LAN-211	Avg.
	SRI	Van Horn	Van Horn	SRI	Van Horn	Van Horn		SRI	SRI	SRI		SRI	SRI	SRI	
Reptilia	0.0	0.1	5.3	0.4	0.4	0.8	1.4	0.8	6.5	6.1	4.5	2.0	1.4	13.2	5.6
Aves	3.4	0.1	5.4	0.2	1.2	3.4	2.1	8.5	2.1	1.1	3.9	6.9	2.4	8.6	5.9
Mammalia	96.6	2.8	17.1	73.8	68.0	86.2	49.6	76.4	89.6	88.1	84.7	86.8	81.7	43.6	70.7
Chondrichthyes	0.0	75.5	57.1	1.4	14.2	7.4	31.1	4.4	0.6	0.5	1.8	0.5	2.6	3.8	2.3
Osteichthyes	0.0	21.5	15.0	24.2	16.2	2.3	15.8	9.9	1.2	4.3	5.1	3.8	11.9	30.7	15.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Key: Avg. = average

Conclusions

John G. Douglass and Richard Ciolek-Torrello

The overarching goal of this report has been to document the data recovery fieldwork and perform the subsequent analysis of a sample of recovered remains from LAN-63, LAN-64, and LAN-206A, all located on the West Bluffs property. The work here was guided by a research design created to test competing models of site structure at LAN-64 (and, by extension, LAN-63 and LAN-206A). Therefore, in addition to focusing on the data collected by SRI, the authors have connected and correlated their work to previous research on the property by Van Horn and Associates in the 1980s (Van Horn 1987; Van Horn and White 1997c). Although the Corps determined that the work accomplished by Van Horn did not meet current Section 106 standards, it should be noted that Van Horn and his colleagues excavated a tremendous amount of material at LAN-63 and LAN-64 and produced a major report documenting their work (Van Horn 1987). Van Horn and his colleagues are to be commended for their effort.

The previous two chapters in this report (Chronology [Chapter 14] and Subsistence and Settlement [Chapter 15]) have already synthesized much of the data presented in the various analytical chapters in this report. The goal of this chapter is to highlight some of the general conclusions reached by various authors in this report and to draw overall conclusions, which relate to the competing research paradigms outlined in the Chapter 3. In this chapter, we consider two broad topics, chronology and site structure, to inform our analysis with the new data collected and to address the primary research themes that have structured our work at West Bluffs. We conclude by summarizing our contributions to the understanding of the three sites at West Bluffs and their place in the prehistory of the Ballona (Table 16.1).

Chronology

As discussed in the chronology chapter (Chapter 14), Van Horn and his colleagues identified several broad time periods of occupation for the West Bluffs property (see Table 16.1). They determined that LAN-63 was occupied primarily during the Intermediate period based on radiocarbon dating, whereas diagnostic artifacts suggested that smaller Late period and Mission period occupations were also present. Radiocarbon dates also indicated that LAN-64 was occupied only during the Intermediate period. No radiocarbon dates were obtained from LAN-206A. Based primarily on the lack of shell in the midden, Van Horn and his associates suggested that this site also may have been occupied during the Intermediate period (Van Horn and White 1997c).

LAN-63

SRI's work complements the Van Horn data and provides new insight into the chronology of West Bluffs and the broader Ballona region. SRI's research at LAN-63 and LAN-64 suggests that both sites hosted roughly simultaneous occupations during the Intermediate period. The presence of cogged stones and discoidals suggests a possible Millingstone period component to LAN-63, although these artifacts are often found in sites dating to later time periods and therefore cannot be considered accurate diagnostics for the Millingstone period. No radiocarbon dates confirming this earlier occupation were obtained either by Van Horn's or SRI's investigations. Van Horn did obtain a single date from his excavations at the main part of LAN-206 that indicated an occupation at the beginning of the Millingstone period (Van Horn and White 1997c). None of Van Horn's excavations of the bluff- tops sites yielded features or materials that dated between 6500 and 5000 B.P. (see Figure 14.1 in the chronology chapter), suggesting to him that there had been a hiatus in the occupation of the Ballona.

Van Horn also identified a Late period occupation at LAN-63 based on a number of diagnostic projectile points found in the northern-central section of the site. SRI's investigations found no evidence of this component either through radiocarbon dating or the analysis of diagnostic lithic artifacts. Although all temporally diagnostic lithic artifacts were analyzed from both Phase II and III of work at LAN-63, it is possible that our failure to identify a Late period component at this site may result from sampling error. Van Horn's Late period component—isolated in one small part of the site—may represent a very brief occupation that we simply did not encounter in our investigations. Similarly, Van Horn's identification of a Mission period presence at the site, based on the presence of several glass trade beads, was not confirmed by our investigations. Using the term "occupation" for the Mission period at LAN-63 is inappropriate, because no radiocarbon dates, features, or artifacts (other than the beads) dating to this period were found by either Van Horn or SRI.

In sum, then, it is clear from the concentration of radiocarbon dates and the bulk of the diagnostic artifacts that LAN-63 was occupied during the Intermediate period, with possible evidence for some activities at the site during the Late and Mission periods. Furthermore, the tight clustering of dates from the top and bottom of the midden to an approximately 250-year period (see Chapter 14) suggests that the Intermediate period occupation at LAN-63 was relatively intense and short-lived. This brief time period, as outlined by Wigand in this report, corresponds closely with a peak in regional precipitation that followed a long dry period. This extraordinarily high precipitation resulted in an episode of peak resource productivity for the freshwater marsh in the Ballona Lagoon below the bluffs and the Los Angeles Prairie and its associated vernal pools to the south of the bluffs. The intense occupation of LAN-63 in a location at the interface of these two habitats and precisely at the time that they would have been most productive is clearly not accidental.

LAN-64

Van Horn's work also identified an Intermediate period occupation at LAN-64 based on radiocarbon dating (Van Horn 1987). SRI also found a scatter of domestic features and burials dating to this period based on radiocarbon dates from shell found in features. It is interesting to note that neither Van Horn nor SRI identified features during data recovery excavations at LAN-64. It was only during Phase III, when the site was subjected to controlled grading, that features were found at this site, emphasizing the importance of this method for investigating midden sites.

Most unexpected was the identification of a Millingstone component at LAN-64. Although several cogged stones were found during the Phase III work at the site, they are not diagnostic of a Millingstone period occupation. Furthermore, the recovery of the cogged stones from isolated and surface contexts renders their association with the features at LAN-64 questionable. A suite of 10 radiocarbon dates from five features, all small shell dumps at the base of the midden at LAN-64, provides the strongest evidence for the Millingstone period occupation. It is interesting to note that most of these dates, which range from about 6500 to 8300 B.P., fit within what is generally considered to be the older Paleocoastal period. The limited remains from this occupation, however, do not represent any of the material-culture evidence that is usually associated with this older period. Thus, we do not believe that these dates represent a Paleo-coastal period occupation along the Los Angeles coast, where no unequivocal evidence of such an early occupation has been found to date. Although SRI is confident of the context for these dates, which derived from confined, minimally disturbed features, dating error is a possibility. Finally, the small size and scattered distribution of the shell dumps from which these dates were derived suggest that the early occupation of LAN-64 was short-term and periodic.

LAN-206A

Although both research teams were able to date LAN-63 and LAN-64, neither Van Horn nor SRI are confident about when LAN-206A was occupied. Van Horn and his colleagues argued that this component of nearby LAN-206 most likely dated to the Intermediate period based on somewhat dubious evidence: the sparseness of shell within the midden (Van Horn and White 1997c). Their three test excavation units did not produce diagnostic or datable material. SRI identified 10 features along the northern portion of this site near Hastings Canyon during their Phase III efforts on the West Bluffs property. Unfortunately, none of these features produced datable material in a reliable context.

It is possible that at least one component of this site dates to the Millingstone period based upon the presence of cogged stones and the early radiocarbon date from LAN-206. Nevertheless, as previously mentioned in discussion of the other two sites, these artifacts are not reliable temporal diagnostics, and there is no reason to conclude that the occupations at LAN-206 and LAN-206A were temporally related. Alternatively, it is possible that the features identified by SRI at LAN-206A date to the Intermediate period, when the other two West Bluffs sites were at the peak of their occupation. The lack of shell in the midden, however, does not appear to be a strong argument for an Intermediate period occupation when one considers the amount of shell at the other two sites, which dated to this period. Although the midden at LAN-64 did not contain much shell, the midden at LAN-63 contained a tremendous amount. As a result, we are still unable to date the occupation at LAN-206A with any degree of confidence.

Site Structure

As discussed in Chapter 3, Van Horn argued that both LAN-63 and LAN-64 functioned as temporary base camps (Van Horn 1987). His analysis of materials recovered from his investigations at West Bluffs in the 1980s suggested that there was little variation in the artifacts or features and that the midden was relatively homogeneous. Van Horn concluded that there was little structure to either site, little formal use of space, and that the sites represented the accumulation of a series of brief and intermittent seasonal occupations of the bluff tops by small, family-sized groups. Based on a reassessment of Van Horn's findings, Altschul (1997) proposed that there was a more formal use of space and activities at the sites and that the occupation represented a more permanent use of the bluff tops by larger social groups. SRI's research at the West Bluffs sites was designed to test these competing hypotheses. Therefore, the research questions guiding SRI in this report are related to a central set of themes. Was there a more complex organization to the sites and the use of space? Were there formal areas for particular activities at either site? Was occupation at the sites temporary and seasonal or more permanent? Were the sites occupied for a long period of time, a single short period, or intermittently?

As discussed in various analytical chapters, as well as in Chapter 15, the two principal sites on the property, LAN-63 and LAN-64, yielded a variety of evidence to test the competing hypotheses. Hundreds of features were identified by SRI during Phases II and III at both sites, over 20 radiocarbon assays were produced, and a full range of artifact classes were analyzed. Unfortunately, because of the extremely limited amount of material from LAN-206A and the insecure dating of this site, it is not considered in this discussion.

LAN-63

The evidence of occupation during the Intermediate period at LAN-63 is overwhelming. A dark midden more than 1.5 m thick was examined, hundreds of features were identified, and thousands of artifacts and subsistence remains were analyzed. In contrast to Van Horn, we recognized a much greater diversity in features and material culture. Features included food-processing features, artifact caches, ritual features, and burials; artifacts and other remains included food-processing, manufacturing, and ritual items. Together, these features and artifacts suggest a much wider range of activities than would be expected in a short-term camp occupied by single family groups. The ritual activities, in particular, suggest that the locale was occupied at least periodically by larger social groups. Based on the distribution of the features and other remains, it appears that use of space also was more formal than suggested by Van Horn, which would be indicative of a permanent occupation (Figure 16.1).

Several patterns concerning the use of space at this site were noted. Burials were generally not placed within domestic areas but rather on the margins of the site, either along the edge of the bluff or along the site's southern margin. Whereas domestic refuse was found throughout the midden, there was a clear pattern for the placement of kitchen refuse (primarily shell) in the depression in the middle portion of the site separating the eastern and western knolls. Ritual activity in a pattern reminiscent of the Mourning Ceremony, which included burning and purposeful destruction of possessions, cremation of human remains, and the burial of these cremated remains, was identified by Van Horn and SRI as having taken place in the same general area along the western edge of the kitchen refuse area. Van Horn identified an earthen oven in this area that appears to have been part of the assemblage related to this ritual activity.

LAN-64

Features dating to two time periods, the Millingstone and Intermediate periods, were found at LAN-64. Millingstone period features generally conformed to Van Horn's model for site structure, characterized by the sparseness of the features, little organization of space, and minimal feature differentiation. In fact, all of these dated Millingstone features were generally alike, consisting of concentrated amounts of shell in a small, shallow pit containing few other artifacts. These features suggest temporary occupation related to subsistence practices focused on the Ballona Lagoon below the bluff.

The Intermediate occupation at LAN-64 did not exhibit as much formal use of space as LAN-63. Domestic features identified at LAN-64 were generally related to mundane uses, such as resource processing, and were scattered across the central portion of the site. There does appear to have been some partitioning of space, however (Figure 16.2). Burials were found clustered along the western margin of the site, away from domestic activities. The presence of cremated remains scattered within almost every burial in this area suggests a complex burial practice similar to that found at LAN-63.

Concluding Thoughts

In sum, we have learned much from data recovery at the West Bluffs sites. We have confirmed our theory that the prehistoric occupation of LAN-63 and LAN-64 was more intense and complex than previously thought. Although we found no houses, we were able to outline the structure of activities at these two settlements in general terms, supporting Altschul's (1997) hypothesis that both sites—LAN-63 in particular—would exhibit a structure consistent with an intensive, semipermanent occupation by multiple families. Unfortunately, we were not able to identify details about the use of this structure, especially those concerning how the location of activities may have shifted over time or what the demographic structure of these settlements might have been. It may still be possible to gather information about site use with a more in-depth spatial analysis of the features and refuse deposits using the data that Van Horn and SRI have collected. By contrast, we gathered little additional information about the occupation at LAN-206A. This was not unexpected, as our assessment of this site from Van Horn's previous work suggested it would contribute little information (Altschul et al. 2000). As a result, the objective of Phase III work at this site was to ensure that any encountered human remains found would be recovered.

In addition to testing the hypotheses about site structure, our research at West Bluffs has contributed much additional information and, consequently, important new insights, into the occupation of the bluffs and the greater Ballona area. Although possible evidence of a Millingstone period occupation of the West Bluffs sites was documented in previous work, our Phase III excavations found indisputable evidence of this earlier component at LAN-64 in the form of several small shell dumps located at the base of the midden. The scattered distribution of these features and the paucity of associated cultural material suggests that these early deposits represent a limited and intermittent occupation consistent with Van Horn's model of seasonal camps. Radiocarbon dates obtained from these features are contemporaneous with the even older Paleocoastal period. A Paleocoastal period assignment for these features, however, is not warranted, as the material culture associated with these features is more consistent with a Millingstone period occupation.

In addition, our research has provided much more information about the Intermediate period occupation of the bluff tops, specifically, and the Ballona in general. Based on SRI's research along Centinela Creek at the base of the bluffs (Altschul et al. 1999, 2003, 2005), we have recognized that the Intermediate period occupation of the Ballona was perhaps the most widespread of any time period; more sites were occupied at this time, and they were distributed in a greater variety of locations than at any other time in the past. Despite this finding, there were several unanswered questions about this time period. Most important were (1) why were the most intensively occupied sites located on the bluff tops, which were relatively distant from the lagoon, whereas sites located along Centinela Creek (near the lagoon) did not exhibit the same intensity of occupation and complex site structure; and (2) why were the bluff-top sites apparently associated with a lagoon-focused subsistence pattern, when sites along Centinela Creek were associated with a more terrestrial-focused subsistence pattern (Altschul et al. 2005)?

Paleoenvironmental research combined with subsistence data collected from LAN-63 and LAN-64 provide answers to these questions. The focus of our research in the region has always been the Ballona Lagoon, as it has been considered the primary attraction for prehistoric inhabitants of the region. It is likely that the earliest settlement of the Ballona centered on the bluff tops because these were the most stable landforms in the early development of the region. The bluff-top sites, however, were located precisely in an area that would have afforded their residents access to two different resource-rich habitats: the Ballona Lagoon, located below the bluffs, and the Los Angeles Coastal Prairie, which covered the Westchester Hills from the bluff tops to an undetermined distance to the south. Although we have long recognized the great diversity of resources that would have been provided by the lagoon and its surrounding freshwater and saltwater marshes, the Los Angeles Coastal Prairie and its numerous vernal pools would have provided another rich set of terrestrial and aquatic resources that we did not recognize before we undertook our research at West Bluffs. Furthermore, the most intensive occupation of the bluff tops during the Intermediate period appears to have taken place during a brief 250-year interlude that correlates closely with a period of maximal precipitation. It is precisely during this period that the prairie and its vernal pools would have been most productive, as would have the freshwater marshes surrounding the lagoon. Subsistence data from LAN-63 and LAN-64 indicates that the inhabitants of these sites took advantage of the diverse set of resources provided by these two habitats, as they exploited a diverse set of terrestrial plants and animals and aquatic species that could be found around freshwater marshes and vernal pools. In addition, the Intermediate period inhabitants of these two sites exhibited a focused subsistence strategy with respect to fish from the lagoon and shellfish from the extensive mudflats that surround it. The greater resource diversity surrounding the bluff tops made it possible for area residents to settle in intensive, multiactivity, and multiseasonal—if not year-round—habitations. By contrast, contemporaneous settlements closer to the lagoon lacked access to the prairie and its vernal pools and appear to have been more specialized, seasonal occupations.

Paleoclimatic data also reveal that this brief period of maximal precipitation was followed in the later part of the Intermediate period by fluctuating climatic conditions that would have resulted in more unpredictable resource availability. The following Late period was associated with generally drier conditions, an infilling of the lagoon with sediment, and a reduction in the extent of the mudflats, the freshwater marsh, and vernal pools. The inhabitants of the Ballona appear to have responded to these changing and more adverse conditions by abandoning the bluff tops and concentrating their habitation in a much smaller number of settlements along Centinela Creek and the lagoon edge. Subsistence patterns also appear to have been affected. There seems to have been an increased utilization of plants and animals associated with the saltwater marsh—which would have expanded at the expense of the freshwater marsh with drier conditions—as well as sea mammals, shellfish from rocky shorelines, and deepwater fish. As the lagoon shrunk and the vernal pools dried up, the focused subsistence strategy associated with Intermediate period occupation shifted to a more mixed strategy involving lagoon and offshore resources.

Finally, our research at West Bluffs has justified our methodological approach to data recovery, one that combines traditional sampling using small, controlled excavation units with excavations that expose larger living areas and the controlled mechanical stripping of the entire affected area of the site. Van Horn’s initial work at LAN-63 and LAN-64 combined with our broader areal exposures would have been sufficient to characterize subsistence patterns at these two sites and to identify some of the features used by the prehistoric inhabitants. Without controlled mechanical stripping, however, few of the burials subsequently found at these sites would have been recovered, and the distribution of features and site structure could not have been mapped.

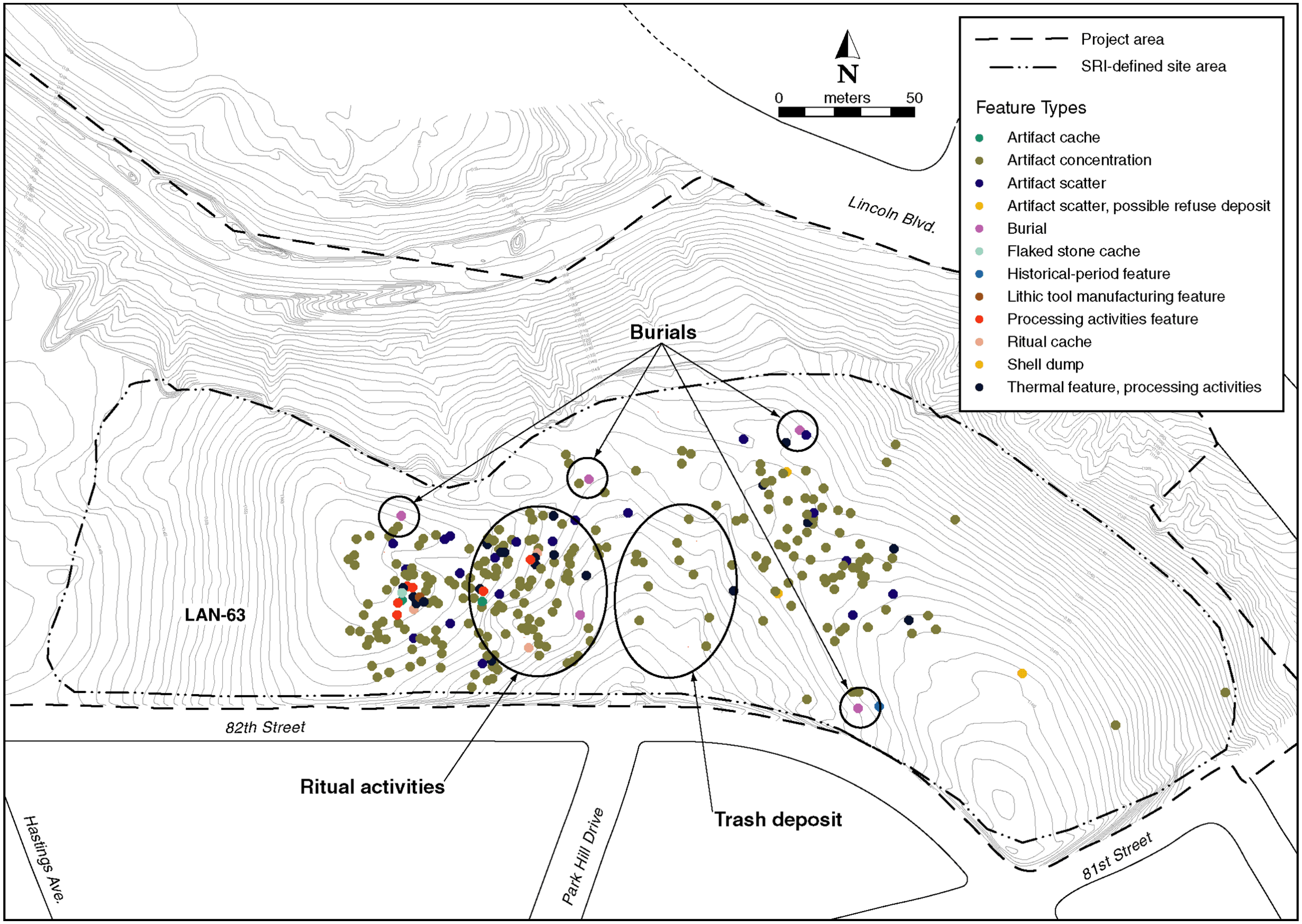


Figure 16.1. Organization of activities during the Intermediate period at LAN-63.

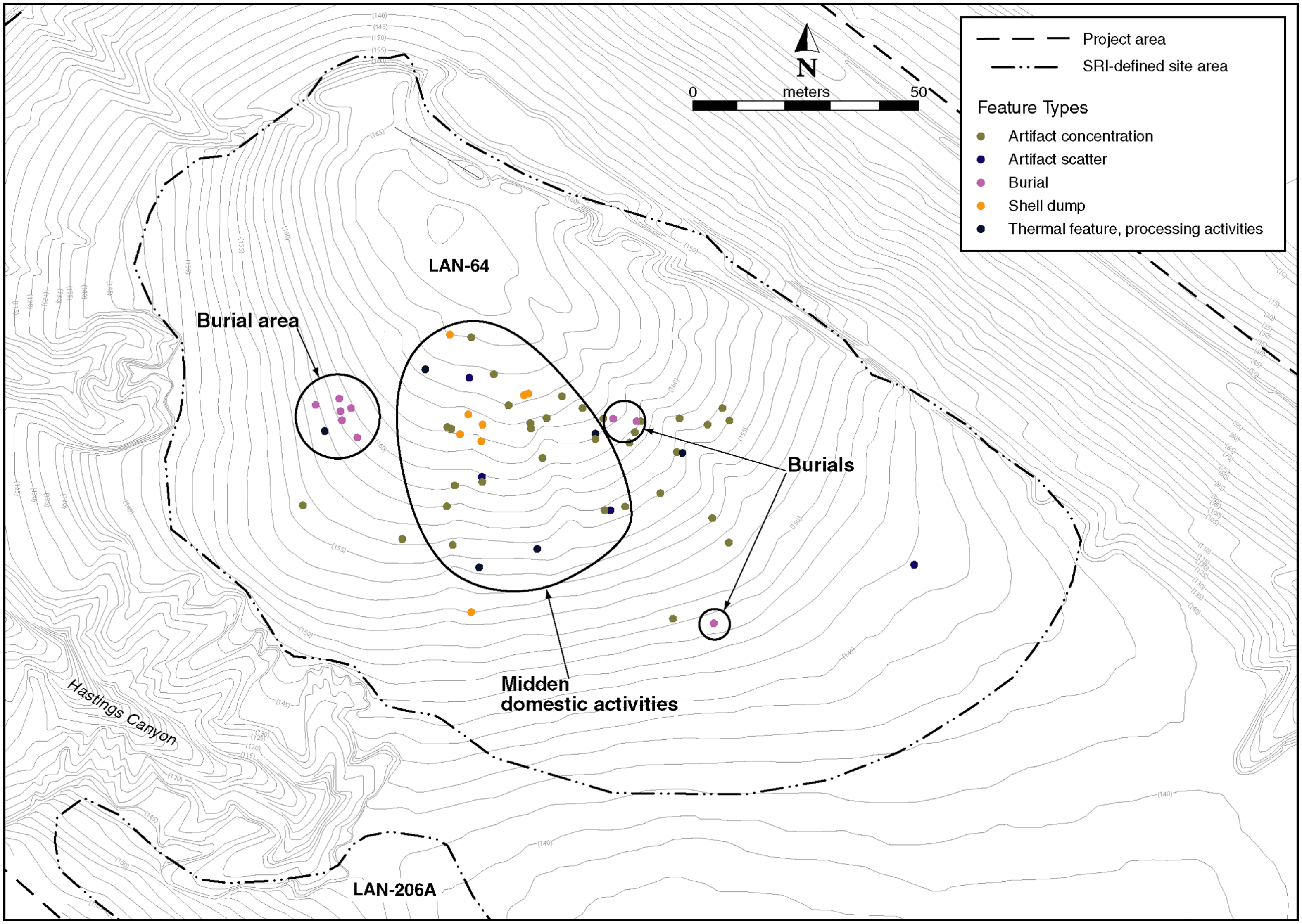


Figure 16.2. Organization of activities during the Intermediate period at LAN-64.

Table 16.1. Summary of Data Recovery Results by Van Horn (1987) and SRI

Research Topic and Site	Van Horn Results	SRI Results
Chronology[a]		
LAN-63	Intermediate period	Millingstone period?
	Late period	Intermediate period
LAN-64	Intermediate period	Millingstone period
		Intermediate period
LAN-206A	Millingstone period?	Millingstone period?
	Intermediate period?	Intermediate period?
Site Structure[b]		
LAN-63	temporary base camp	more permanent occupation
	random feature distribution	more formal site structure (Intermediate period)
		temporary base camp (Millingstone period)
LAN-64	temporary base camp	more permanent occupation
	random feature distribution	more formal site structure (Intermediate period)
		temporary base camp (Millingstone period)
LAN-206	temporary base camp	unknown
	random feature distribution	

[a] Temporal assignments for site's occupation.
[b] Describes the nature of settlement at the site.

Soil Pedon Descriptions for Profiles 1–7

Profile 1

Location of profile description: Del Rey Site (CA-LAN-63), Trench 1, west wall, 1 m north of south end, located about 80 m south-southeast of bluff edge and about 25 m north of 80th Street

Geomorphic setting: upland swale on marine terrace, elevation ?? m (?? feet), 5 percent southeast-facing slope

Parent material: dune sand of Quaternary El Segundo Sand Hills

Vegetation: miscellaneous grasses dominated by introduced cheat grass (*Bromus*)

Described by: Jeff Homburg

Date recorded: September 13, 2000

Unit	Descriptions
Ap	0–19 cm. Brown (10YR 5/3, 10YR 3.5/3 when moist) sand; massive; soft, very friable, nonsticky, nonplastic; many fine and very fine and few medium-sized roots; noneffervescent; slightly acid, pH 6.1; abrupt wavy boundary. (Unit V)
A	19–40 cm. Brown (10YR 5/3, 10YR 3.5/3 when moist) sand; massive; soft to slightly hard, friable, nonsticky, nonplastic; many very fine and common fine roots; noneffervescent; slightly acid, pH 6.0; clear smooth boundary. (Unit V)
Bw	40–66 cm. Brown (10YR 5/3, 10YR 3.5/3 when moist) sand; massive; soft to slightly hard, friable, nonsticky, nonplastic; few fine and very fine roots; noneffervescent; slightly acid, pH 6.2; abrupt smooth boundary. Contains several faint, 3–4-mm-thick lamellae in the upper midden. (Unit V)
2Ab	66–165 cm. Dark grayish brown (10YR 4/2, 10YR 2.5/2 when moist) loamy sand; massive; moderately hard, firm, nonsticky, nonplastic; few fine and very fine roots; noneffervescent; slightly acid, pH 6.5; clear smooth boundary. Midden deposit with abundant *Chione* shells and numerous krotovina; contains several faint, 3-mm-thick, yellowish brown (7.5YR 5/4, 7.5YR 4.4 when moist), sandy loam lamellae in the upper midden. (Unit IV)
2BA	165–187+ cm. Brown to dark brown (10YR 4/3, 10YR 3/3 when moist) loamy sand; massive; slightly hard, friable, nonsticky, nonplastic; noneffervescent; neutral, pH 6.9. (Unit III)

Profile 2

Location of profile description: Del Rey Site (CA-LAN-63), Trench 3, located about 60 m south of bluff edge

Geomorphic setting: backslope of dune on marine terrace, elevation ?? m (?? feet), 3 percent south-southwest-facing slope

Parent material: dune sand of Quaternary El Segundo Sand Hills

Vegetation: miscellaneous grasses

Described by: Jeff Homburg

Date recorded: September 27, 2000

Unit	Descriptions
Ap	0–24 cm. Grayish brown to dark grayish brown (10YR 4.5/2, 10YR 3/2 when moist) sand; weak fine and medium-sized granules; soft, very friable, nonsticky, nonplastic; many fine and very fine roots; noneffervescent; slightly acid, pH 6.5; abrupt wavy boundary. (Unit V)
A	24–60 cm. Grayish brown to dark grayish brown (10YR 4.5/2, 10YR 3/2 when moist) loamy sand; massive; hard, firm, nonsticky, nonplastic; common fine and very fine roots; noneffervescent; slightly acid, pH 6.5; abrupt smooth boundary. (Unit IV)
AB	60–101 cm. Yellowish brown (10YR 5/4, 10YR 4/3 when moist) sandy loam; massive; hard, firm, nonsticky, nonplastic; few fine and very fine roots; noneffervescent; neutral, pH 6.5; clear smooth boundary. (Unit III)
Bt	101–125+ cm. Dark yellowish brown (10YR 4/4, 10YR 3/4 when moist) sandy loam; massive; slightly hard, friable, nonsticky, nonplastic; common fine and very fine roots; noneffervescent; slightly acid, pH 6.2; gradual smooth boundary. (Unit II)

Profile 3

Location of profile description: Bluff Site (CA-LAN-64), Trench 1001, located about 60 m south of bluff edge

Geomorphic setting: summit of dune on marine terrace, elevation ?? m (?? feet), 10 percent west-facing slope

Parent material: dune sand of Quaternary El Segundo Sand Hills

Vegetation: miscellaneous grasses

Described by: Jeff Homburg

Date recorded: September 11, 2000

Unit	Descriptions
A	0–22 cm. Brown (7.5YR 5/2, 7.5YR 4/2 when moist), loamy sand; massive; slightly hard, very friable, nonsticky, nonplastic; many very fine and common fine roots; noneffervescent; moderately acid, pH 5.7; abrupt wavy boundary. (Unit V)
A1	22–38 cm. Brown (10YR 5/3, 10YR 3.5/3 when moist), loamy sand; massive; hard, firm, nonsticky, nonplastic; common very fine and few fine roots; noneffervescent; slightly acid, pH 6.4; abrupt smooth boundary. (Unit IV)
A2	38–78 cm. Brown (10YR 4.5/3, 10YR 3/3 when moist), loamy sand; massive; slightly to moderately hard, friable, nonsticky, nonplastic; common very fine and few fine roots; noneffervescent; neutral, pH 7.0; clear smooth boundary. (Unit IV)
A3	78–101 cm. Dark yellowish brown (10YR 4/4, 10YR 3/4 when moist), loamy sand; massive; moderately hard, friable, nonsticky, nonplastic; common very fine and few fine roots; noneffervescent; slightly acid, pH 6.5; gradual smooth boundary. (Unit IV)
AB	101–125+ cm. Dark yellowish brown (10YR 4/4, 10YR 3/4 when moist), loamy sand; massive; hard, friable, nonsticky, nonplastic; common very fine and few fine roots; noneffervescent; neutral, pH 6.8. (Unit III)

Note: Single 3–4-mm-thick, yellowish brown (7.5YR 5/4, 7.5YR 4.4 when moist), sandy loam lamellae were noted at the boundaries between subhorizons.

Profile 4

Location of profile description: Bluff Site (CA-LAN-64), Trench 1003, located about 60 m south of bluff edge

Geomorphic setting: shoulder slope of dune on marine terrace, elevation ?? m (?? feet), 2 percent southwest-facing slope

Parent material: dune sand of Quaternary El Segundo Sand Hills

Vegetation: miscellaneous grasses

Described by: Jeff Homburg

Date recorded: September 27, 2000

Unit	Descriptions
Ap	0–16 cm. Grayish brown (10YR 5/2, 10YR 3.5/2 when moist) sand; weak fine and medium-sized granules; soft, very friable, nonsticky, nonplastic; many fine roots; noneffervescent; slightly acid, pH 6.2; abrupt wavy boundary. (Unit V)
A	16–23 cm. Grayish brown (10YR 5/2, 10YR 3.5/2 when moist) sand; single grain; soft to slightly hard, friable, nonsticky, nonplastic; common very fine and few fine roots; noneffervescent; moderately acid, pH 5.9; clear smooth boundary. (Unit IV)
BA	23–37 cm. Yellowish brown (10YR 5/4, 10YR 4/3 when moist), loamy sand; massive; slightly to moderately hard, friable, nonsticky, nonplastic; few very fine and few fine roots; noneffervescent; moderately acid, pH 6.0; clear smooth boundary. (Unit III)
Bt1	37–57 cm. Yellowish brown (10YR 5/4, 10YR 4/3 when moist) loamy sand; massive; moderately hard, friable, nonsticky, nonplastic; common, distinct brown (7.5YR 5/4, 7.5YR 4.4 when moist) clay bridges; few very fine and fine roots; noneffervescent; neutral, pH 6.9; clear smooth boundary. (Unit II)
Bt2	57–104 cm. Yellowish brown (10YR 5/4, 10YR 4/3 when moist) loamy sand; massive; hard, friable, nonsticky, nonplastic; few faint, brown (7.5YR 5/4, 7.5YR 4.4 when moist) clay bridges; few very fine and fine roots; noneffervescent; neutral, pH 6.9; gradual smooth boundary. (Unit II)
BC	104–146 cm. Light yellowish brown (10YR 6/4, 10YR 4/4 when moist), loamy sand; massive; moderately hard, friable, nonsticky, nonplastic; few very fine and few fine roots; noneffervescent; slightly alkaline, pH 7.7; gradual smooth boundary. (Unit I)
C	146–168+ cm. Pale brown (10YR 6/3, 10YR 4.5/3) and light yellowish brown (10YR 6/4, 10YR 4/4 when moist) sand; massive; hard, friable, nonsticky, nonplastic; common very fine and few fine roots; noneffervescent; neutral, pH 6.9. (Unit I)

Note: A compact traffic pan was noted in the A and BA horizons; 3–6-mm-thick yellowish brown (7.5YR 5/4, 7.5YR 4.4 when moist) lamellae were noted at depths of 3 8, 91, 96, 109, 114, and 129 cm consisting of highly undulating ribbons, some of which bifurcate and merge with others.

Profile 5

Location of profile description: Del Rey Site (CA-LAN-63), Trench 4, located about 25 m northeast of Trench 3/Profile 2.

Geomorphic setting: shoulder slope of dune on marine terrace, elevation ?? m (?? feet), 3 percent southwest-facing slope

Parent material: dune sand of Quaternary El Segundo Sand Hills

Vegetation: miscellaneous grasses

Described by: Jeff Homburg

Date recorded: September 27, 2000

Unit	Descriptions
Ap	0–23 cm. Grayish brown to dark grayish brown (10YR 4.5/2, 10YR 3/2 when moist) sand; weak fine and medium-sized granules; soft, very friable, nonsticky, nonplastic; many fine and very fine roots; noneffervescent; slightly acid, pH 6.5; abrupt wavy boundary. (Unit V)
A	23–53 cm. Grayish brown to dark grayish brown (10YR 4.5/2, 10YR 3/2 when moist) loamy sand; massive; hard, firm, nonsticky, nonplastic; common fine and very fine roots; noneffervescent; slightly acid, pH 6.5; abrupt smooth boundary. (Unit IV)
Bt	53–96+ cm. Dark yellowish brown (10YR 4/4, 10YR 3/4 when moist) sandy loam; massive; slightly hard, friable, nonsticky, nonplastic; common fine and very fine roots; noneffervescent; slightly acid, pH 6.2; gradual, smooth boundary. Approximately 15–20 percent of the volume of the upper 25 cm of this horizon consists of infilled animal burrows (krotovina). (Unit II)

Profile 6

Location of profile description: Berger Site (CA-LAN-206A), Trench 1002, located about 80 m south of Hastings Canyon within about 15 m northeast of intersection at 80th Street and Berger Avenue

Geomorphic setting: shoulder slope of dune on marine terrace, elevation ?? m (?? feet), 9 percent northeast-facing slope

Parent material: dune sand of Quaternary El Segundo Sand Hills

Vegetation: miscellaneous grasses and forbs and ice plant

Described by: Jeff Homburg

Date recorded: December 18, 2000

Unit	Descriptions
Ap	0–20 cm. Brown (10YR 5/3, 10YR 3/3 when moist) loamy sand; massive; soft, very friable, nonsticky, nonplastic; many fine and very fine roots; noneffervescent; slightly acid, pH 6.5; abrupt smooth boundary. (Unit V)
BA	20–46 cm. Brown to pale brown (10YR 5.5/3, 10YR 4/4 when moist) loamy sand; massive; hard, firm, nonsticky, nonplastic; common fine and very fine roots; noneffervescent; slightly acid, pH 6.5; clear smooth boundary. (Unit III)
Bt/C	46–122 cm. Brown to pale brown (10YR 5.5/3, 10YR 3/4 when moist) loamy sand; massive; hard, firm, nonsticky, nonplastic; common very fine and few fine roots; noneffervescent; neutral, pH 6.5; clear smooth boundary. (Unit I)

Note: 2–25-mm thick, dark yellowish brown (10YR 4/4, 10YR 3/4 when moist), sandy loam lamellae noted at depths of 46, 51, 56, 62, 71, 84, 87, 91, 98, 103, 108, 111, 118, and 122 cm; the deeper lamellae are thicker, more irregular, and have a jagged, wavy appearance.

Profile 7

Location of profile description: Trench ??, west wall, located between Del Rey (CA-LAN-63) and Berger (CA-LAN-206A) sites, about 130 m south-southwest of bluff edge and about 30 m north of 80th Street

Geomorphic setting: upland depression, elevation ?? m (?? feet), 0 percent slope

Parent material: dune sand of Quaternary El Segundo Sand Hills

Vegetation: miscellaneous grasses

Described by: Jeff Homburg

Date recorded: September 13, 2000

Unit	Descriptions
Ap	0–20 cm. Brown (10YR 5/3, 10YR 3.5/3 when moist) loam to clay loam; moderate, medium-sized and coarse subangular blocks; hard, firm, slightly sticky, slightly plastic; many fine and very fine, and common medium roots; noneffervescent; strongly acid, pH 5.5; abrupt wavy boundary. (Unit V)
A	20–28 cm. Brown (10YR 5/3, 10YR 3.5/3 when moist) loam; massive; moderately hard, firm, slightly sticky, slightly plastic; common fine and very fine roots; noneffervescent; moderately acid, pH 5.6; clear smooth boundary. (Unit V)
Bw	28–40 cm. Dark yellowish brown (10YR 4/4, 10YR 4/3 when moist) loamy sand; massive; moderately hard, firm, nonsticky, nonplastic; common fine and very fine roots; noneffervescent; moderately acid, pH 5.8; abrupt smooth boundary. (Unit V)
2Ab1	40–64 cm. Brown to dark brown (10YR 4/3, 10YR 3/3 when moist) sandy loam; massive; slightly hard, friable, slightly sticky, slightly plastic; common fine and very fine roots; noneffervescent; slightly acid, pH 6.2; gradual smooth boundary. (Unit IV)
2Ab2	57–104 cm. Yellowish brown (10YR 5/4, 10YR 4/3 moist) loamy sand; massive; hard, friable, nonsticky, nonplastic; few faint, brown (7.5YR 5/4, 7.5YR 4.4 moist) clay bridges; few very fine and fine roots; noneffervescent; neutral, pH 6.9; gradual smooth boundary. (Unit II)
2AB	97–112 cm. Brown to dark brown (10YR 4/3, 10YR 3/3 when moist) sandy loam; massive; slightly hard, friable, slightly sticky, slightly plastic; few fine and very fine roots; noneffervescent; slightly acid, pH 6.4; clear smooth boundary. (Unit III)
2Btb1	112–126 cm. Yellowish brown (10YR 5/4, 10YR 4/4 when moist) sandy loam, with few faint, medium dark yellowish brown (10YR 4/6, 10YR3/6 when moist) mottles; massive; moderately hard, very firm, slightly sticky, slightly plastic; few fine and very fine roots; noneffervescent; slightly acid, pH 6.5; abrupt smooth boundary. (Unit II)

2Btb2 126–130 cm. Yellowish brown (10YR 5/4, 10YR 4/4 when moist) sandy loam to sandy clay loam, with common faint, medium dark yellowish brown (10YR 4/6, 10YR3/6 when moist) mottles; massive; hard, very firm, slightly sticky, slightly plastic; few fine and very fine roots; noneffervescent; slightly acid, pH 6.5; abrupt smooth boundary. (Unit II)

2Btb3 130–146 cm. Brown (10YR 4/3, 10YR 3/3 when moist) sandy loam, with few faint, medium dark yellowish brown (10YR 4/6, 10YR3/6 when moist) mottles; massive; moderately hard, friable, slightly sticky, slightly plastic; few fine and very fine roots; noneffervescent; slightly acid, pH 6.5. (Unit II)

Introduction to Geophysical Survey Methods

David Maki and Lewis Somers

A brief introduction to magnetic field gradient survey methods is presented below to aid the archaeologist in interpretation of these survey results. An in-depth study of these methods as applied to archaeology can be found in Clark (1996). A more rigorous overview of geophysical method and theory is presented by Sharma (1997). Technical issues specifically related to this investigation are discussed in Chapter 6, in the section titled, "Survey Design and Technical Parameters."

Magnetic Field Gradient Survey

For the purpose of this survey and in the absence of archaeological and geological contributions, the earth's magnetic field near the surface of the earth is uniform, and the gradient of this field is zero (Somers 1998). When there is an archaeological or geological magnetic field, it adds to the earth's magnetic field and the magnetic field gradient is no longer zero.

Magnetic field gradient surveys measure this deviation from uniformity and report it as positive data when the deviation is in the direction of the earth's magnetic field, and as negative data when the deviation is in the direction opposite the earth's magnetic field. In these surveys, the more "magnetic" the archaeological record, the greater the magnetic field distortion and the greater the feature contrast in the survey map.

The archaeological record has two basic properties, or mechanisms, by which it distorts the earth's magnetic field. These are called the remanent magnetization (a permanent magnetic effect) and the magnetic susceptibility (a bulk magnetic property similar to density). Both mechanisms are dependent on the presence of iron (e.g., iron oxides in soils, ceramic vessel fragments, and hearths), and both mechanisms alter the magnetic field at the surface of the site. They are thus mapped as distortions of the earth's magnetic field.

Remanent magnetization is the familiar "permanent magnet" effect and is associated with iron and steel objects (including rust), as well as with ceramics, hearths, fire pits, fire-altered soils, and stone. In these materials, the remanent magnetization originates from heating the iron oxides found in most soils above a critical temperature (565–675°C), called the Curie temperature. When the soil cools, the temperature-induced changes in the iron oxide crystals are "frozen" and become permanent. It is this change in the magnetic state of the soil (ceramic, hearth, etc.) that creates a remanent magnetic field. This thermally created magnetic field adds vectorially to the earth's magnetic field to cause a local distortion. Thus, many cultural objects and processes associated with heating are potential archaeomagnetic survey objects of interest.

The magnetic susceptibility alters the earth's magnetic field directly in a manner roughly analogous to the way porosity alters the flow of water through a solid. That is, where the magnetic susceptibility is large (high porosity), the magnetic field is increased; and where the magnetic susceptibility is low (low porosity), the magnetic field is decreased. Many cultural objects and processes (thermal, chemical, biological and biochemical, physical and mechanical) locally increase the magnetic susceptibility of the soil. The mechanism for this increase is also associated with changes in the iron oxide crystal structures within the soils. Local changes in site magnetic susceptibility alter the earth's magnetic field, and it is this distortion that is mapped. In magnetic surveys, remanent magnetization (permanent magnet) effects are usually significantly greater than susceptibility effects.

Many magnetic highs are a combination of induced field and remanent magnetization. The observed magnetic field strength is the result of the total magnetization of an object. The total magnetization is a vector sum of the induced magnetization and the remanent magnetization.

Magnetic Field Gradient Data Processing

All magnetic field gradient data are processed with Geoplot software, which is provided by the manufacturer of the survey instruments. Typically, the data are “cleaned up” using a “Zero Mean Traverse” algorithm, which removes scan-to-scan instrument and operator-bias defects. A gaussian lowpass filter is used to remove high-frequency spatial detail, or smooth the data. The data are also interpolated (up or down) to an appropriate density for viewing and export to graphical-editing software.

As with high-pass filtered resistance data, magnetic field gradient data are also a zero mean bipolar dataset. Magnetic field gradient maps can be thought of as containing features that increase the field gradient by locally adding to the earth’s field and features which decrease the field gradient by locally subtracting from the earth’s magnetic field. The zero-data regions correspond to areas of uniform or undisturbed magnetic field.

Thus, all positive data can be interpreted as features with increased magnetic field due to increased susceptibility or remanent magnetization oriented in the same direction as the earth’s magnetic field (e.g., hearths, fire-altered soils, bricks, sherds, and iron). All negative data can be interpreted as features with decreased magnetic fields due to decreased susceptibility or remanent magnetization oriented in the direction opposite the earth’s magnetic field (e.g. bricks, sherds, and iron).

Appendix C

Geophysical Survey Results from LAN-63 and LAN-64

David Maki and Lewis Somers

Native American Monitor and Most Likely Descendent–Representative Attendance, May–September 2003

Date	MLD Representatives				Native American Monitors		
	Jordan David	Ed Sosa	George Dorame	Adrien Kinsella	Martin Alcala	Dana Alcala	Tonantzin Carmelo
May 12, 2003	—	—	—	—	—	X	—
May 14, 2003	—	—	—	—	X	—	—
May 15, 2003	—	—	—	—	—	X	—
June 6, 2003	—	—	—	—	X	—	—
June 9, 2003	—	—	—	—	X	—	—
June 10, 2003	—	—	—	—	X	—	—
June 11, 2003	—	—	—	—	X	—	—
June 12, 2003	—	—	—	—	X	—	—
June 13, 2003	—	—	—	—	X	—	—
June 16, 2003	X	—	—	—	X	—	—
June 17, 2003	X	—	—	—	X	—	—
June 18, 2003	X	—	—	—	X	—	—
June 19, 2003	X	—	—	—	X	—	—
June 20, 2003	X	—	—	—	X	—	—
June 23, 2003	—	—	—	X	X	—	—
June 24, 2003	X	—	—	—	—	X	—
June 25, 2003	X	—	—	—	X	—	—
June 26, 2003	X	—	—	X	—	X	—
June 27, 2003	X	—	—	X	X	—	—

Date	MLD Representatives				Native American Monitors		
	Jordan David	Ed Sosa	George Dorame	Adrien Kinsella	Martin Alcala	Dana Alcala	Tonantzin Carmelo
June 30, 2003	X	—	—	—	X	—	—
July 1, 2003	X	—	—	—	—	X	—
July 2, 2003	—	—	X	—	X	—	—
July 3, 2003	—	—	X	—	—	X	—
July 7, 2003	—	X	—	—	X	—	—
July 8, 2003	—	X	—	—	X	X	—
July 9, 2003	X	X	—	—	X	X	—
July 10, 2003	X	X	—	—	X	X	—
July 11, 2003	X	X	—	—	X	X	—
July 14, 2003	—	X	—	—	X	—	X
July 15, 2003	—	X	—	—	X	X	—
July 16, 2003	X	X	—	—	X	X	—
July 17, 2003	X	X	—	—	X	X	—
July 18, 2003	X	—	—	—	X	X	—
July 21, 2003	X	—	—	—	X	X	—
July 22, 2003	X	—	—	—	X	X	—
July 23, 2003	X	X	—	—	X	—	X
July 24, 2003	X	X	—	—	X	X	—
July 25, 2003	X	X	—	—	X	X	—
July 28, 2003	X	X	—	—	X	—	—
July 29, 2003	X	X	—	—	X	—	—
July 30, 2003	X	X	—	—	X	—	—
July 31, 2003	X	X	—	—	X	—	—
August 1, 2003	X	X	—	—	X	—	—
August 4, 2003	—	X	—	X	X	—	—
August 5, 2003	X	X	—	—	—	—	—
August 6, 2003	X	X	—	—	X	—	—
August 7, 2003	X	X	—	—	—	—	X
August 8, 2003	X	X	—	—	X	—	—

Date	MLD Representatives				Native American Monitors		
	Jordan David	Ed Sosa	George Dorame	Adrien Kinsella	Martin Alcala	Dana Alcala	Tonantzin Carmelo
August 11, 2003	X	—	—	—	X	—	—
August 12, 2003	X	—	—	—	X	—	—
August 13, 2003	X	—	—	—	X	—	—
August 14, 2003	X	—	—	—	X	—	—
August 15, 2003	X	—	—	—	—	—	X
August 18, 2003	—	—	—	X	X	—	—
August 19, 2003	X	—	—	—	—	—	X
August 20, 2003	X	—	—	—	X	—	—
August 21, 2003	X	—	—	—	—	—	X
August 22, 2003	X	—	—	—	X	—	—
August 25, 2003	X	—	—	—	X	—	—
August 26, 2003	X	—	—	—	—	—	X
August 27, 2003	X	—	—	—	X	—	—
August 28, 2003	—	—	X	—	—	—	X
August 29, 2003	—	—	X	—	X	—	—
September 2, 2003	X	—	—	—	X	—	—
September 3, 2003	X	—	—	—	X	—	—
September 4, 2003	—	—	—	—	X	—	—
September 5, 2003	—	—	—	—	X	—	—

Most Likely Descendent's Recovery and Reburial Procedures

Gabrielino Tongva Indians of California
Recovery and Reburial Procedures

There are certain rules and methods developed by the Gabrielino Tongva Indians of California that are required when removing Gabrielino Tongva Remains from the earth. Conditions may occur that could alter one or more issues on this list. Consultation with the most likely descendent (MLD) and the Native American monitors assigned to the site should then be scheduled to determine other procedures that may be acceptable to the Gabrielino Tongva people.

Excavation:

1. Consultation between the MLD and the archaeological firm must take place when remains are unearthed and prior to any action taken.
2. A 50 foot perimeter for each uncovered burial will be required to safeguard further destruction until the area is examined for additional remains and associated grave goods.
3. In the event blade machines are operating in an adjacent area, a maximum of 2" cuts or less will be permitted in all cultural areas.
4. Additional monitors must be required if more than one area is being excavated at the same time. Each excavated burial will be monitored exclusively.
5. Wooden tools are preferred; electric chisels or other power tools should be avoided.
6. If remains are pedestaled, they will be placed on plywood for removal. If remains cannot be pedestaled due to soil conditions, remains must be carefully placed in cloth bags.
7. Soils adjacent to burials will be saved for reburial in plastic containers.
8. No photography, digital or video is allowed. Drawings of remains will be permitted to retain the orientation of the ancestors for re-interment purposes only. If the Coroner photographs the remains, the photos may not be published for any purpose.

Soil Removal and Handling:

1. 30-40cm of soil surrounding ancestors must be retained for reburial.
2. Soils surrounding ancestors may be dry-screened outside this measurement using $1/16^{th}$ mesh.
3. Water-screening of soil may be permitted with 1/8 mesh with consultation of NA monitor.

Testing:

1. No DNA testing is allowed.
2. No invasive testing is allowed.
3. Macroscopic analysis is permitted.
4. Shell associated with each burial may be used for dating purposes.
5. When remains are unearthed, the 1'x1' test pits will be allowed to determine the extent of the burial area.
6. All windrows within a 50 foot area must be dry or wet screened.

Storage:

1. Natural Cotton bags and sheeting or cotton drop cloths will be used to store remains until time of re-interment. Deer hides maybe used to cover the bagged and wrapped remains until time of reburial and may become the burial wrapping. Rabbit skins may be used for females.
2. Until scope of project is completed, storage of ancestors should be in close proximity to location of excavation or a protected area must be provided by the landowner or archaeologist.
3. Bone fragments will be bagged in natural cotton.

Reburial:

1. If at all possible, remains should stay within the same location or in as close proximity to the removal as possible, preferably within a ½ mile radius of the original grave site. When no

appropriate location can be identified within this radius, a secure location will be valued over distance.

2. If the preponderance of remains are uncovered in or excavated from one area, the re-interment should be in that area.
3. The reburial site should offer the best long-term protection against any additional disturbances.
4. Each reburial requires approximately 4' x 5 ½' when fully articulated and should be at a depth of 6 – 10 feet. The purpose of this depth is to insure difficulty in disturbing the reburial and to allow adequate room for a concrete cap or steel wire mesh buried approximately 4' below the surface of the ground. a backhoe is recommended for excavation of the burial pit.
5. All isolated bone fragments that are uncovered on site will be buried together in an individual burial pit with one or more deer skins, other indigenous animal skins, sea weed or the natural cloth used for all bagged fragments.
6. All associated grave goods and artifacts will be reentered with the ancestors.
7. No drawings or any other images of ancestral remains may be used for publication without consultation and the approval of the Native American Monitors and the appointed MLD for the site.

Costs:

1. The landowner(s) will be responsible for all costs related to the proper storage and reburial of remains excavated on their property to include all burial materials required in this document.
2. Landowner(s) will be financially responsible for providing reburial plots that are acceptable and approved by the MLD.

Revised 05/01/03

Summary List of Features at LAN-63

Field No.	Feature Type	Brief Description
1	thermal feature, processing activities	FAR, flaked and ground stone
2	thermal feature, processing activities	FAR, flaked and ground stone
3	thermal feature, processing activities	FAR, flaked and ground stone
4	thermal feature, processing activities	FAR, flaked and ground stone
5	flaked stone cache	flaked stone concentration
6	processing activities feature	flaked and ground stone
7	thermal feature, processing activities	FAR, flaked and ground stone
8	processing activities feature	flaked and ground stone
9	thermal feature, processing activities	FAR, flaked and ground stone
10	processing activities feature	flaked stone, manuports
11	ritual cache	ground and flaked stone, purposefully broken; ochre, shell
12	lithic tool manufacturing feature	flaked and ground stone, debitage
13	thermal feature, processing activities	FAR, flaked and ground stone
14	thermal feature, processing activities	FAR, flaked and ground stone
15	ritual cache	abalone shell, ground stone, manuports
16	processing activities feature	flaked and ground stone, manuports
17	thermal feature, processing activities	FAR, flaked stone and ground stone
18	artifact cache	flaked and ground stone, manuports, shell, bone
19	processing activities feature	flaked and ground stone, manuports
20	artifact cache	FAR, flaked and ground stone, pendant
21	processing activities feature	FAR, flaked and ground stone
300	shell dump	concentration of shell
302	artifact concentration	FAR, ground stone
303	artifact concentration	FAR, flaked and ground stone
305	artifact concentration	FAR, ground stone
306	artifact concentration	flaked and ground stone
307	artifact concentration	FAR, flaked and ground stone
308	artifact concentration	FAR, ground stone, hammer stone
309	artifact scatter	FAR, flaked and ground stone, possible hammer stone

Field No.	Feature Type	Brief Description
310	artifact concentration	dense concentration of FAR, flaked and ground stone, piece of glass surrounded by scattered artifacts
311	artifact scatter	FAR, ground stone, hammer stone
312	artifact scatter, possible refuse deposit	flaked and ground stone, shell
314	artifact concentration	FAR, ground stone, shell; high density of granulated FAR dispersed throughout feature
316	artifact scatter	flaked and ground stone, hammer stone
317	artifact concentration	FAR, ground stone
318	thermal feature, processing activities	dense concentration of flaked and ground stone
319	artifact concentration	FAR, shell, flaked and ground stone
320	artifact concentration	shell, ground stone
321	artifact concentration	FAR, flaked and ground stone
322	artifact concentration	concentration of ground stone
323	artifact concentration	FAR, ground stone
324	artifact concentration	dense concentration of FAR, flaked and ground stone
325	artifact concentration	concentration of ground stone
326	artifact concentration	dense concentration of FAR, flaked and ground stone
327	artifact concentration	dense concentration of FAR, flaked and ground stone
329	artifact concentration	ground stone and shell
330	artifact concentration	FAR, flaked and ground stone
331	artifact concentration	dense concentration of FAR and ground stone
332	artifact concentration	FAR, shell, ground stone, hammer stone
333	artifact concentration	FAR, flaked and ground stone
334	artifact concentration	concentration of a steatite bowl, flaked stone, shell, possible asphaltum
335	artifact concentration	broken stone bowl, ground stone
336	artifact concentration	FAR, ground stone, small amounts of shell
337	thermal feature, processing activities	dense concentration of FAR, ground and flaked stone, charcoal
338	artifact concentration	FAR, flaked and ground stone
339	artifact concentration	FAR, ground stone, shell, cobble fragments, charcoal
340	thermal feature, processing activities	dense concentration of FAR, flaked and ground stone, shell

Field No.	Feature Type	Brief Description
341	artifact scatter, possible refuse disposal	shell, flaked and ground stone, hammer stone
342	artifact concentration	FAR, flaked and ground stone, hammer stone
343	artifact concentration	FAR, shell, bone, ground stone
344	artifact concentration	FAR, ground stone
345	artifact concentration	distinct, dense concentrations of FAR; flaked and ground stone (Features 345 and 346 were recorded together)
346	artifact concentration	distinct, dense concentrations of FAR; flaked and ground stone
347	artifact scatter	FAR, ground stone
348	artifact concentration	FAR, flaked and ground stone
349	artifact concentration	FAR, ground stone, hammer stone
351	artifact concentration	FAR, flaked and ground stone
353	artifact concentration	flaked and ground stone
354	artifact concentration	FAR, flaked and ground stone, hammer stone
355	artifact concentration	FAR, flaked and ground stone, shell, bone
356	artifact concentration	FAR, ground stone
357	artifact concentration	flaked and ground stone, hammer stone
358	artifact concentration	FAR, ground stone
359	artifact concentration	FAR, flaked and ground stone, an incised piece of schist or steatite
360	artifact concentration	flaked and ground stone
362	artifact concentration	dense concentration of FAR, flaked and ground stone, hammer stone
363	artifact scatter	FAR, flaked and ground stone, shell
364	artifact concentration	FAR, ground stone
366	artifact concentration	flaked and ground stone, hammer stone
367	artifact scatter	flaked and ground stone
368	artifact concentration	dense concentration of ground stone and hammer stone
369	artifact concentration	FAR, ground stone, hammer stone, faunal bone, shell, charcoal
372	artifact concentration	isolated piece of possible human bone, possible clump of asphaltum, large bifacial core
374	artifact concentration	FAR, ground stone
376	artifact concentration	FAR, flaked and ground stone

Field No.	Feature Type	Brief Description
377	artifact concentration	dense concentration of FAR, flaked and ground stone, charcoal
378	artifact concentration	dense concentration of FAR, flaked and ground stone, hammer stone, burnt faunal bone, charcoal
379	artifact concentration	stone bowl, flaked and ground stone, hammer stone, shell
380	artifact concentration	FAR, flaked and ground stone
381	artifact concentration	FAR, flaked and ground stone
382	artifact concentration	FAR, flaked and ground stone
383	artifact concentration	FAR, ground stone
384	artifact concentration	FAR, flaked and ground stone
385	artifact concentration	dense concentration of FAR and ground stone
387	artifact concentration	unaltered cobbles and flaked stone
388	artifact concentration	two concentrations of ground stone and shell
390	artifact concentration	tight concentration containing FAR, flaked and ground stone, faunal bone, charcoal (Features 390 and 391 were drawn and collected together)
391	artifact concentration	tight concentration containing FAR, flaked and ground stone, faunal bone, charcoal
392	artifact concentration	FAR, flaked and ground stone
393	artifact concentration	FAR, flaked and ground stone
394	artifact concentration	FAR, flaked and ground stone
395	artifact concentration	dense concentration of FAR, flaked and ground stone
396	artifact scatter	flaked and ground stone
397	artifact concentration	flaked and ground stone, shell
399	artifact concentration	stone bowl, flaked and ground stone
400	artifact concentration	FAR, shell
401	artifact concentration	FAR
402	artifact concentration	FAR, ground stone
404	artifact concentration	two concentrations of FAR, bone, flaked and ground stone, possible asphaltum
405	artifact concentration	FAR and flaked stone
406	artifact concentration	FAR, flaked and ground stone, possible asphaltum
407	artifact concentration	dense concentration of FAR and ground stone

Field No.	Feature Type	Brief Description
408	artifact concentration	FAR, flaked and ground stone
409	thermal feature, processing activities	distinct concentration of FAR, flaked and ground stone, large-mammal bone (Features 409, 411, and 412 were drawn together on one map)
410	artifact concentration	FAR, ground stone
411	artifact concentration	distinct concentration of FAR, flaked and ground stone, large-mammal bone
412	artifact concentration	distinct concentration of FAR, flaked and ground stone, large-mammal bone
413	artifact concentration	FAR and ground stone
414	artifact concentration	FAR
415	artifact concentration	FAR, flaked and ground stone
416	artifact concentration	FAR, flaked and ground stone
417	artifact concentration	dense concentration of FAR, ground stone, shell, charcoal
420	artifact concentration	FAR, flaked and ground stone
422	artifact concentration	dense concentration of FAR and ground stone
423	artifact concentration	dense concentration of FAR, flaked and ground stone
426	artifact concentration	FAR, ground stone
428	artifact concentration	FAR, ground stone
429	artifact concentration	FAR, flaked and ground stone
431	artifact concentration	FAR, flaked and ground stone, hammer stone
433	artifact concentration	FAR and ground stone
434	artifact concentration	FAR, flaked and ground stone
435	artifact concentration	FAR, flaked and ground stone
436	artifact scatter	FAR, flaked and ground stone
438	artifact concentration	FAR, flaked and ground stone
439	artifact concentration	FAR, flaked and ground stone
440	artifact concentration	FAR, flaked and ground stone
441	artifact scatter	FAR, ground stone
442	artifact concentration	FAR, flaked and ground stone
443	artifact concentration	FAR, flaked and ground stone
444	thermal feature, processing activities	FAR, flaked and ground stone with scattered artifacts around main concentration
445	artifact concentration	FAR, possible flaked stone

Field No.	Feature Type	Brief Description
446	thermal feature, processing activities	dense concentration of FAR, flaked and ground stone, and pebbles
447	artifact concentration	dense concentration of FAR, flaked and ground stone surrounded by scattered artifacts
448	artifact concentration	FAR, flaked and ground stone
449	artifact concentration	FAR, flaked and ground stone, faunal bone
450	artifact scatter	FAR, flaked and ground stone, hammer stone
453	artifact concentration	dense concentration of FAR, flaked and ground stone, and charcoal
454	artifact concentration	FAR, flaked and ground stone, faunal bone
455	artifact concentration	FAR, flaked and ground stone
457	artifact concentration	FAR, flaked and ground stone
459	artifact concentration	FAR, flaked and ground stone
460	artifact concentration	FAR, ground stone, shell
461	artifact concentration	dense concentration surrounded by scatter of artifacts, including FAR, flaked and ground stone, shell, faunal bone
462	thermal feature, processing activities	dense concentration of FAR, flaked and ground stone
463	artifact concentration	FAR, flaked and ground stone
464	artifact concentration	FAR, flaked and ground stone and faunal bone
465	artifact concentration	FAR, flaked and ground stone
468	thermal feature, processing activities	dense concentration of FAR and ground stone
469	artifact scatter	FAR, shell, flaked stone, faunal bone, charcoal
470	artifact concentration	FAR, flaked and ground stone, shell
472	artifact concentration	FAR
473	artifact concentration	FAR, ground stone
474	artifact concentration	FAR, charcoal
475	burial	incomplete skeleton of child (possibly 4–5 years old) of indeterminate sex and body position, with steatite object
476	artifact concentration	FAR and ground stone, with small bits of faunal bone and shell
477	artifact concentration	FAR, ground stone
479	artifact concentration	FAR, flaked and ground stone, hammer stone, with granulated FAR throughout feature

Field No.	Feature Type	Brief Description
480	burial	flexed adult skeleton, of indeterminate sex, in disturbed context
481	artifact concentration	FAR, flaked and ground stone, shell, faunal bone
482	artifact scatter	FAR, flaked and ground stone
483	artifact concentration	FAR, flaked and ground stone, hammer stone
484	artifact scatter	flaked and ground stone, hammer stone
485	artifact concentration	FAR, flaked and ground stone, faunal bone
487	artifact concentration	FAR, flaked and ground stone
488	artifact concentration	FAR, flaked and ground stone
489	artifact concentration	FAR, flaked and ground stone, faunal bone
490	artifact concentration	FAR, ground stone, faunal bone
492	burial	adult skeleton, probable secondary burial, elements had been disturbed from anatomical position
493	artifact concentration	flaked and ground stone, faunal bone
494	artifact concentration	FAR, flaked and ground stone, charcoal
495	artifact concentration	FAR, flaked and ground stone
496	artifact concentration	FAR, flaked and ground stone, shell, charcoal
497	artifact concentration	FAR, ground and flaked stone, shell
498	artifact concentration	FAR, ground stone
499	artifact concentration	ground and flaked stone
500	artifact concentration	FAR, ground stone
503	artifact concentration	dense concentration of FAR and flaked and ground stone
504	artifact concentration	flaked and ground stone
505	artifact concentration	FAR, ground stone
506	artifact concentration	FAR, flaked stone, possible asphaltum
507	artifact concentration	FAR, flaked and ground stone, shell, faunal bone, charcoal
508	artifact concentration	flaked and ground stone
509	thermal feature, processing activities	FAR, flaked and ground stone, shell
510	artifact concentration	FAR, flaked and ground stone
512	artifact concentration	FAR, flaked and ground stone
516	artifact concentration	FAR and possible ground stone

Field No.	Feature Type	Brief Description
517	artifact concentration	FAR, flaked and ground stone
518	artifact concentration	FAR, shell
519	artifact concentration	FAR and flaked stone
520	artifact concentration	FAR and flaked stone
521	thermal feature, processing activities	FAR, ground stone, a stone bowl
522	artifact scatter	FAR, flaked and ground stone, shell
523	artifact concentration	FAR and flaked stone
524	artifact concentration	FAR, flaked and ground stone
525	artifact concentration	FAR, ground stone
527	artifact concentration	FAR, ground stone
534	artifact concentration	FAR, flaked stone
535	artifact concentration	FAR, flaked and ground stone
536	artifact concentration	FAR, ground stone
538	artifact concentration	FAR, flaked and ground stone
539	artifact concentration	FAR, flaked and ground stone
540	artifact concentration	FAR, flaked and ground stone
541	artifact concentration	FAR, flaked and ground stone
542	artifact scatter	FAR, possible flaked stone
544	artifact concentration	FAR, flaked and ground stone
545	artifact concentration	FAR, flaked and ground stone, faunal bone
546	artifact concentration	FAR, flaked and ground stone, shell, faunal bone
548	artifact concentration	dense concentration of FAR and ground stone
549	artifact concentration	FAR, ground stone, shell
550	artifact concentration	FAR, flaked and ground stone, shell, faunal bone
551	artifact concentration	dense concentration of FAR, flaked and ground stone, shell
552	artifact concentration	FAR, flaked and ground stone
554	artifact concentration	dense concentration of FAR, flaked and ground stone
555	artifact scatter	FAR, flaked and ground stone, hammer stone, faunal bone, shell
556	artifact concentration	FAR, flaked and ground stone
557	artifact concentration	stone bowl, flaked and ground stone

Field No.	Feature Type	Brief Description
558	artifact concentration	FAR, flaked and ground stone
560	artifact concentration	possible complete metate, FAR, flaked stone, shell
561	artifact scatter	FAR, flaked and ground stone, faunal bone
563	artifact concentration	FAR, flaked and ground stone
564	artifact concentration	FAR, flaked and ground stone
565	artifact concentration	FAR, ground stone
566	artifact concentration	stone bowl, ground stone, shell
567	artifact scatter	abalone shell with FAR and faunal bone
568	artifact concentration	FAR, ground stone, hammer stone
569	artifact concentration	FAR, flaked and ground stone, unaltered cobbles
570	artifact concentration	FAR, flaked and ground stone, hammer stone
571	artifact scatter	FAR, flaked and ground stone
574	artifact concentration	dense concentration of FAR, flaked and ground stone, and faunal bone
575	artifact concentration	FAR, flaked and ground stone, possible pendant
576	artifact concentration	FAR, flaked and ground stone
577	artifact concentration	broken bowl fragments, flaked stone
578	artifact concentration	concentration of ground stone
579	artifact concentration	FAR, flaked and ground stone, shell
581	artifact concentration	dense concentration of FAR and ground stone
582	artifact concentration	FAR, flaked and ground stone
583	artifact concentration	FAR, ground stone
584	artifact concentration	FAR, ground stone
585	artifact concentration	FAR, ground stone, faunal bone, shell
586	artifact concentration	FAR, flaked stone and shell
587	ritual cache	dense concentration of artifacts, including FAR, flaked and ground stone, and large-mammal bone; isolated pieces of burnt human bone and possible human bone found within feature
589	artifact concentration	dense concentration of FAR, flaked and ground stone, shell
590	artifact concentration	FAR, flaked and ground stone
594	thermal feature, processing activities	FAR, flaked and ground stone, shell, faunal bone

Field No.	Feature Type	Brief Description
595	artifact scatter	FAR, flaked and ground stone, glass
596	artifact concentration	FAR, flaked and ground stone
597	artifact concentration	ground stone
600	burial	incomplete adult flexed skeleton, possibly female
601	thermal feature, processing activities	dense concentration of FAR, flaked and ground stone, and bone
603	artifact concentration	flaked and ground stone
604	artifact concentration	FAR, ground stone
605	artifact concentration	FAR, flaked and ground stone, shell
607	artifact concentration	flaked and ground stone, shell
608	artifact concentration	flaked and ground stone, shell, faunal bone
610	artifact concentration	FAR, ground stone
611	artifact concentration	FAR, ground stone
612	artifact concentration	flaked and ground stone
613	artifact concentration	FAR, flaked and ground stone
614	artifact concentration	FAR, ground stone
615	artifact concentration	FAR, ground stone
616	artifact concentration	FAR, flaked and ground stone
617	burial	isolated adult partial cranial vault, in disturbed context
618	artifact concentration	ground stone
619	artifact concentration	stone bowl, other ground stone, faunal bone
620	artifact concentration	FAR, ground and flaked stone, shell, faunal bone
621	artifact concentration	dense concentration of FAR and ground stone
624	artifact concentration	FAR, ground stone
626	artifact concentration	dense concentration of FAR and ground stone
627	artifact concentration	flaked and ground stone
628	artifact concentration	FAR, flaked and ground stone, shell, charcoal
629	artifact concentration	FAR, flaked and ground stone, shell
630	artifact concentration	FAR, ground stone, shell
632	artifact concentration	FAR, flaked and ground stone
633	artifact concentration	FAR, flaked stone, shell

Field No.	Feature Type	Brief Description
635	artifact concentration	FAR, flaked and ground stone
636	historical-period feature	septic system, including brick-lined septic tank, 19 feet deep, adjacent to an unlined circular feature of similar depth containing dark, organic soil
638	artifact concentration	unaltered stones and glass, possibly disturbed
639	artifact concentration	ground stone
640	artifact concentration	ground stone
641	artifact concentration	ground stone
642	artifact concentration	ground stone
643	artifact concentration	FAR, ground stone
644	artifact concentration	ground stone, faunal bone
645	artifact concentration	FAR, ground stone
646	artifact concentration	flaked and ground stone, shell
647	artifact concentration	FAR, ground stone, faunal bone, charcoal
648	artifact concentration	FAR, flaked and ground stone
649	artifact concentration	FAR, flaked and ground stone
650	artifact concentration	ground stone
651	artifact concentration	FAR, flaked and ground stone
652	artifact concentration	FAR, possible ground stone
653	artifact concentration	FAR, flaked and ground stone
654	artifact concentration	FAR, flaked and ground stone
655	artifact concentration	FAR, ground stone, bits of charcoal and shell
656	artifact concentration	FAR, flaked and ground stone
657	artifact concentration	FAR, flaked and ground stone, and hammer stone
658	artifact concentration	FAR, flaked and ground stone, and hammer stone

Key: FAR = fire-affected rock

Summary List of Features at LAN-64

Field No.	Feature Type	Brief Description
1	artifact concentration	FAR
2	artifact concentration	FAR, ground stone
3	artifact concentration	FAR
4	artifact concentration	FAR
5	artifact concentration	FAR
6	artifact concentration	FAR
7	artifact concentration	FAR, ground stone
8	artifact concentration	FAR
9	artifact concentration	FAR, flaked and ground stone, shell
10	artifact concentration	FAR
11	artifact concentration	FAR
12	thermal feature, processing activities	FAR, flaked and ground stone, shell
13	artifact concentration	FAR
14	artifact concentration	FAR
15	artifact concentration	FAR with ground stone
16	artifact scatter	shell
17	thermal feature, processing activities	FAR and ground stone, with possible fire-affected soil
18	artifact concentration	FAR
19	artifact concentration	FAR
20	artifact concentration	FAR
21	artifact concentration	FAR, ground stone
22	artifact scatter	FAR, ground stone
23	thermal feature, processing activities	FAR, ground stone
24	artifact concentration	FAR
25	artifact concentration	FAR
26	artifact scatter	FAR, ground stone

Field No.	Feature Type	Brief Description
27	artifact concentration	FAR
28	artifact concentration	FAR, ground stone
29	artifact concentration	FAR
30	artifact concentration	FAR, ground and flaked stone
31	artifact concentration	FAR, ground stone
32	burial	poorly preserved adult, fragmented skeleton
33	thermal feature, processing activities	FAR, ground stone, unaltered stones
34	artifact concentration	FAR, ground stone, unaltered stones
35	artifact concentration	ground stone, unaltered stones
36	thermal feature, processing activities	FAR, flaked and ground stone
37	artifact concentration	FAR, ground stone
38	artifact concentration	FAR, ground stone
39	artifact concentration	FAR, ground stone
40	artifact concentration	ground stone, unaltered stones
42	shell dump	shell
43	burial	flexed adult skeleton, poorly preserved, placed in prepared shallow pit
45	shell dump	shell
46	artifact scatter	ground stone fragments, out of context
48	artifact concentration	concentration of FAR, ground and flaked stone
49	shell dump	dense concentration of shell with flaked stone
50	shell dump	dense concentration of shell and faunal bone
51	artifact concentration	FAR, ground stone
52	burial	flexed older adult skeleton, possibly male, with stone bowl fragment inverted over face
55	shell dump	dense concentration of shell and a polished stone
56	burial	prone adult skeleton, previously disturbed and incomplete
57	shell dump	shell
58	shell dump	shell

Field No.	Feature Type	Brief Description
60	shell dump	dense concentration of shell with flaked stone
61	burial	possible semiflexed, child’s (1–3 years) skeleton, very incomplete, previously disturbed
62	burial	possible adult upper postcranial elements, position unclear, previously disturbed
64	burial	flexed, adult, possible male skeleton, with head facing north; fairly complete
65	burial	flexed, subadult or young adult skeleton of indeterminate sex; gracile skeleton, previously disturbed
66	burial	supine and flexed adult female skeleton, with femora and right pelvis; abalone shell present; previously disturbed
76	thermal feature, processing activities	concentration of FAR, flaked and ground stone, faunal bone, charcoal

Key: FAR = fire-affected rock

Summary List of Features at LAN-206A

Field No.	Feature Type	Brief Description
100	burial	partial human cranium with fragments located in an area with visible historical-period or modern plow scars; disturbed context
102	artifact concentration	ground stone
103	artifact concentration	FAR, ground stone
104	artifact concentration	FAR, ground stone
105	thermal feature, processing activities	FAR, ground stone
106	thermal feature, processing activities	FAR, ground stone
107	thermal feature, processing activities	FAR, ground stone, hammer stone
108	artifact concentration	FAR, flaked and ground stone, possible pigment stone
109	artifact concentration	ground stone
110	artifact concentration	ground stone

Key: FAR = fire-affected rock

Ornaments Metric Data

Table I.1. *Olivella* Beads Recovered from LAN-63, by Type and Catalog Number

Bead Type	Style Code	Catalog No.	Provenience	Diameter	Thickness	Perforation		Comments
						Diameter	Shape	
Whole shell beads								
Spire-removed small	A1a	10003	F 587	6.4	—	1.0	—	length = 10.0; spire ground
Spire-removed small	A1a	10017	F 587	4.5	—	1.0	—	length = 7.0; spire ground
End-ground	B2	10016	F 587	4.9	—	2.0	—	length = 5.2; spire and end ground
End-ground	B2	10023	F 587	6.4	—	2.8	—	length = 8.2; spire and end ground
Wall beads								
Tiny Saucer	G1	10002	F 587, U 209, L 7	4.6	1.0	1.5	conical	blackened
Tiny Saucer	G1	10004	F 587	3.1–3.2	0.9	1.1	straight	
Tiny Saucer	G1	10009	F 587, U 211, L 4	3.8–4.0	1.1	1.0	conical	calcined
Tiny Saucer	G1	10014	F 587, U 211, L 5	4.0–4.3	1.2	1.2	conical	blackened
Saucer	G2	10001	F 587, U 222, L 3	8.4	1.2	2.4	conical	calcined
Saucer	G2	10006	F 587, U 210, L 6	7.5	1.5	2.5	conical	calcined
Saucer	G2	10010	F 587, U 211, L 4	5.2–5.3	1.1	1.9	conical	
Saucer	G2	10011	F 475	7.3	0.8	2.0	biconical	
Saucer	G2	10022	F 587	7.3	1.2	2.1	biconical	blackened
Oval Saucer	G5	10005	F 587	7.5–8.2	0.9	2.5	conical	perforation off-center
Oval Saucer	G5	10008	F 587, U 229, L 2	5.5–6.0	0.8	2.0	conical	perforation off-center, asphaltum on ventral surface
Wall Disk	J	10012	F 475	4.6–5.0	0.8	1.0	biconical	
Unidentifiable wall	—	10007	F 587, U 207, L 5	—	1.1	—	conical	blackened
Unidentifiable wall	—	10013	F587, U 211, L 5	—	—	—	—	5 fragments, all calcined, likely from one bead

Note: All measurements in millimeters. Types are from Bennyhoff and Hughes (1987). F = feature; L = level; U = unit

Table I.2 Stone Beads from LAN-63

Feature No.	Catalog No.	PD	Material	Type	Portion	Length (mm)	Width (mm)	Thickness (mm)	Plan Shape	Cross Section Shape	Perforation Diameter (mm)	Perforation Shape
475	1845	4151	slate	disk	complete	3.7	3.8	0.9	round	rectangular	1.8	conical
546	1844	4222	slate	disk	nearly complete	5.1	5	1.1	round	undetermined	2.1	conical
587	1066	4826	undetermined	cylinder	complete	12.7	7.2	7.5	cylindrical		5.4	biconical
587	1850	4994	slate	disk	complete	7.4	7	2.3	heptagonal	rectangular	2.4	biconical
587	2060	4920	slate	disk	complete	6	6	1	round		2.2	conical
587	2095		slate	disk	complete	4.7	4.7	1.1	round		2.3	conical
587	2096		slate	disk	complete	6.1	6.1	1.3	round		2.1	conical
587	2097		slate	disk	complete	6	6	1.1	round		2.1	conical
587	2098		slate	disk	complete	5.9	5.9	1.2	round		2.3	conical
587	2099		slate	disk	complete	6	5.8	1.1	round		1.8	conical
PP	1867	279	slate	disk	complete	5.2	5.3	1	round		1.9	conical
PP	2061	107	slate	disk	complete	4.8	4.7	1.1	round		2	conical
PP	2062	160	slate	disk	complete	4.8	4.8	1.6	round		2.2	conical

Table I.3. Stone Beads from LAN-64

Feature No.	Catalog No.	PD	Material	Type	Portion	Length (mm)	Width (mm)	Thickness (mm)	Plan Shape	Cross Section Shape	Perforation Diameter (mm)	Perforation Shape
52	6	1251	slate	disk	complete	4.3	4.2	1.7	round	rectangular	2.1	conical
52	7	1251	slate	disk	complete	4.3	4.2	1.1	round	rectangular	1.7	conical
52	8	1251	slate	disk	complete	4	4	1.4	round	rectangular	1.9	biconical
52	11	1252	slate	disk	complete	3.7	3.5	1.1	round	rectangular	1.5	conical
52	12	1252	slate	disk	complete	3.7	3.7	1.3	round	rectangular	1.5	conical
52	14	1406	slate	disk	complete	3.4	3.4	1.1	round	rectangular	1.8	biconical
52	15	1406	slate	disk	complete	4.1	4.1	1.2	round	rectangular	1.9	conical
52	272	1410	slate	disk	complete	4	4.1	1.3	round	rectangular	1.9	biconical
62	21	1454	slate	disk	complete	4.1	4.2	1	round	rectangular	1.5	biconical
64	24	1479	slate	disk	complete	4.3	4.3	1.2	round	rectangular	2.4	conical
64	25	1479	slate	disk	complete	3.8	3.8	1.2	round	rectangular	1.6	conical
64	26	1479	slate	disk	complete	4	4	1	round	rectangular	1.6	conical
64	27	1479	slate	disk	complete	3.5	3.4	1.3	round	rectangular	1.3	conical
65	32	1480	slate	disk	complete	4.4	4.2	1.1	round	triangular	2.1	biconical
65	33	1480	slate	disk	complete	4.5	4.5	1	round	rectangular	1.7	biconical
65	34	1480	slate	disk	complete	3.6	3.5	1.1	round	triangular	1.7	conical
65	35	1480	slate	disk	complete	3.6	3.4	1.1	round	rectangular	1.6	conical
65	36	1480	undetermined	disk	complete	4.8	4.8	1.5	round	rectangular	1.9	biconical
66	38	1505	slate	disk	complete	4	4	1.2	round	rectangular	1.5	biconical
66	39	1505	slate	disk	complete	4.4	4.4	0.9	round	rectangular	1.8	conical
66	40	1505	igneous	disk	complete	4	4.1	1	round	rectangular	1.7	conical
66	41	1505	slate	disk	complete	4.3	4.2	0.9	round	rectangular	1.7	conical
66	42	1505	undetermined	disk	complete	4.6	4.7	1.3	round	rectangular	2.2	conical
66	274	1503	slate	disk	nearly complete	4.1	4.1	1.2	round	rectangular	2.1	conical
66	275	1503	slate	disk	complete	3.7	3.7	0.9	round	rectangular	1.3	biconical
PP	266	1346	slate	disk	complete	4.5	4.5	1	round	rectangular	2.3	conical
PP	267	1364	slate	disk	complete	3.6	3.6	1.1	round	rectangular	1.8	conical

Feature No.	Catalog No.	PD	Material	Type	Portion	Length (mm)	Width (mm)	Thickness (mm)	Plan Shape	Cross Section Shape	Perforation Diameter (mm)	Perforation Shape
PP	268	1364	slate	disk	complete	4	4	0.9	round	rectangular	1.7	conical
PP	269	1364	slate	disk	complete	4.2	4.2	1.2	round	rectangular	1.8	conical
PP	270	1367	slate	disk	complete	4.4	4.4	1.5	round		2	biconical
PP	271	1381	slate	disk	complete	3.6	3.7	1.5	round	rectangular	1.9	biconical
PP	273	1495	slate	tube	complete	50.5	44.5	38.7	oval	irregular	27.6	biconical
PP	276	1557	slate	disk	complete	4.2	4	1.4	round	rectangular	2	conical

Native American Uses for Major Components of the Coastal Shrub (Chaparral) Community

Peter E. Wigand

Table J.1. Native American Uses for Major Components of the Coastal Shrub (Chaparral) Community

Family Name	Scientific Name (Common Name)	Native American Group	Drug or Medicinal	Food or Other	Reference
Asteraceae	*Baccharis pilularis DC.* (coyotebrush)	Costanoan	Panacea—infusion of plant used as a general remedy.		Bocek (1984:26)
Lamiaceae	*Salvia mellifera* Greene (black sage)	Costanoan	Analgesic—green leaves chewed for gas pains; poultice of heated leaves applied to the ear for earache pain.		Bocek (1984:16)
			Carminative—green leaves chewed for gas pains.		
			Cough medicine—decoction of plant taken for coughs.		
			Ear medicine—poultice of heated leaves applied to the ear for earache pain.		
			Heart medicine—infusion of green leaves taken for heart disorders.		
			Orthopedic aid—decoction of plant used as a bath for paralysis.		
			Throat aid—poultice of heated leaves applied to the neck for sore throats.		
Lamiaceae	*Salvia mellifera* Greene (black sage)	"Mahuna" (Wanakik Cahuilla [Romero 1954:4–5])	Cough medicine—infusion of plant taken for chronic bronchial coughs. Respiratory aid—infusion of plant taken for chronic bronchial coughs.		Romero (1954:19)
Lamiaceae	*Salvia mellifera* Greene (black sage)	Cahuilla		Spice—leaves and stalks used as a food flavoring. Staple—parched seeds ground into a meal.	Bean and Saubel (1972:136)
Lamiaceae	*Salvia mellifera* Greene (black sage)	Luiseño		Unspecified—seeds used for food.	Sparkman (1908: 229)

Family Name	Scientific Name (Common Name)	Native American Group	Drug or Medicinal	Food or Other	Reference
Asteraceae	*Artemisia californica* Less. (California sagebrush)	Cahuilla	Cold remedy—leaves used for colds. Gynecological aid—decoction of plant taken to start menstrual activity, for easy childbirth and postnatal recovery. —decoction of plant taken to prevent dysmenorrhea and ease menopause trauma. Pediatric aid—decoction of plant given to newborn babies one day after birth to flush out their system. Unspecified—plant used in the sweathouses for various cures.		Bean and Saubel (1972:42)
Asteraceae	*Artemisia californica* Less. (California sagebrush)	Costanoan	Analgesic—poultice of leaves applied to the tooth for pain. Antirheumatic (external)—decoction of plant used as a bath for rheumatism. Cold remedy—decoction of plant used as a bath for colds. Cough medicine—decoction of plant used as a bath for coughs. Dermatological aid—poultice of leaves applied to wounds. Respiratory aid—poultice of plant applied to the back or decoction of plant taken for asthma. Toothache remedy—poultice of leaves applied to the tooth for pain.		Bocek (1984:240–255)
Asteraceae	*Artemisia californica* Less. (California sagebrush)	"Mahuna" (Wanakik Cahuilla [Romero 1954:4–5])	Gynecological aid—infusion of plants taken for vaginal troubles.		Romero (1954:14)
Asteraceae	*Artemisia californica* Less. (California sagebrush)	Cahuilla		Smoke plant—leaves chewed fresh or dried and smoked after mixing with tobacco and other leaves.	Bean and Saubel (1972:42)

Family Name	Scientific Name (Common Name)	Native American Group	Drug or Medicinal	Food or Other	Reference
Asteraceae	*Artemisia californica* Less. (California sagebrush)	Luiseño		Ceremonial items—plant and white sage used to build a ceremonial fire before a hunt.	Sparkman (1908:199)
Asteraceae	*Encelia farinosa* Gray ex Torr. (goldenhills)	Cahuilla	Toothache remedy—decoction of blossoms, leaves, and stems held in the mouth for toothaches.		Bean and Saubel (1972:69)
Polygonaceae	*Eriogonum fasciculatum* Benth. (Eastern Mojave buckwheat)	Cahuilla	Analgesic—decoction of leaves taken for headache and stomach pain. Eye medicine—infusion of flower used as an eyewash. Gastrointestinal aid—decoction of leaves taken for stomach pain and headache.		Barrows (1967:78)
Polygonaceae	*Eriogonum fasciculatum* Benth. (Eastern Mojave buckwheat)	Costanoan	Urinary aid—decoction of plant used for urinary problems.		Bocek (1984:11)
Polygonaceae	*Eriogonum fasciculatum* Benth. (Eastern Mojave buckwheat)	Diegueño	Antidiarrheal—decoction of flowers given to babies for diarrhea. Emetic—decoction of flowers taken to "throw up badness in the stomach." Pediatric aid—decoction of flowers given to babies for diarrhea.		Hedges (1986:21)
Polygonaceae	*Eriogonum fasciculatum* Benth. (Eastern Mojave buckwheat)	Diegueño	Heart medicine—decoction of dried flowers or dried roots taken for a healthy heart.		Hinton (1975:216)
Polygonaceae	*Eriogonum fasciculatum* Benth. (Eastern Mojave buckwheat)	Tubatulabal	Antidiarrheal—decoction of dried flowers given to children for bloody flux. Infusion of dried heads taken for diarrhea. Gastrointestinal aid—infusion of dried heads taken for stomachaches. Pediatric aid—decoction of dried flowers given to children for bloody flux.		Voegelin (1938:59)

Note: There is no information on ***Ceanothus megacarpus***.

Appendix K

Micro- and Macrobotanical Data

Table K.3. West Bluffs Macrofossils at LAN-63, Sample Numbers 1–22

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
PD no.	18	57	289	290	291	293	308	324	325	328	330	332	334	367	369	371	373	374	414	416	418	420
Bone																						
Burnt	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unburnt	—	—	5	1	—	9	1	—	—	5	—	—	—	1	—	—	4	—	—	—	1	1
Fish vertebrae	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Freshwater snails (cf. *Gyraulus*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rodent dung	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cupressaceae twigs	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Charcoal[a]	C	A	C	C	R	C	A	C	C	C	R	A	C	C	A	A	A	A	A	A	C	C
Seed no.																						
Carbonized	0	34	31	39	9	0	9	6	5	9	1	7	2	0	10	1	48	69	4	5	2	2
Non-carbonized	1	7	13	5	0	0	0	0	0	0	0	0	2	0	0	0	2	2	1	0	0	0
Volume (liters)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total seeds (per liter)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total non-carbonized seeds (per liter)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total carbonized seeds (per liter)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Modern spiral awn nc (*erodium* cf. *cicutarium*)	—	—	—	41	—	2	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Non-carbonized seeds																						
Caryophyllaceae																						
Silene cf. *gallica*	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Spergula cf.	—	1	3	2	—	—	—	—	—	—	—	—	1	—	—	—	1	2	—	—	—	—

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
arvensis																						
Geraniaceae																						
Erodium cf. *cicutarium*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Geranium sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Portulacaceae																						
Calandrinia cf. *ciliata* v. 1	—	5	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Calandrinia cf. *ciliata* v. 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Asteraceae																						
Sonchus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hieracium-type	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
cf. *Anthemis*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hemizonia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fabaceae																						
cf . *lupinus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Trifolium sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Astragulus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Solanaceae (*solanum* sp.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Polygonaceae (*polygonum* sp.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxalidaceae # *(oxalis* cf. *stricta)*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brassicaceae																						
Brassica sp.	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sisymbrium sp.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Papaveraceae																						

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Papaver sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
cf. *Sanguinaria*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Boraginaceae (*borago* sp.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Amaranthaceae																						
Amaranthus sp. 1	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Amaranthus sp. 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chenopodiaceae																						
Chenopod	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Atriplex	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Poaceae (poaceae)	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Carbonized seeds																						
Brassicaceae *(brassica* sp.*)*	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chenopodiaceae (chenopod)	—	—	1	1	—	—	—	1	—	1	—	—	—	—	—	—	4	22	1	—	—	—
Lamiaceae *(salvia* sp.*)*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Solanaceae *(solanum* sp.*)*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cupressaceae																						
Scirpus Type 1 sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Scirpus Type 2 sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Scirpus Type 3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Poaceae																						
Poaceae	—	1	7	4	3	—	2	1	2	2	—	—	—	—	1	—	3	10	—	1	—	—
Agropyron sp.	—	1	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
Agrostis sp.	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Aristida cf.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Festuca cf. *obtusa*	—	—	1	1	1	—	—	—	1	—	—	—	—	—	—	—	1	1	1	—	—	—
Vulpia cf. *octoflora* (= *festuca* cf. *octoflora*)	—	—	2	3	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—
Hordeum cf. *pusillum*	—	—	1	5	3	—	2	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—
Lolium cf. *temulentum*	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Leptochloa sp.	—	—	—	4	1	—	1	—	—	—	—	—	—	—	1	—	1	8	—	—	—	—
Panicum sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Poa sp.	—	—	1	6	—	—	—	—	—	2	—	1	—	—	—	—	4	8	—	1	1	1
Stipa sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Polygonaceae																						
Rumex sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Asteraceae (other composite)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Uknown carbonized seeds																						
Type A (tear-shaped)	—	1	1	—	—	—	—	—	1	—	—	1	—	—	1	—	3	3	—	—	—	—
Type B (skewed flat tear-shaped)	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—
Type C (round with flat side)	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Type D (legume-shaped)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Type E (flattened ovate)	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Type F (flattened	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ovate with nipple)																						
Type G (dendritic pattern)	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Type G (crescentic)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	1	—	—	—	—
Uknown seeds																						
Carbonized	—	18	12	15	—	—	2	2	—	2	1	5	—	—	5	1	31	12	2	3	1	1
Uncarbonized	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[a]C = common; A = abundant; R = rare

Isolated Finds of Bones Identified as Human or Possibly Human in the West Bluffs Excavations

Feature	PD	Identification	Description	Screen Size	Count
LAN-63					
0	69	possible human	burned bone	0.25	1
0	87	possible human	burned bone	0.125	1
0	118	possible human	unidentified bone fragment	0.125	3
0	128	probable human	probable cranial vault	0.125	1
0	130	possible human	unidentified bone fragment	0.25	1
0	139	probable human	long-bone fragment: burned	0.25	1
0	146	possible human	burned bone	0.25	2
0	255	probable human	cranial vault: burned	0.25	1
0	266	probable human	human tooth fragment: burned	0.25	2
0	266	probable human	unidentified	0.25	2
0	304	possible human	burned bone	0.25	1
0	326	possible human	burned bone	0.125	1
0	398	possible human	misc. postcranial	0.125	1
0	4303	probable human	probable postcranial	0.5	8
0	4304	probable human	misc. postcranial	0.125	32
0	5437	probable human	unidentified	0.25	6
11	305	possible human	unidentified bone fragment	0.125	1
587	4563	human	cervical (C2) fragment	0.5	2
587	4563	human	frontal bone fragment	0.5	2
587	4563	human	tooth fragments—lower premolar or molar	0.125	3
587	4573	human	distal middle manual phalanx: burned	0.25	1
587	4573	human	long-bone fragment: burned		1
587	4579	possible human	long-bone epiphysis	0.25	1
587	4581	human	cranial vault: burned		1
587	4581	human	tooth enamel fragment (molar): burned		1
587	4584	human	cranial vault: burned		1
587	4584	human	manual phalange: burned		1
587	4584	human	misc. postcranial: burned		4
587	4608	probable human	long-bone fragment: burned	0.25	1
587	4613	human	misc. postcranial: burned		6
587	4613	human	misc. postcranial: burned		2
587	4669	human	frontal: burned		1
587	4669	human	long-bone epiphysis	0.25	1
587	4713	human	parietal: burned	0.25	4

Feature	PD	Identification	Description	Screen Size	Count
587	4719	human	parietal: burned	0.5	1
587	4722	human	middle manual phalanx, left side	0.25	1
587	4773	human	proximal manual phalanx: burned	0.25	1
587	4778	possible human	burned bone	0.125	1
587	4779	human	cranial vault: burned	0.5	2
587	4779	human	misc. postcranial	0.5	2
587	4781	possible human	unidentified bone fragment	0.25	1
587	4788	human	parietal: burned	0.5	1
587	4788	possible human	burned bone	0.25	3
587	4788	possible human	burned bone	0.125	5
587	4788	possible human	burned bone	0.125	1
587	4790	possible human	burned bone	0.125	4
587	4792	human	cranial vault: burned		2
587	4792	human	long-bone fragment: burned		1
587	4792	human	misc. postcranial: burned		1
587	4792	human	distal pedal phalanx	0.125	1
587	4807	human	cranial vault: burned		1
587	4807	human	long-bone fragment: burned		2
587	4807	human	misc. postcranial: burned		30
587	4807	human	phalange fragment: burned		1
587	4809	human	middle pedal phalanx	0.25	1
587	4810	possible human	unidentified bone fragment	0.25	1
587	4811	human	middle pedal phalanx, left side	0.25	1
587	4812	human	misc. postcranial: burned		1
587	4817	human	long-bone fragment: burned	0.25	1
587	4817	human	proximal. pedal phalanx, right side: burned	0.25	1
587	4820	human	tooth fragment-lower molar: burned	0.25	1
587	4824	human	cranial vault: burned	0.5	1
587	4848	human	cranial vault: burned	0.25	1
587	4848	possible human	burned bone	0.125	18
587	4848	probable human	cancellous bone: burned	0.25	3
587	4852	human	cranial vault	0.5	1
587	4852	human	cancellous bone: burned	0.5	1
587	4918	possible human	burned bone	0.25	3
587	4919	human	femur shaft fragment: burned		1
587	4919	human	misc. postcranial: burned		3
587	4919	human	pedal phalange: burned		1
587	4990	human	cranial vault: burned		3
587	4991	possible human	unidentified bone fragment	0.125	13
587	4992	human	1st manual distal phalanx: burned	0.5	1
587	4992	human	carpal–lunate, right side: burned	0.25	1
587	4992	human	distal metacarpal fragment: burned	0.5	1

Feature	PD	Identification	Description	Screen Size	Count
587	4992	human	tooth fragment—molar cusp: burned	0.25	1
587	4993	human	cranial vault: burned	0.5	2
587	4994	human	tooth fragment—upper PM: burned	0.125	1
587	4994	human	tooth fragment—possible molar	0.25	1
587	4994	human	upper right central incisor	0.25	1
587	6000	human	frontal bone: burned	0.5	1
587	6000	human	probable distal femur shaft: burned	0.5	1
587	6000	possible human	burned bone	0.125	5
587	6001	human	cranial vault: burned	0.25	2
587	6001	human	cancellous bone: burned	0.25	1
587	6038	human	carpal-pisiform, left side: burned	0.25	1
587	6038	human	tooth fragment—probable incisor: burned	0.25	1
LAN-64					
32	1141	human	postcranial or mandible fragment	0.25	1
32	1141	human	cranial vault	0.25	55
32	1141	human	cranial vault	1.0	1
32	1141	human	cranial vault—frontal and parietal	2.0	2
32	1141	human	cranial vault—frontal and parietal	0.5	23
32	1141	probable human	probable cranial vault and misc. postcranial	0.125	208
32	1141	possible human	unidentified bone fragment	0.25	2
52	1281	probable human	misc. postcranial	0.125	24
0	1346	probable human	cranial vault: burned	0.125	1
0	1367	possible human	unidentified bone fragment	0.25	11
0	1481	human	cranial vault		10
0	1481	human	femur shaft fragments: burned		17
0	1481	human	misc. postcranial		7
0	1481	human	rib fragment: burned		1
0	1481	human	unidentified long bone: burned		3
0	1553	probable human	misc. postcranial	0.25	116
0	1563	possible human	unidentified bone fragment	0.125	1
0	502	probable human	misc. postcranial	0.125	147
32	1125	possible human	cranial vault: burned	0.125	97
32	1125	possible human	misc. postcranial: burned	0.25	10
32	1125	possible human	misc. postcranial: burned	0.125	
32	1139	possible human	misc. postcranial: burned	0.25	1
32	1219	possible human	long-bone fragments: burned	0.5	5
LAN-206					
0	2134	human	long-bone fragments	0.25	9
0	2134	probable human	unidentified bone fragments	0.125	60

Appendix M

Descriptive Data for Burnt Human Bone from LAN-63

Feature No.	PD	Identification	Element	n	Wt. (g)	Sub. Color	Pantone Color							
							Ext. 1	Ext. 1 %	Ext. 2	Ext. 2 %	Int. 1	Int. 1%	Int. 2	Int. 2 %
0	255	probable human	cranial vault	1	0.26	br	450	100			450	100		
0	4834	human	1st proximal hand phalanges	1	0.8	b		100				100		
0	6039	human	1st proximal foot phalanges	1	1.8	b		100				100		
0	6039	probable human	cranial vault	1	5.4	b	462	100			405	100		
0	6039	probable human	cranial vault	1	1.7	br	463	100			462	100		
0	6039	probable human	cranial vault	1	1.0	w		50	407	50	402	100		
0	6039	probable human	cranial vault	1	10.5	b/w	400	75	462	25	450	100		
587	4563	probable human	distal and shaft of metatarsal	3	0.8	b	409	100				100		
587	4583	probable human	cranial vault	1	10.7	b		40	451	60		70	464	30
587	4613	human	lower M2	8	0.9	b		80	404	20				
587	4613	human	tooth root	8	0.2	b						100		
587	4613	probable human	cranial vault	1	2.6	br/w	450	60		40	450	50	430	50
587	4613	probable human	cranial vault	8	8.9	br/w	463	100			430	100		
587	4615	probable human	cranial vault	1	1.1	br/b	450	100				100		
587	4713	human	parietal	4	0.73	w	409	100			429	100		
587	4719	human	parietal	1	1.81	w	423	100			422	50		50
587	4719	human	cranial base	1	2.0	b	433	100			433	100		
587	4773	human	manual proximal phalanx	1	0.19	w		100						
587	4774	probable human	cranial vault	1	1.1	b/w	421	50	426	50	421	100		
587	4774	probable human	cranial vault	1	0.7	b/w	422	60		40	422	100		
587	4778	probable human	cranial vault	1	0.7	br	451	100			451	100		
587	4779	human	cranial vault	2	0.7	b/w	451	100			421	100		
587	4779	human	postcranial	2	2.01	w	452	100						
587	4780	human	tibia	1	8.4	br/b	444	90	451	10	451	100		
587	4780	human	cranial vault	1	1.7	b		100				100		
587	4788	human	parietal	1	2.78	w		80	444	20	468	50	424	50
587	4790	probable human	cranial vault	4	0.9	b	405	50	420	50	405	50	451	50
587	4794	probable human	cranial vault	1	2.0	w		50	430	50		100		
587	4806	probable human	os coxae	1	3.3	b	430	100			429	100		

587	4809	probable human	cranial vault	1	1.8	w		50	404	50		100		
587	4809	probable human	cranial vault	1	2.9	w		50	431	50		100		
587	4810	human	maxilla	1	7.4	b		100				100		
587	4810	human	lower canine ?	1	0.9	b						100		
587	4810	human	lower canine ?	1	0.7	b						100		
587	4810	human	hand phalange	1	0.1	b		100				100		
587	4810	probable human	cranial vault	1	1.4	b/w					428	100		
587	4810	probable human	cranial vault	1	0.8	w	401	100			402	100		
587	4812	human	temporal	1	21.6	b		100				100		
587	4812	human	molar	1	1.3	b	468	100				100		
587	4817	human	long-bone fragment	1	0.32	b/w		100			423	100		
587	4819	human	pterygoid	1	8.0	b		100				100		
587	4819	human	female frontal	3	3.4	br	465	100			465	100		
587	4819	probable human	cranial vault	3	1.8	b/w		100			433	100		
587	4820	human	lower M1 or M2	1	0.44	br/b		100			466	50	424	50
587	4821	human	parietal	1	18.6	br					450	100		
587	4823	probable human	cranial vault	1	3.0	b/w		100			402	100		
587	4824	human	cranial vault	1	4.18	w	468	100			430	100		
587	4824	human	cranial vault	1	14.2	b/w	430	50		50		50	425	50
587	4825	probable human	cranial vault	1	0.8	w		100			424	100		
587	4828	human	auditory meatus	1	4.9	b/w		100			430	100		
587	4848	human	cranial vault	18	0.36	b/w	404	50		50	463	100		
587	4848	probable human	unidentified	4	0.11	br					465	100		
587	4848	probable human	unidentified	4	0.1	br					465	100		
587	4848	probable human	unidentified	4	0.05	b					404	100		
587	4852	human	proximal radius	2	2.3	b/w	400	100				100		
587	4853	human	pterygoid	1	4.1	b	405	100			405	100		
587	4916	poss	long-bone fragment	1	1.2	br	403	100						
587	4916	probable human	cranial vault	1	1.8	br/b	449	100			423	100		
587	4917	human	auditory meatus	1	0.8	b		100				100		
587	4920	human	cranial vault	1	1.1	w					429	100		

587	4920	human	frontal	1	2.4	b/w		50	431	50	428	100		
587	4952	probable human	cranial vault	1	1.3	w		100			422	100		
587	4989	probable human	cranial vault	1	2.8	w	403	90		10	430	90		10
587	4992	human	1st manual distal phalanx	1	0.26	b		100						
587	4992	human	unidentified	2	0.11	b					404	100		
587	4992	probable human	cranial vault	1	1.8	b	404	80	401	10		100		
587	4992	probable human	r. ulna fragment	1	5.7	w		100				100		
587	4992	probable human	rib	1	4.9	b	405	100			404	100		
587	4993	human	cranial vault	1	1.07	w	454	100			454	100		
587	4993	human	cranial vault	2	1.39	b		100				100		
587	4993	human	subadult premolar	1	0.1	w		50	430	50				
587	4993	human	mandible	1	6.6	br	465	100			466	50	403	50
587	4993	human	proximal hand phalanges	9	1.0	b	432	100			432	100		
587	4993	human	tooth root	9	0.4	b						100		
587	4993	probable human	cranial vault	9	0.8	br/b	410	100			409	100		
587	4994	human	upper PM	1	0.36	br					465	100		
587	6000	human	distal femur shaft	1	4.1	br		100				70	465	30
587	6000	human	frontal	1	3.4	b	467	100			453	70	465	30
587	6000	human	mastoid sulcus	5	1.8	b	411	100			462	100		
587	6000	probable human	cranial vault	1	2.9	b	425	90	463	10	429	100		
587	6000	probable human	cranial vault	5	0.5	w		100			429	100		
587	6001	human	cranial vault	3	0.55	w	468	100			468	100		
587	6001	human	cancellous bone	3	0.36	w					423	50	420	50
587	6001	human	cancellous bone	3	0.01	b					411	100		
587	6038	human	probable incisor	1	0.26	br/b						70	463	30

Key:
PD = provenience number
Identification = certainty of identification: human or probable human
r. = right, l = left
Sub.Color = subjective color(s) of bone: b = black, br = brown, w = white
Ext. 1 = predominate Pantone color of external surface
Ext. 1 % = percent of external surface occupied by predominate Pantone color
Ext. 2 = secondary Pantone color of external surface
Ext. 2 % = percent of external surface occupied by secondary Pantone color
Int. 1 = predominate Pantone color of internal surface
Int. 1% = percent of surface occupied by predominate Pantone color
Int. 2 = secondary Pantone color of internal surface
Int. 2 % = percent of internal surface occupied by secondary Pantone color

Radiocarbon Analysis

Beta Analytic, Inc.

FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)
(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

September 17, 2004

Mr. Jeffrey Altschul
Statistical Research, Incorporated
6099 East Speedway Boulevard
Tucson, AZ 85712
USA

RE: Radiocarbon Dating Results For Samples PD62-97247, PD1236-97746, PD1260-97747, PD367-97728, PD371-97729, PD377-97730, PD4068-97731, PD4078-97727, PD4106-97732, PD4824-97726

Dear Jeff:

Enclosed are the radiocarbon dating results for ten samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses went normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice is enclosed. Please, forward it to the appropriate officer or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Mr. Jeffrey Altschul — Report Date: 9/17/2004

Statistical Research, Incorporated — Material Received: 8/20/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 195169	210 +/- 40 BP	-24.3 o/oo	220 +/- 40 BP

SAMPLE : PD62-97247
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1640 to 1680 (Cal BP 310 to 260) AND Cal AD 1730 to 1810 (Cal BP 220 to 140)
Cal AD 1930 to 1950 (Cal BP 20 to 0)

Beta - 195170	6780 +/- 90 BP	0.0 o/oo	7190 +/- 90 BP

SAMPLE : PD1236-97746
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal BC 5680 to 5340 (Cal BP 7630 to 7290)

Beta - 195171	1740 +/- 40 BP	+0.1 o/oo	2150 +/- 40 BP

SAMPLE : PD1260-97747
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 360 to 590 (Cal BP 1590 to 1360)

Beta - 195172	1690 +/- 40 BP	+0.5 o/oo	2110 +/- 40 BP

SAMPLE : PD367-97728
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 420 to 630 (Cal BP 1540 to 1320)

Beta - 195173	1720 +/- 40 BP	+0.8 o/oo	2140 +/- 40 BP

SAMPLE : PD371-97729
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 380 to 600 (Cal BP 1570 to 1350)

Mr. Jeffrey Altschul

Report Date: 9/17/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 195174 SAMPLE : PD377-97730 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal AD 460 to 670 (Cal BP 1490 to 1280)	1660 +/- 40 BP	-1.0 o/oo	2050 +/- 40 BP
Beta - 195175 SAMPLE : PD4068-97731 ANALYSIS : Radiometric-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal AD 540 to 890 (Cal BP 1410 to 1060)	1510 +/- 70 BP	-0.4 o/oo	1920 +/- 80 BP
Beta - 195176 SAMPLE : PD4078-97727 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal AD 380 to 600 (Cal BP 1570 to 1350)	1730 +/- 40 BP	+0.3 o/oo	2140 +/- 40 BP
Beta - 195177 SAMPLE : PD4106-97732 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal AD 400 to 620 (Cal BP 1540 to 1330)	1710 +/- 40 BP	-0.3 o/oo	2120 +/- 40 BP
Beta - 195178 SAMPLE : PD4824-97726 ANALYSIS : Radiometric-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal AD 280 to 660 (Cal BP 1670 to 1290)	1720 +/- 60 BP	+0.5 o/oo	2140 +/- 70 BP

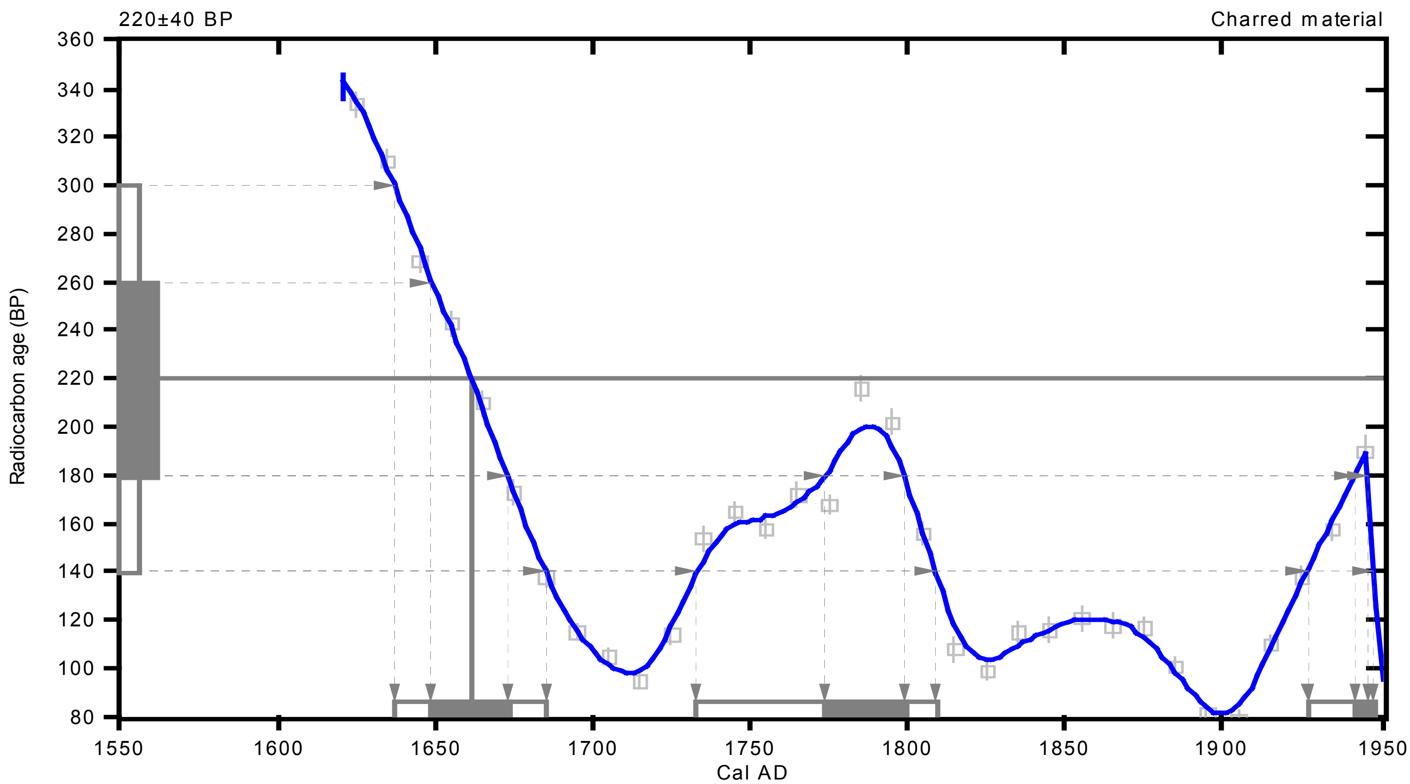
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.3:lab. mult=1)

Laboratory number:	**Beta-195169**
Conventional radiocarbon age:	**220±40 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal AD 1640 to 1680 (Cal BP 310 to 260) and** **Cal AD 1730 to 1810 (Cal BP 220 to 140) and** **Cal AD 1930 to 1950 (Cal BP 20 to 0)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1660 (Cal BP 290)
1 Sigma calibrated results: (68% probability)	Cal AD 1650 to 1670 (Cal BP 300 to 280) and Cal AD 1770 to 1800 (Cal BP 180 to 150) and Cal AD 1940 to 1950 (Cal BP 10 to 0)



References:

Database used
Intcal98

Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

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A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-195170**

Conventional radiocarbon age: **7190±90 BP**

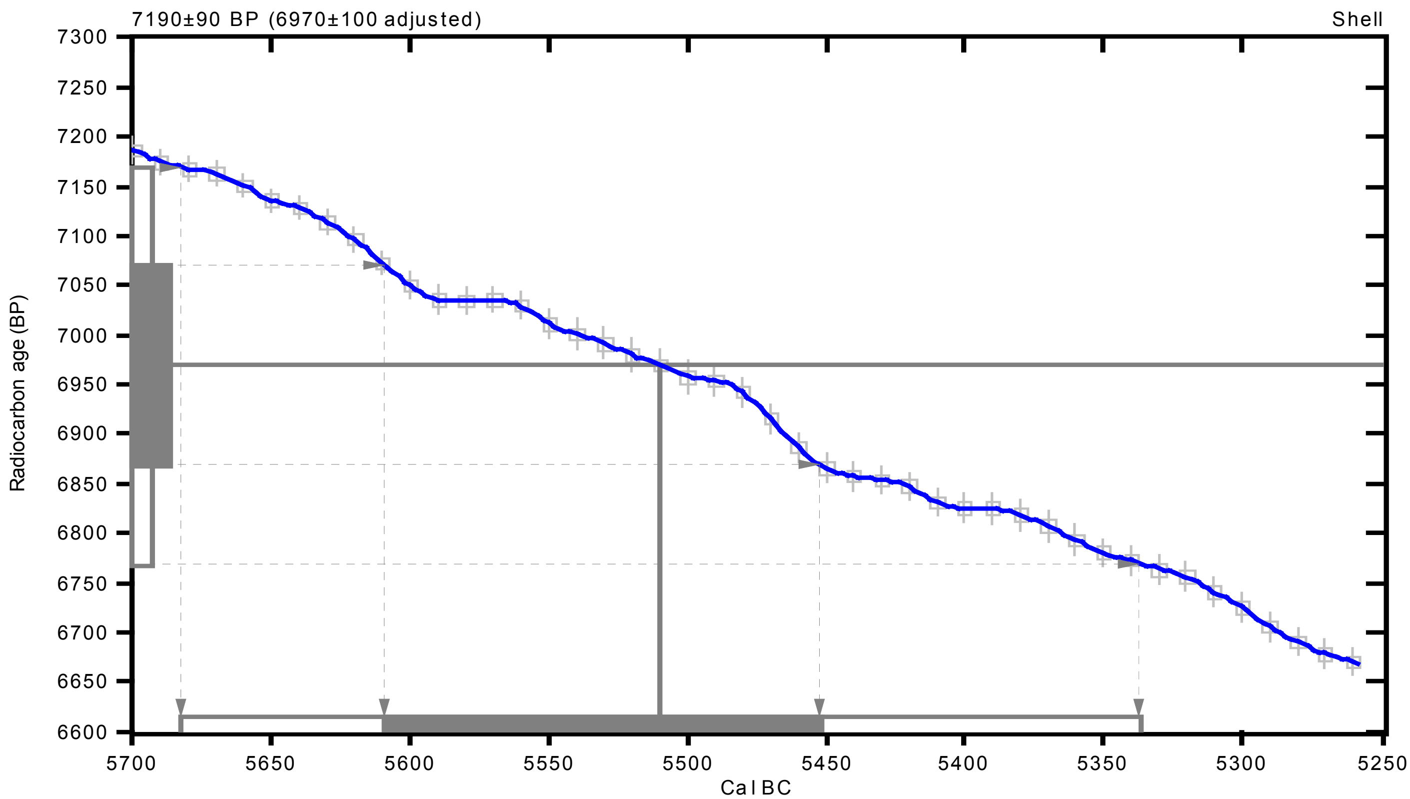
(6970±100 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal BC 5680 to 5340 (Cal BP 7630 to 7290)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 5510 (Cal BP 7460)

1 Sigma calibrated result: Cal BC 5610 to 5450 (Cal BP 7560 to 7400)
(68% probability)



References:

Database used
Marine98
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Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.1:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-195171**

Conventional radiocarbon age: **2150±40 BP**

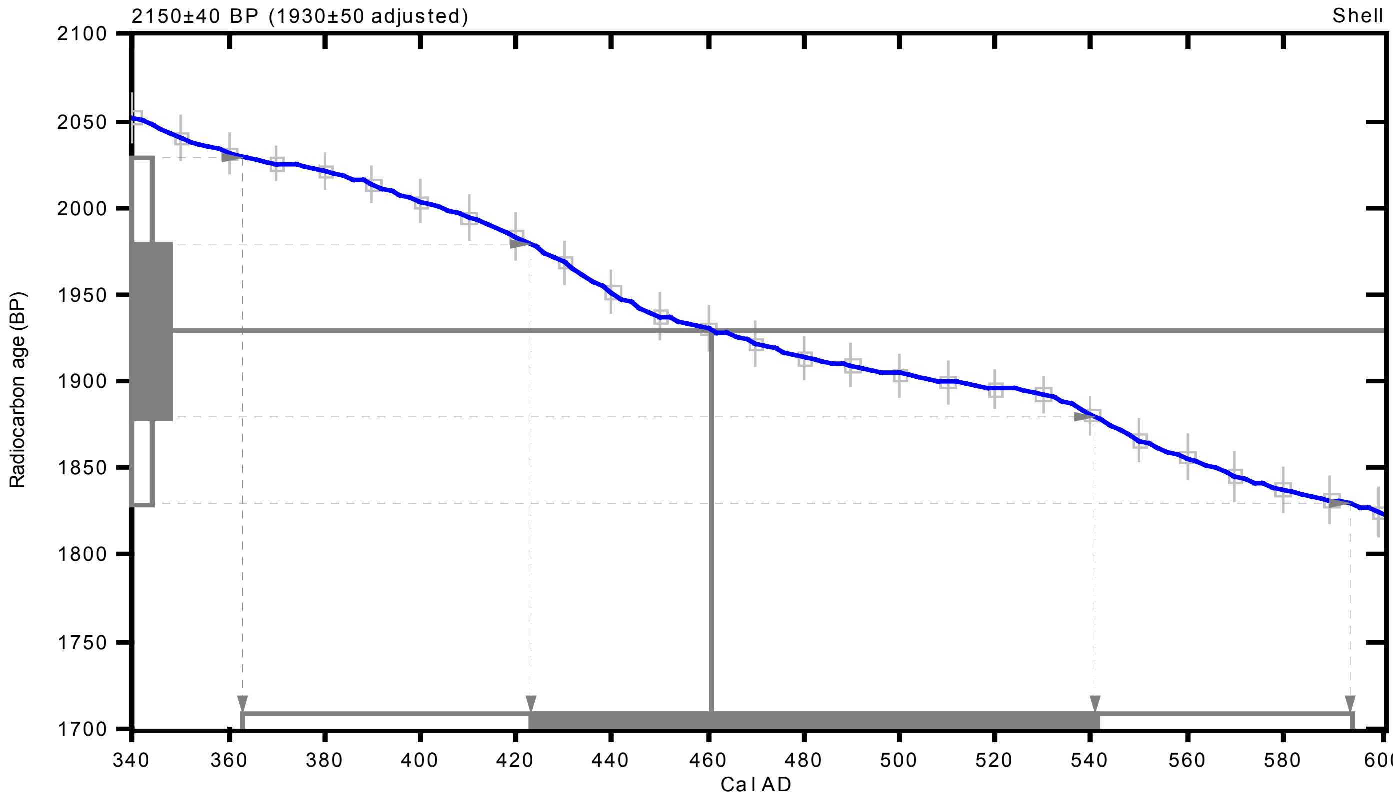
(1930±50 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal AD 360 to 590 (Cal BP 1590 to 1360)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 460 (Cal BP 1490)

1 Sigma calibrated result: (68% probability) Cal AD 420 to 540 (Cal BP 1530 to 1410)



References:

Database used

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INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.5:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: Beta-195172

Conventional radiocarbon age: 2110±40 BP

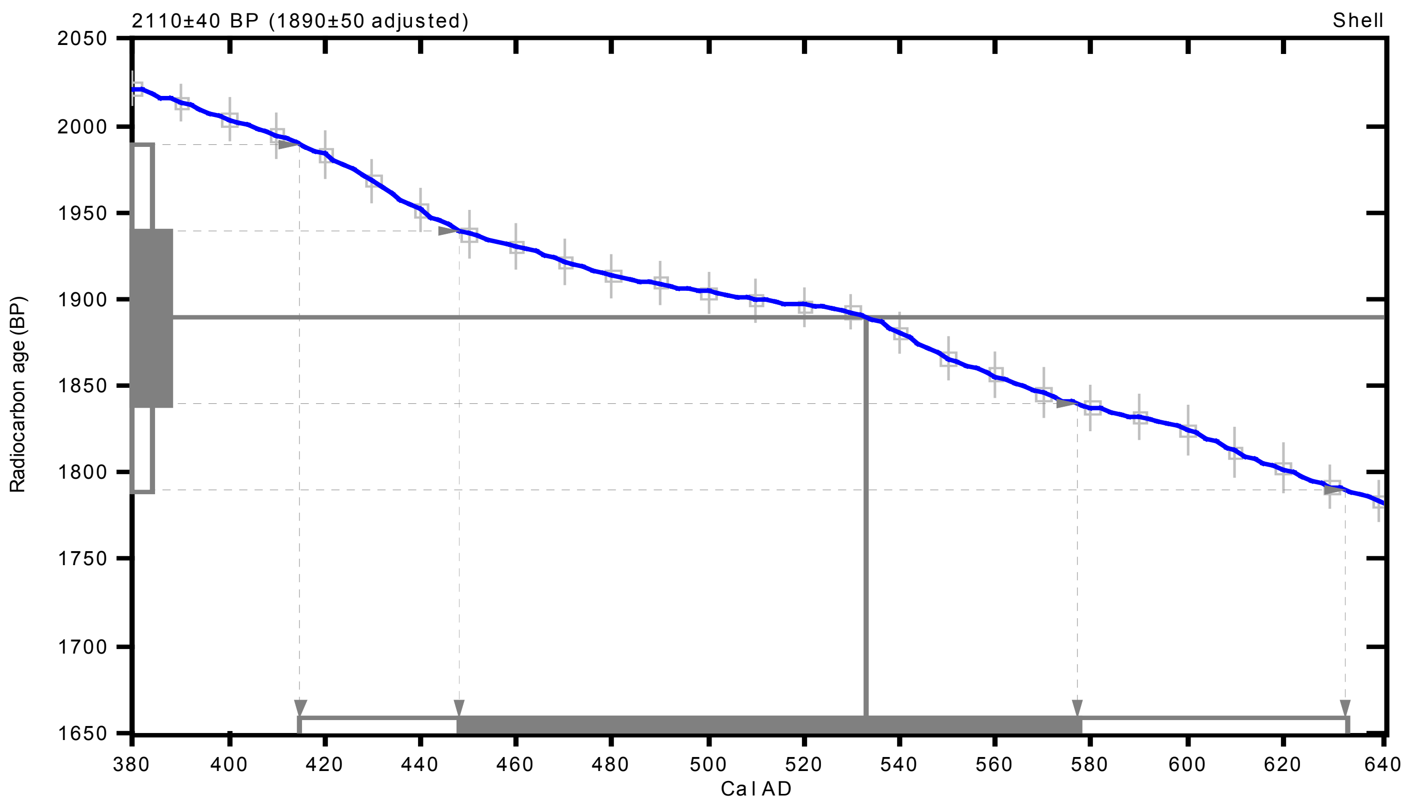
(1890±50 adjusted for local reservoir correction)

2 Sigma calibrated result: Cal AD 420 to 630 (Cal BP 1540 to 1320)
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 530 (Cal BP 1420)

1 Sigma calibrated result: Cal AD 450 to 580 (Cal BP 1500 to 1370)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.8:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-195173**

Conventional radiocarbon age: **2140±40 BP**

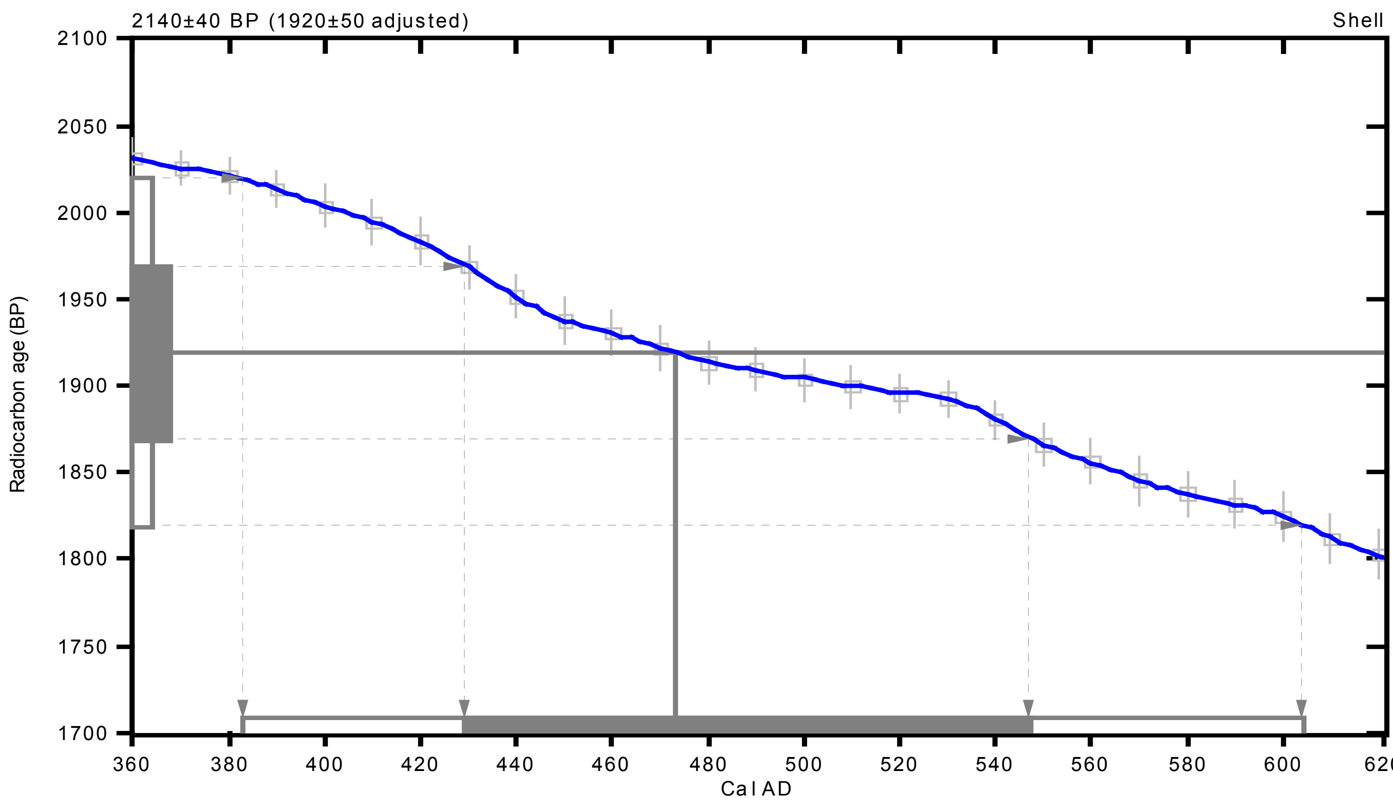
(1920±50 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal AD 380 to 600 (Cal BP 1570 to 1350)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 470 (Cal BP 1480)

1 Sigma calibrated result: (68% probability) Cal AD 430 to 550 (Cal BP 1520 to 1400)



References:

Database used

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INTCAL98 Radiocarbon Age Calibration

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-1:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: Beta-195174

Conventional radiocarbon age: 2050±40 BP

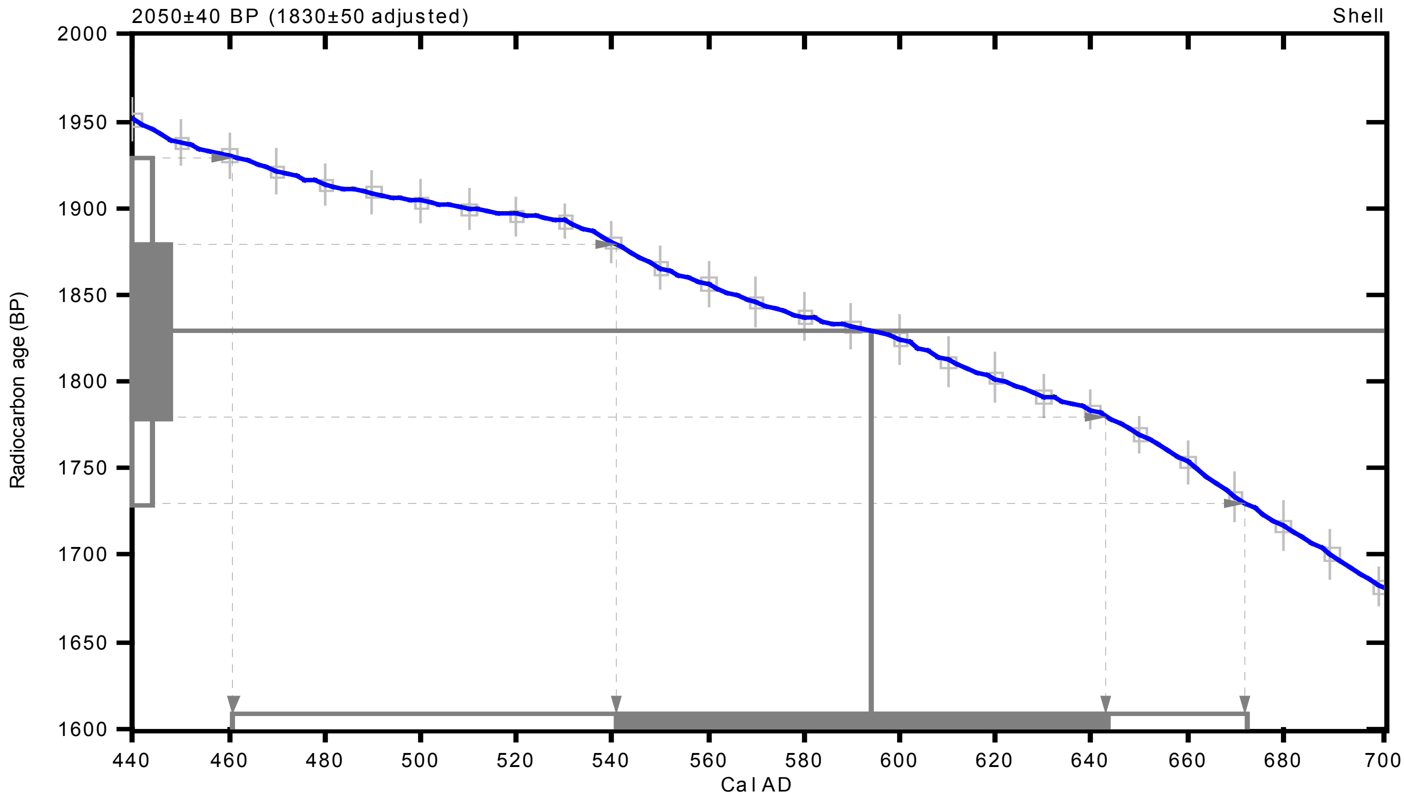
(1830±50 adjusted for local reservoir correction)

2 Sigma calibrated result: Cal AD 460 to 670 (Cal BP 1490 to 1280)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 590 (Cal BP 1360)

1 Sigma calibrated result: Cal AD 540 to 640 (Cal BP 1410 to 1310)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-0.4:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-195175**

Conventional radiocarbon age: **1920±80 BP**

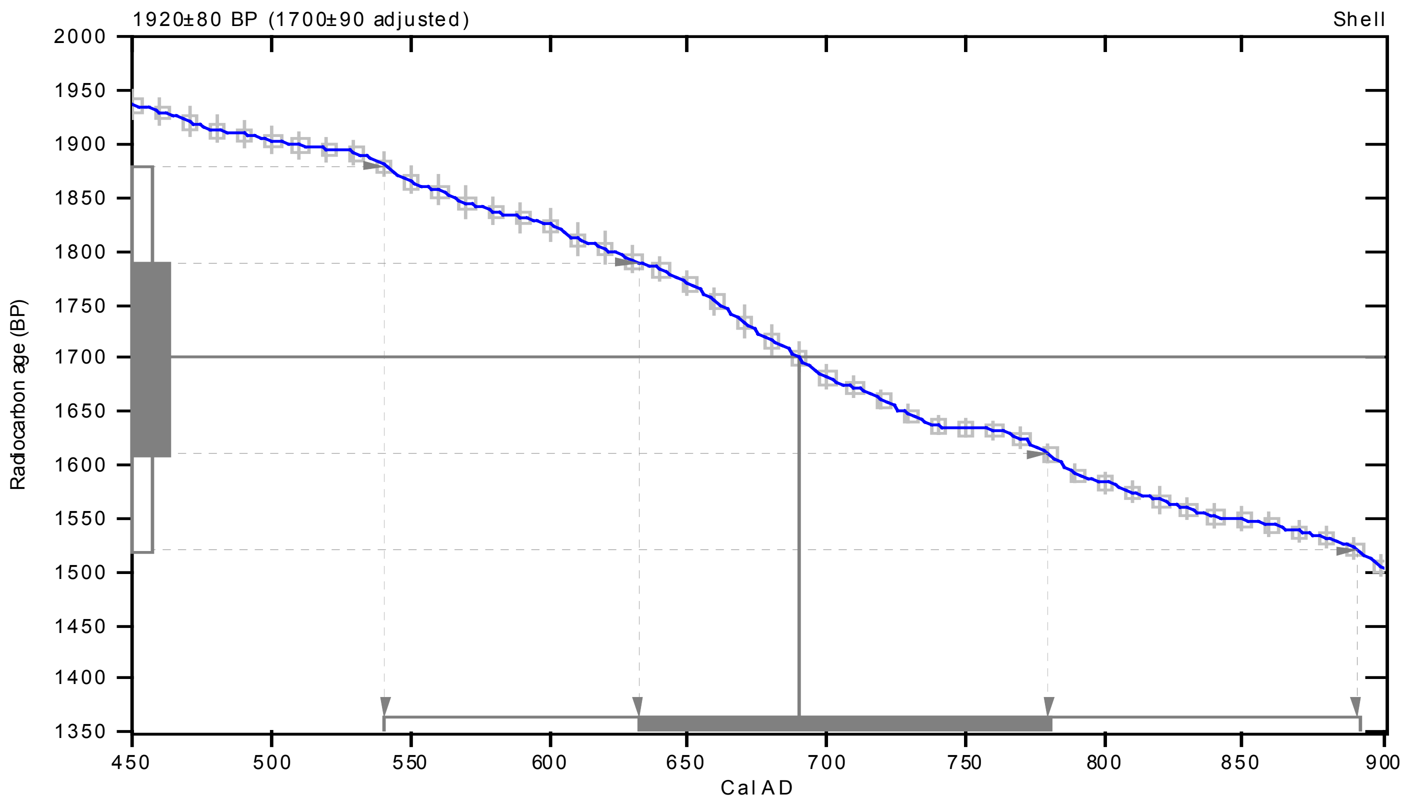
(1700±90 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal AD 540 to 890 (Cal BP 1410 to 1060)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 690 (Cal BP 1260)

1 Sigma calibrated result: (68% probability) Cal AD 630 to 780 (Cal BP 1320 to 1170)



References:

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INTCAL98 Radiocarbon Age Calibration

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.3:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-195176**

Conventional radiocarbon age: **2140±40 BP**

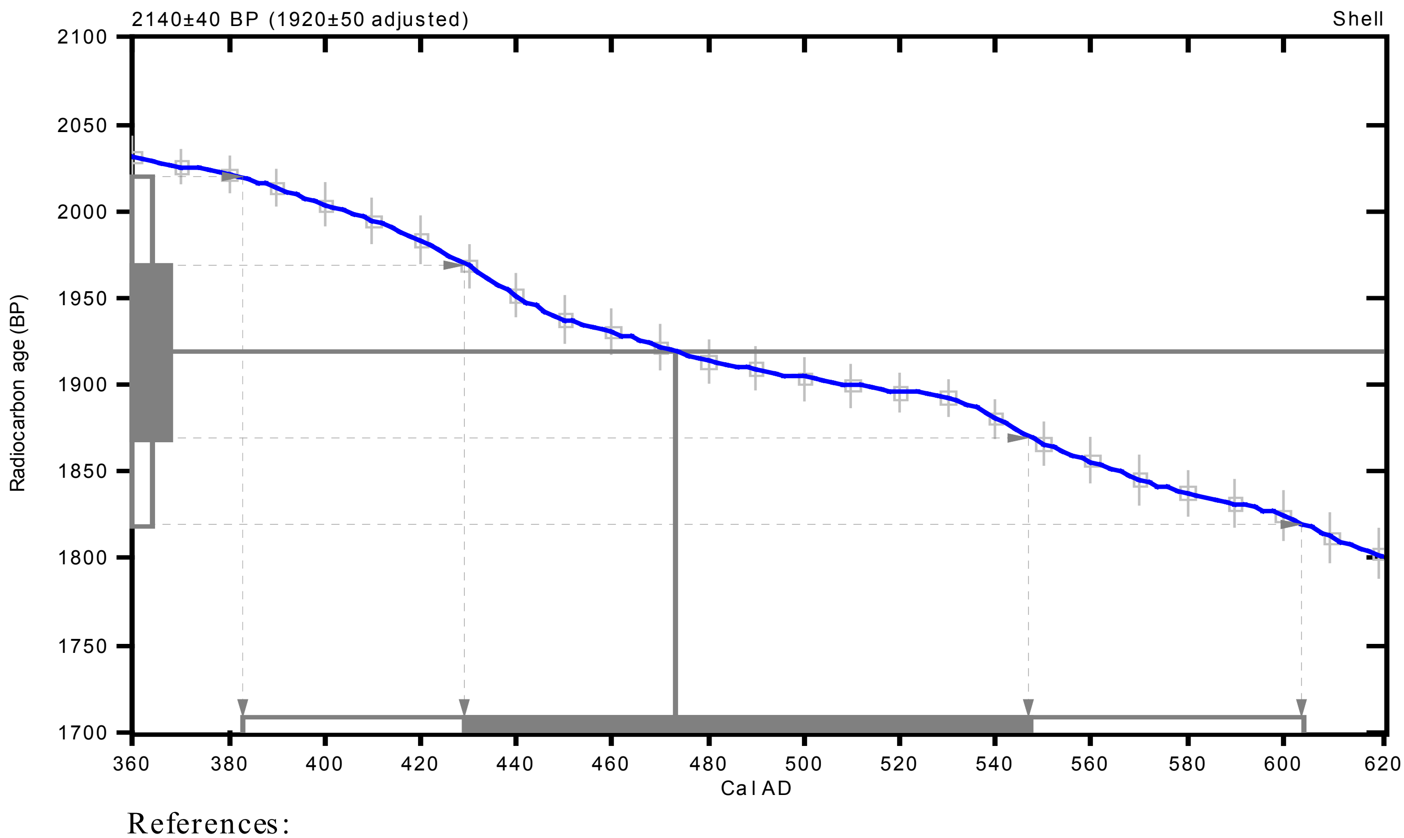
(1920±50 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal AD 380 to 600 (Cal BP 1570 to 1350)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 470 (Cal BP 1480)

1 Sigma calibrated result: (68% probability) Cal AD 430 to 550 (Cal BP 1520 to 1400)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-0.3:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: Beta-195177

Conventional radiocarbon age: 2120±40 BP

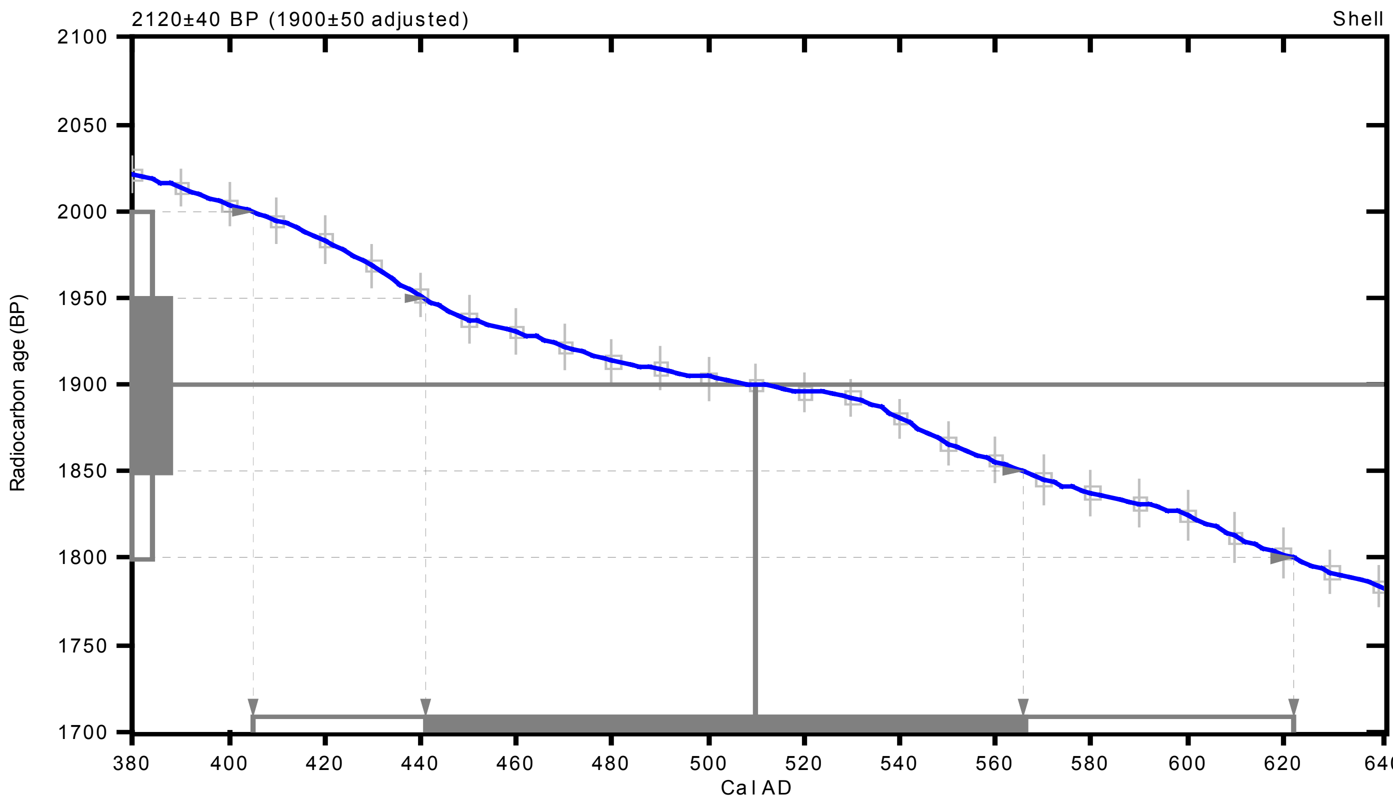
(1900±50 adjusted for local reservoir correction)

2 Sigma calibrated result: Cal AD 400 to 620 (Cal BP 1540 to 1330)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 510 (Cal BP 1440)

1 Sigma calibrated result: Cal AD 440 to 570 (Cal BP 1510 to 1380)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.5:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-195178**

Conventional radiocarbon age: **2140±70 BP**

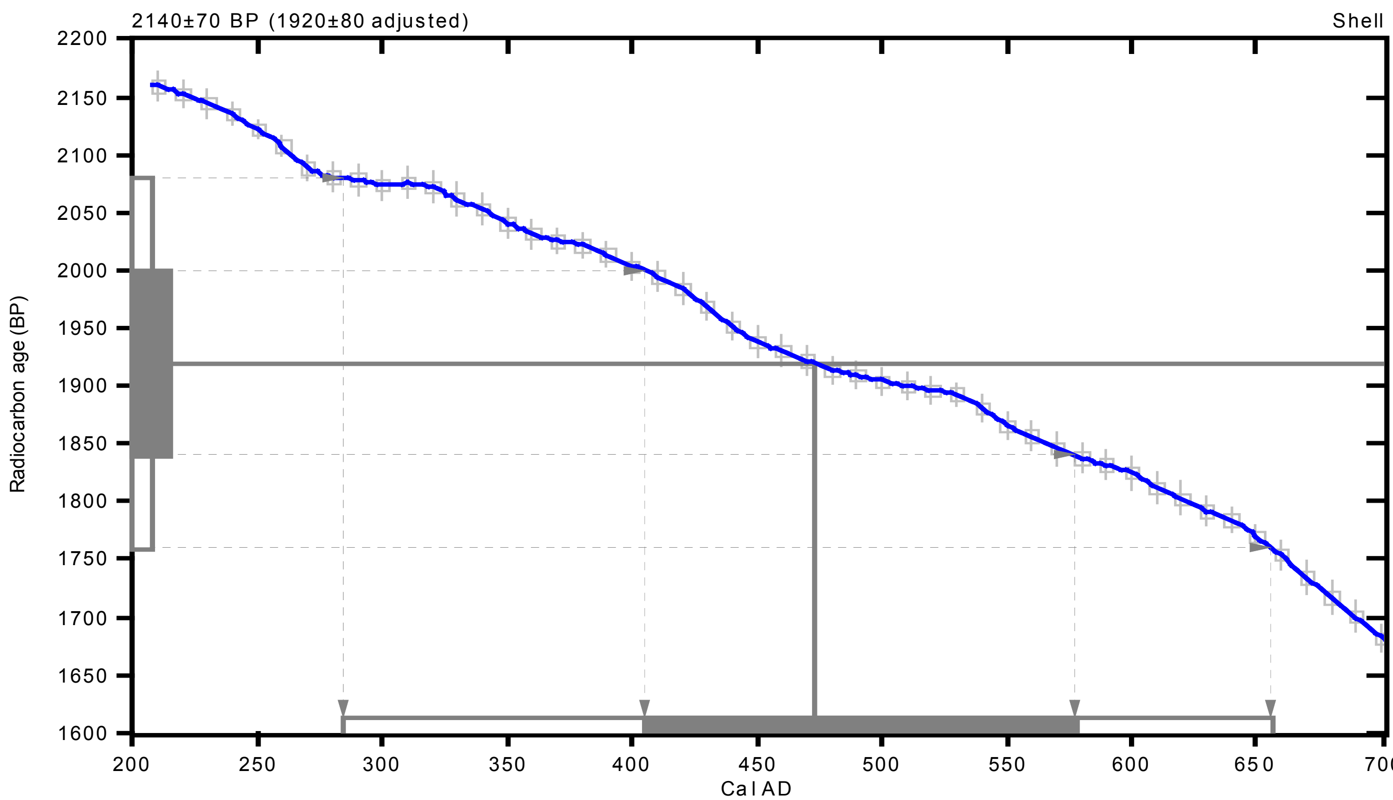
(1920±80 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal AD 280 to 660 (Cal BP 1670 to 1290)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 470 (Cal BP 1480)

1 Sigma calibrated result: (68% probability) Cal AD 400 to 580 (Cal BP 1540 to 1370)



References:

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Marine98

Calibration Database

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INTCAL98 Radiocarbon Age Calibration

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FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)
(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

November 30, 2004

Mr. William A. Feld
Statistical Research, Incorporated
21 W. Stuart Avenue
PO Box 390
Redlands, CA 92373-0123
USA

RE: Radiocarbon Dating Results For Samples PD133-5830, PD159-5826, PD301-5828, PD3383-5829, PD3403-5827, PD1065-6250, PD1197-6248, PD1197-6249, PD1236-6251, PD1241-6252, PD1241-6254, PD1259-6247, PD1259-6253, PD1343-6246

Dear Mr. Feld:

Enclosed are the radiocarbon dating results for 14 samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses went normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice is enclosed. Please, forward it to the appropriate officer or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Mr. William A. Feld — Report Date: 11/30/2004

Statistical Research, Incorporated — Material Received: 11/2/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 197362	1990 +/- 70 BP	+0.4 o/oo	2410 +/- 70 BP

SAMPLE : PD133-5830
ANALYSIS : Radiometric-Standard delivery (with extended counting)
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal BC 10 to Cal AD 360 (Cal BP 1960 to 1590)

Beta - 197363	1860 +/- 50 BP	0.0 o/oo	2270 +/- 60 BP

SAMPLE : PD159-5826
ANALYSIS : Radiometric-Standard delivery (with extended counting)
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 150 to 490 (Cal BP 1800 to 1460)

Beta - 197364	1980 +/- 60 BP	-1.1 o/oo	2370 +/- 60 BP

SAMPLE : PD301-5828
ANALYSIS : Radiometric-Standard delivery (with extended counting)
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 60 to 390 (Cal BP 1890 to 1560)

Beta - 197365	1800 +/- 60 BP	-0.3 o/oo	2210 +/- 60 BP

SAMPLE : PD3383-5829
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 240 to 570 (Cal BP 1700 to 1380)

Beta - 197366	1720 +/- 40 BP	-0.5 o/oo	2120 +/- 40 BP

SAMPLE : PD3403-5827
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 400 to 620 (Cal BP 1540 to 1330)

Mr. William A. Feld

Report Date: 11/30/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 197367 SAMPLE : PD1065-6250 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal AD 720 to 960 (Cal BP 1230 to 990)	1370 +/- 40 BP	-0.2 o/oo	1780 +/- 40 BP
Beta - 197368 SAMPLE : PD1197-6248 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal BC 5860 to 5670 (Cal BP 7810 to 7620)	7070 +/- 40 BP	-0.2 o/oo	7480 +/- 40 BP
Beta - 197369 SAMPLE : PD1197-6249 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal BC 5750 to 5600 (Cal BP 7700 to 7550)	6970 +/- 40 BP	-0.2 o/oo	7380 +/- 40 BP
Beta - 197370 SAMPLE : PD1236-6251 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal BC 5660 to 5480 (Cal BP 7610 to 7440)	6840 +/- 40 BP	+1.5 o/oo	7270 +/- 40 BP
Beta - 197371 SAMPLE : PD1241-6252 ANALYSIS : Radiometric-Standard delivery (with extended counting) MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal BC 5370 to 4780 (Cal BP 7320 to 6730)	6360 +/- 120 BP	0.0 o/oo	6770 +/- 130 BP

Mr. William A. Feld

Report Date: 11/30/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 197372	6760 +/- 40 BP	+0.5 o/oo	7180 +/- 40 BP
SAMPLE : PD1241-6254			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (shell): acid etch			
2 SIGMA CALIBRATION : Cal BC 5600 to 5440 (Cal BP 7550 to 7390)			
Beta - 197373	6750 +/- 100 BP	-0.9 o/oo	7150 +/- 110 BP
SAMPLE : PD1259-6247			
ANALYSIS : Radiometric-Standard delivery (with extended counting)			
MATERIAL/PRETREATMENT : (shell): acid etch			
2 SIGMA CALIBRATION : Cal BC 5680 to 5280 (Cal BP 7630 to 7230)			
Beta - 197374	6830 +/- 50 BP	+0.8 o/oo	7250 +/- 50 BP
SAMPLE : PD1259-6253			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (shell): acid etch			
2 SIGMA CALIBRATION : Cal BC 5660 to 5470 (Cal BP 7610 to 7420)			
Beta - 197375	7910 +/- 40 BP	-3.5 o/oo	8260 +/- 40 BP
SAMPLE : PD1343-6246			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (shell): acid etch			
2 SIGMA CALIBRATION : Cal BC 6640 to 6430 (Cal BP 8590 to 8380)			

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.4:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197362**

Conventional radiocarbon age: **2410±70 BP**

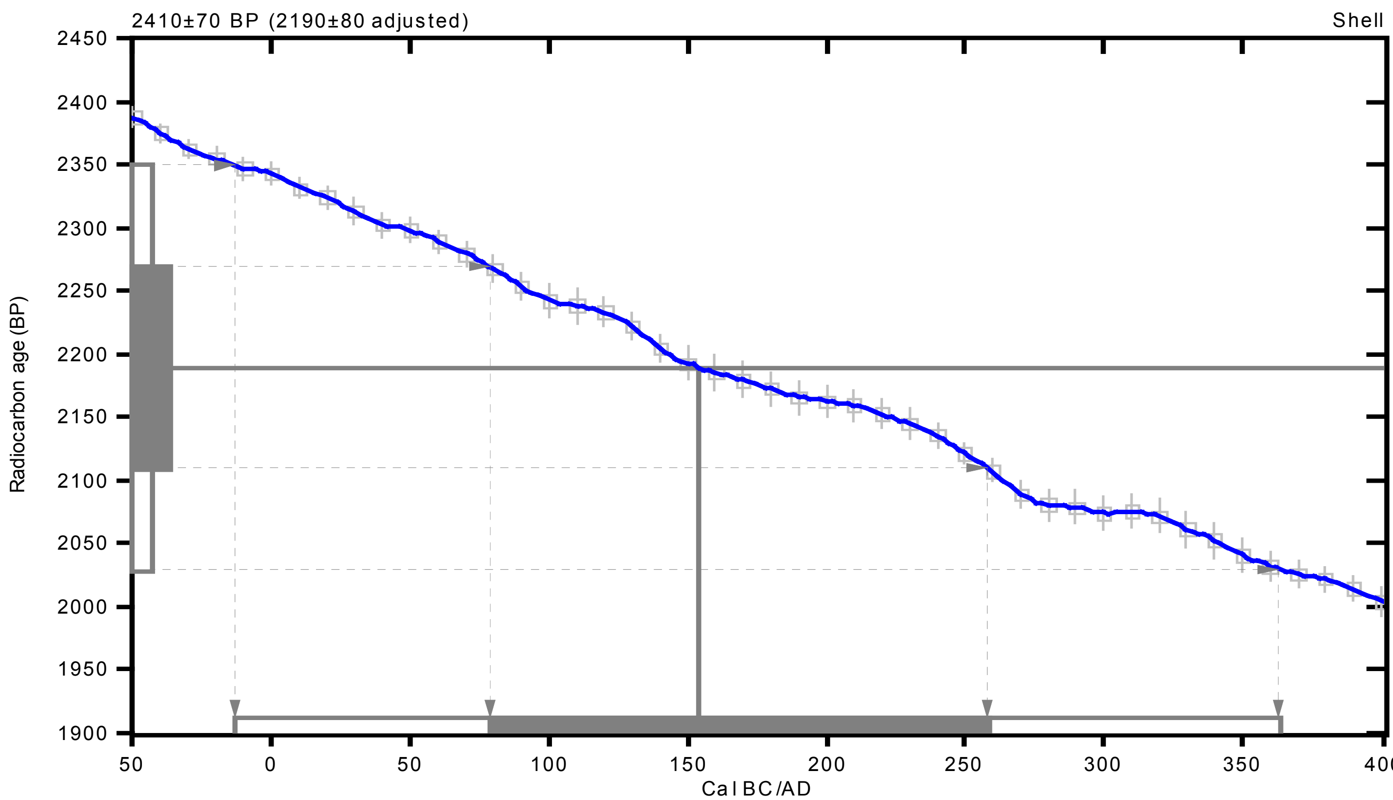
(2190±80 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal BC 10 to Cal AD 360 (Cal BP 1960 to 1590)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 150 (Cal BP 1800)

1 Sigma calibrated result: Cal AD 80 to 260 (Cal BP 1870 to 1690)
(68% probability)



References:

Database used
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: Beta-197363

Conventional radiocarbon age: 2270±60 BP

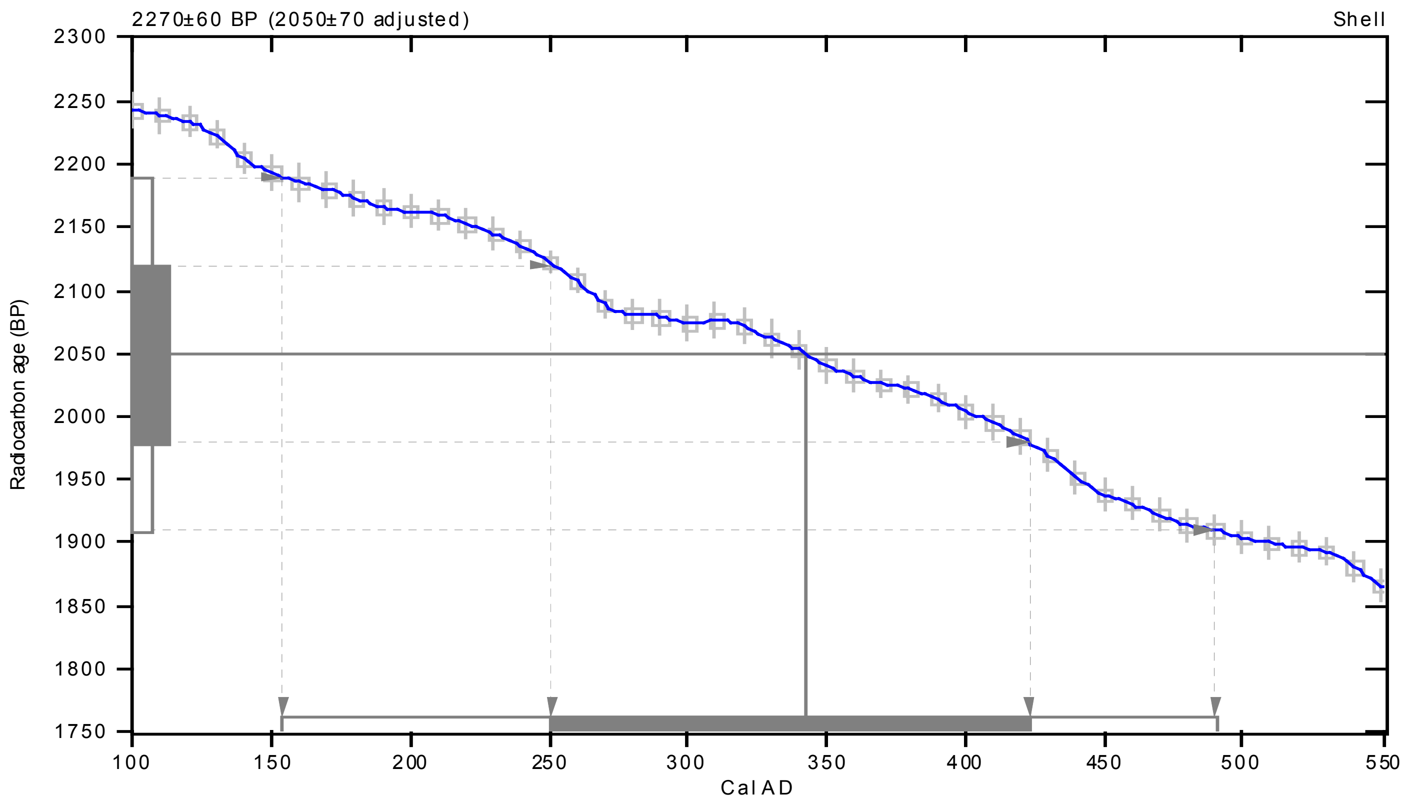
(2050±70 adjusted for local reservoir correction)

2 Sigma calibrated result: Cal AD 150 to 490 (Cal BP 1800 to 1460)
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 340 (Cal BP 1610)

1 Sigma calibrated result: Cal AD 250 to 420 (Cal BP 1700 to 1530)
(68% probability)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-1.1:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197364**

Conventional radiocarbon age: **2370±60 BP**

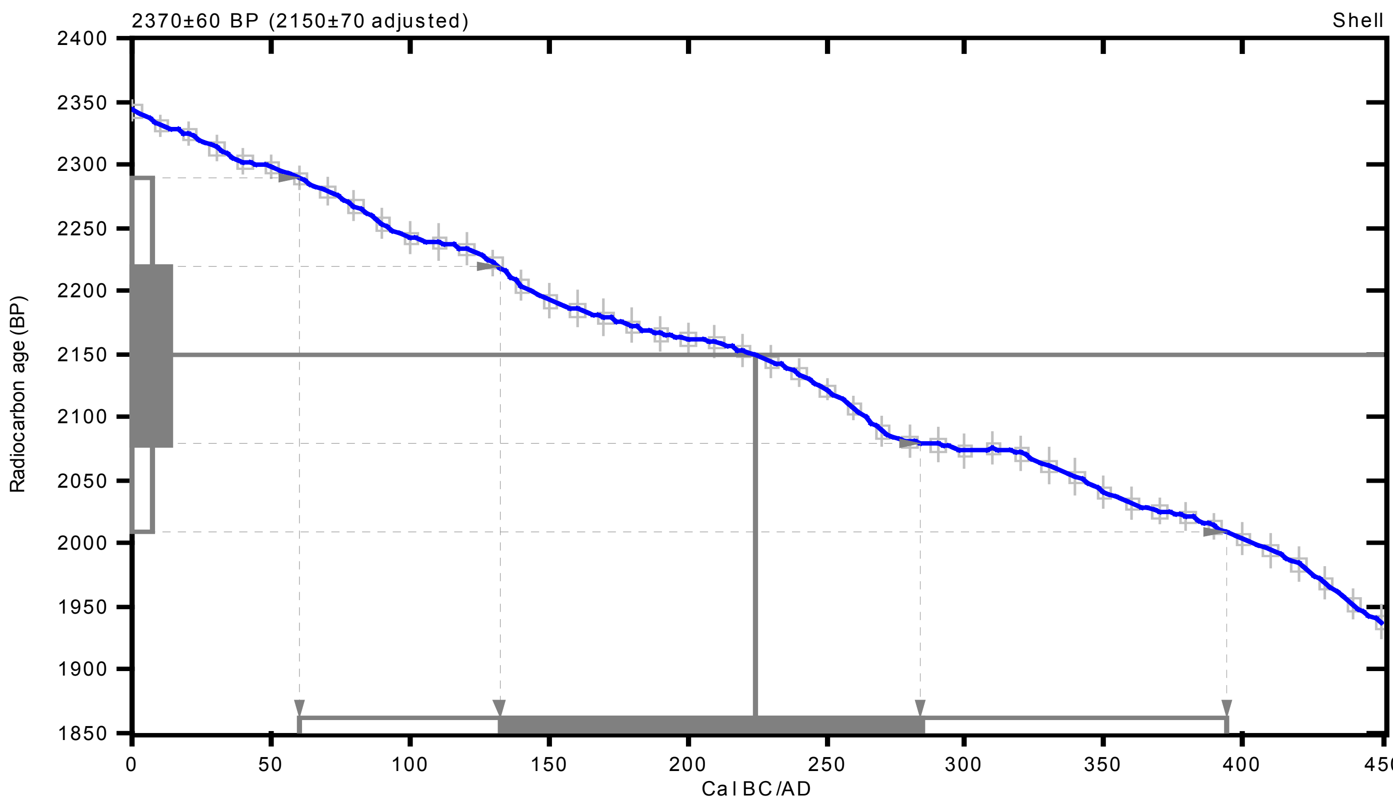
(2150±70 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal AD 60 to 390 (Cal BP 1890 to 1560)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 220 (Cal BP 1730)

1 Sigma calibrated result: Cal AD 130 to 280 (Cal BP 1820 to 1670)
(68% probability)



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Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-0.3:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197365**

Conventional radiocarbon age: **2210±60 BP**

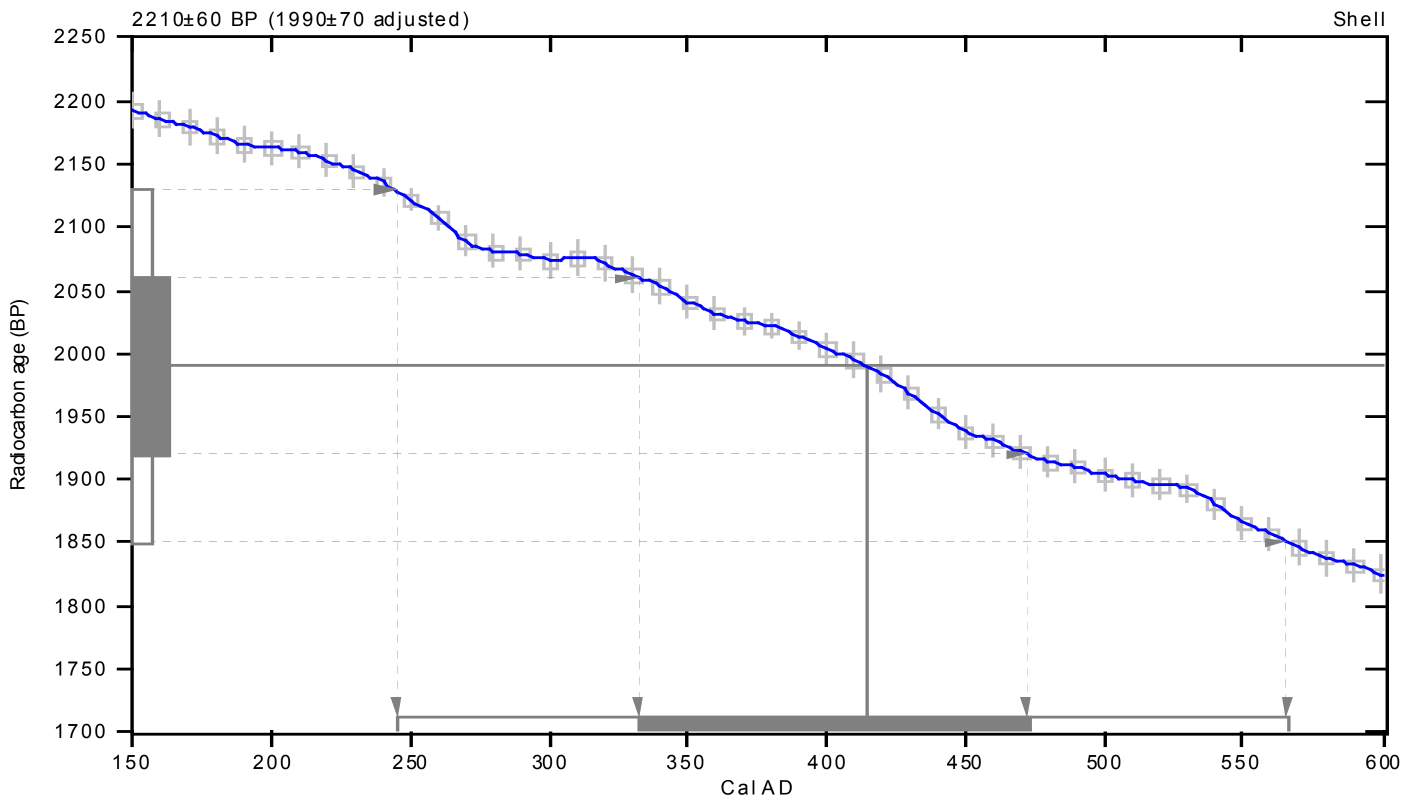
(1990±70 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal AD 240 to 570 (Cal BP 1700 to 1380)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 420 (Cal BP 1540)

1 Sigma calibrated result: Cal AD 330 to 470 (Cal BP 1620 to 1480)
(68% probability)



References:

Database used
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(Variables: C13/C12=-0.5:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197366**

Conventional radiocarbon age: **2120±40 BP**

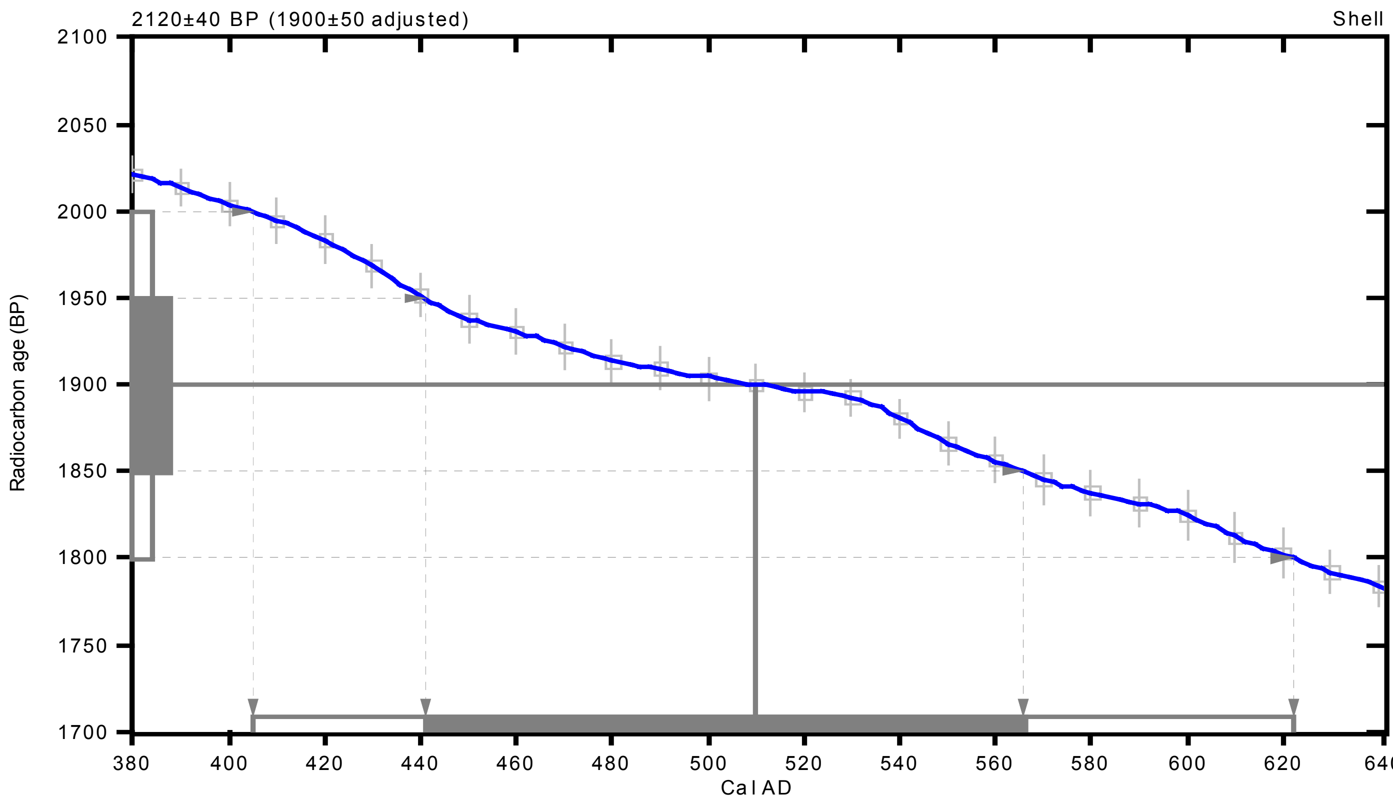
(1900±50 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal AD 400 to 620 (Cal BP 1540 to 1330)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 510 (Cal BP 1440)

1 Sigma calibrated result: Cal AD 440 to 570 (Cal BP 1510 to 1380)
(68% probability)



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(Variables: C13/C12=-0.2:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197367**

Conventional radiocarbon age: **1780±40 BP**

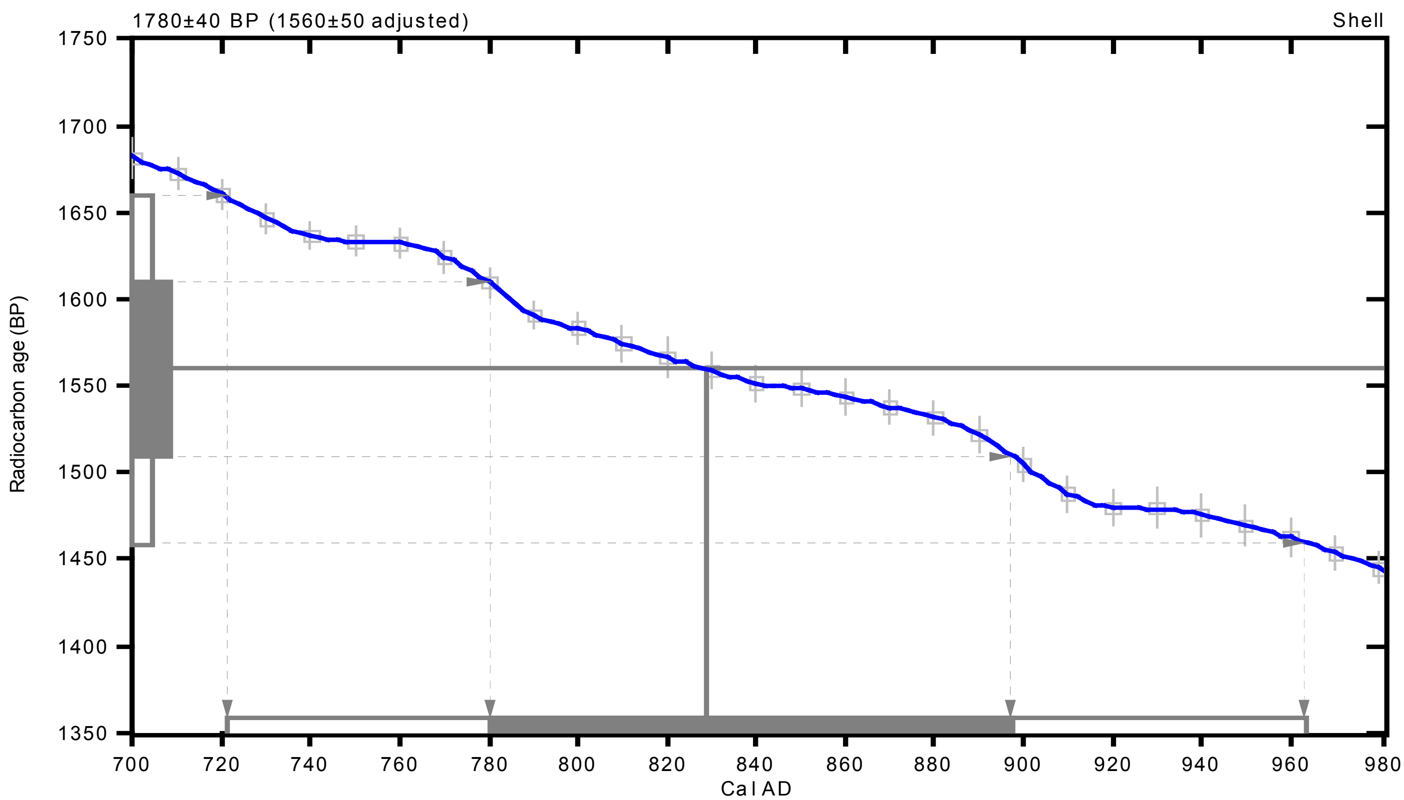
(1560±50 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal AD 720 to 960 (Cal BP 1230 to 990)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 830 (Cal BP 1120)

1 Sigma calibrated result: Cal AD 780 to 900 (Cal BP 1170 to 1050)
(68% probability)



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(Variables: C13/C12=-0.2:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197368**

Conventional radiocarbon age: **7480±40 BP**

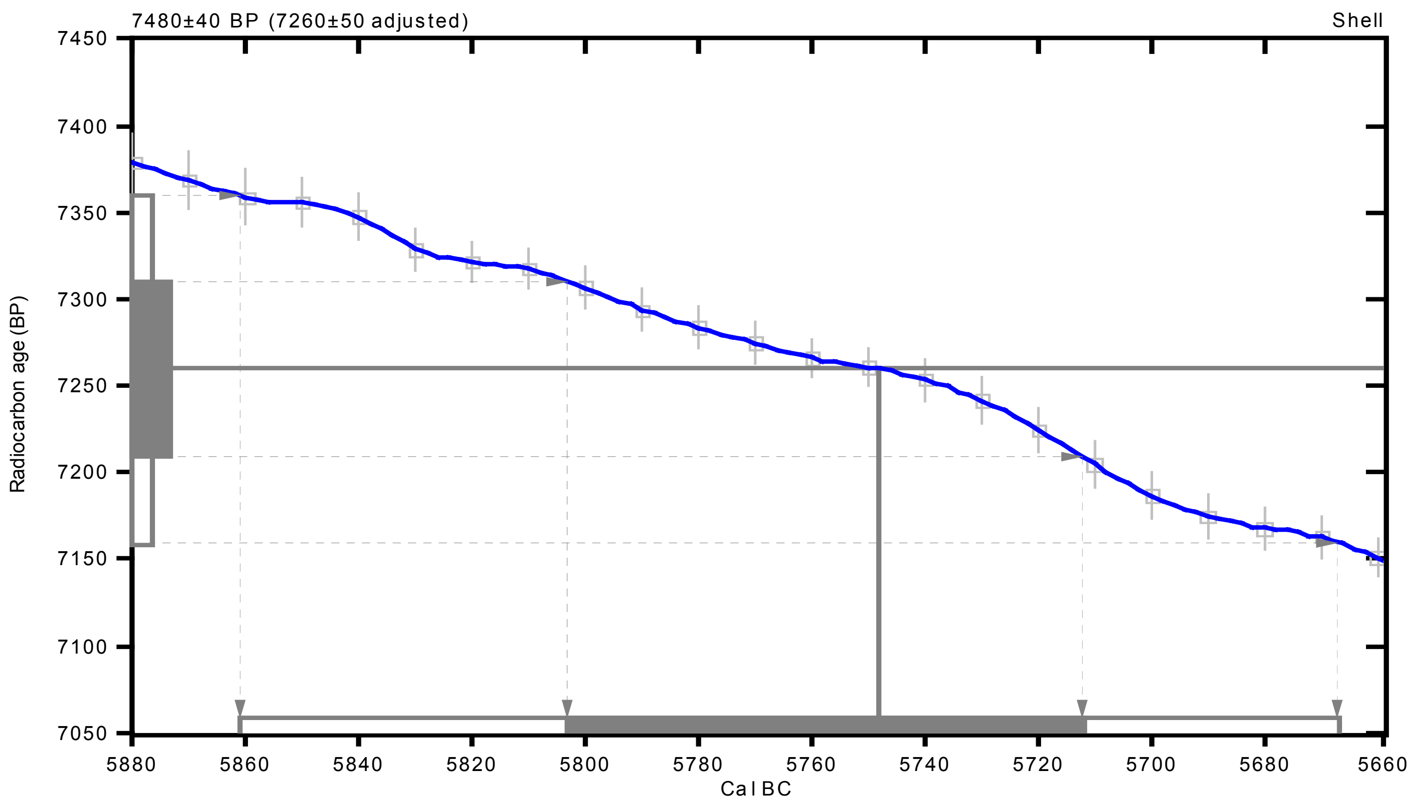
(7260±50 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal BC 5860 to 5670 (Cal BP 7810 to 7620)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 5750 (Cal BP 7700)

1 Sigma calibrated result: Cal BC 5800 to 5710 (Cal BP 7750 to 7660)
(68% probability)



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Laboratory number: **Beta-197369**

Conventional radiocarbon age: **7380±40 BP**

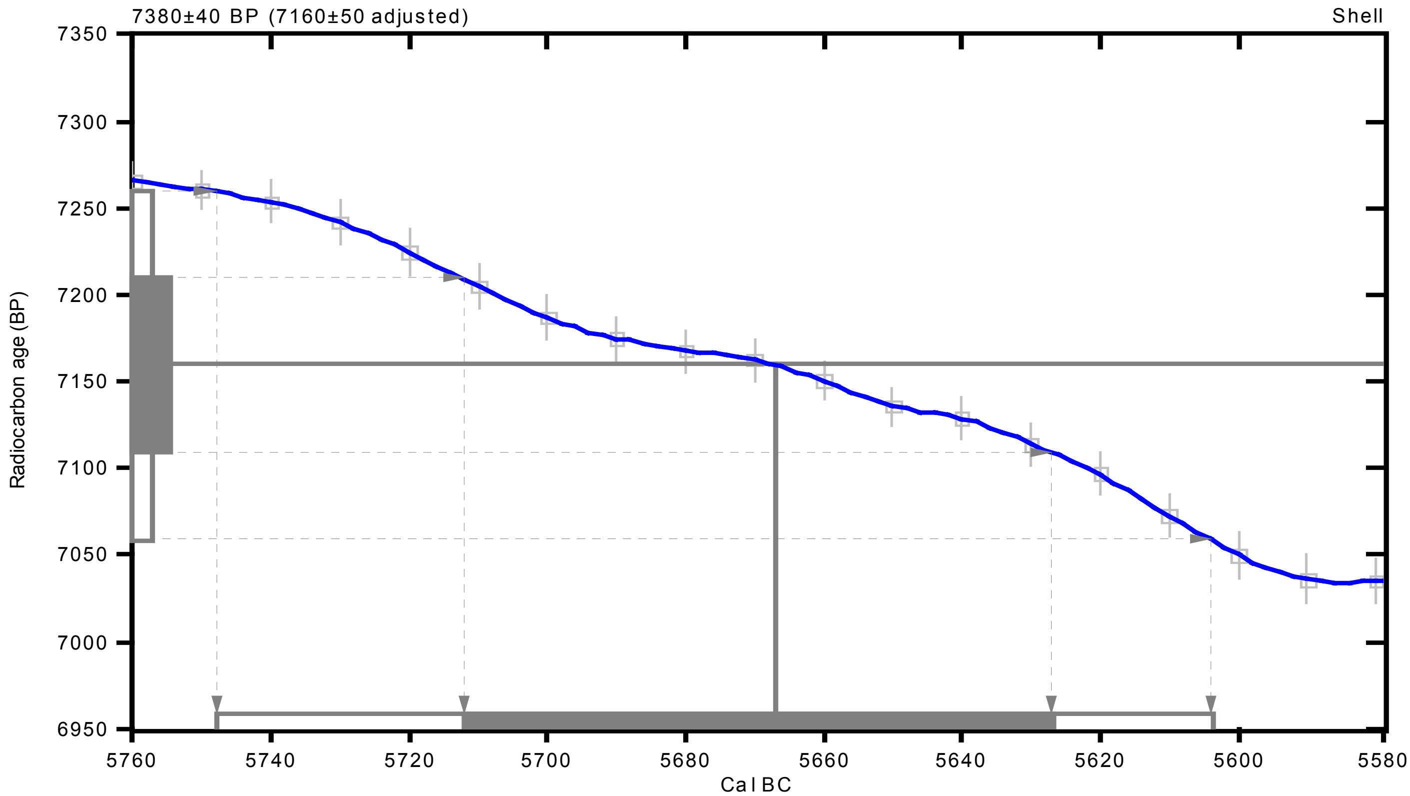
(7160±50 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal BC 5750 to 5600 (Cal BP 7700 to 7550)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 5670 (Cal BP 7620)

1 Sigma calibrated result: Cal BC 5710 to 5630 (Cal BP 7660 to 7580)
(68% probability)



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(Variables: C13/C12=1.5:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197370**

Conventional radiocarbon age: **7270±40 BP**

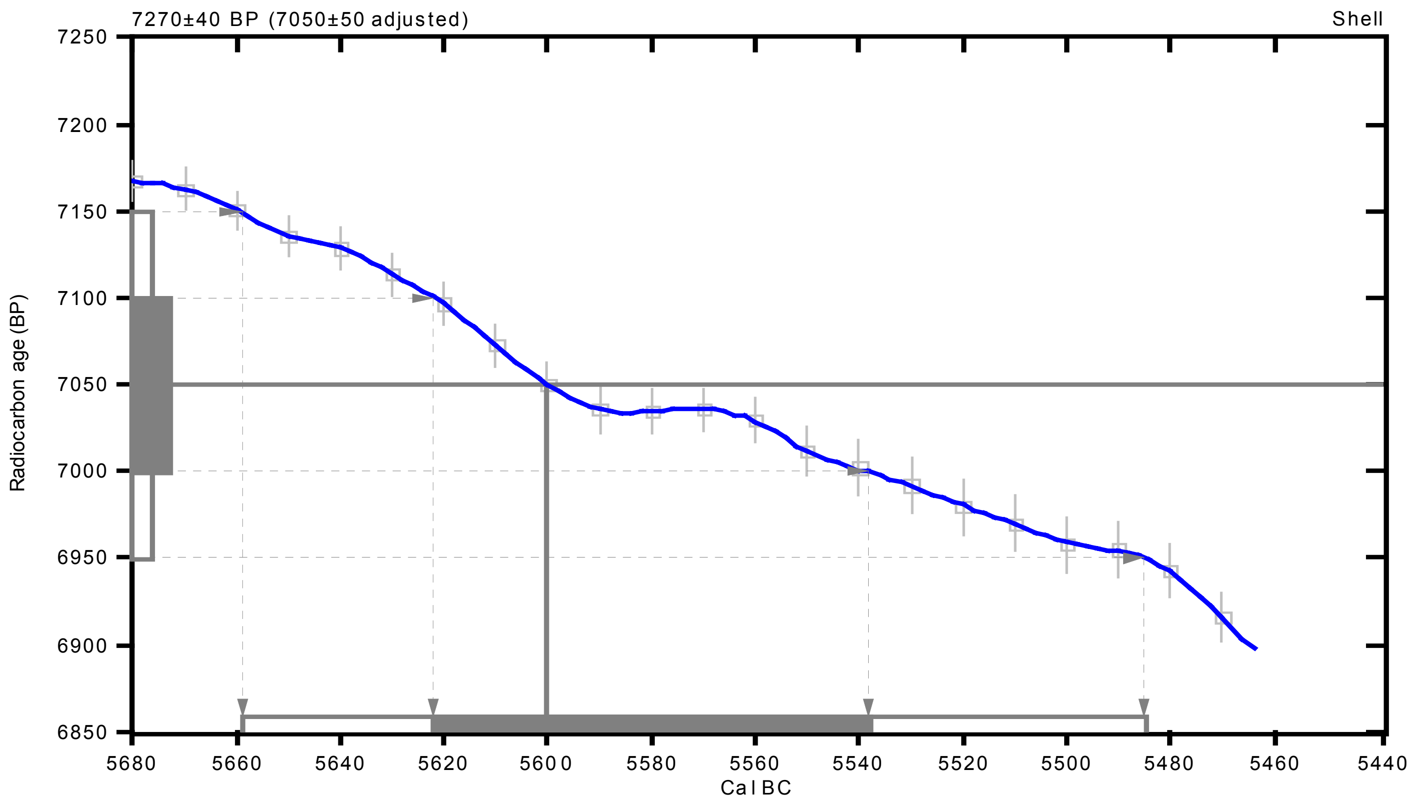
(7050±50 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal BC 5660 to 5480 (Cal BP 7610 to 7440)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 5600 (Cal BP 7550)

1 Sigma calibrated result: (68% probability) Cal BC 5620 to 5540 (Cal BP 7570 to 7490)



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(Variables: C13/C12=0:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197371**

Conventional radiocarbon age: **6770±130 BP**

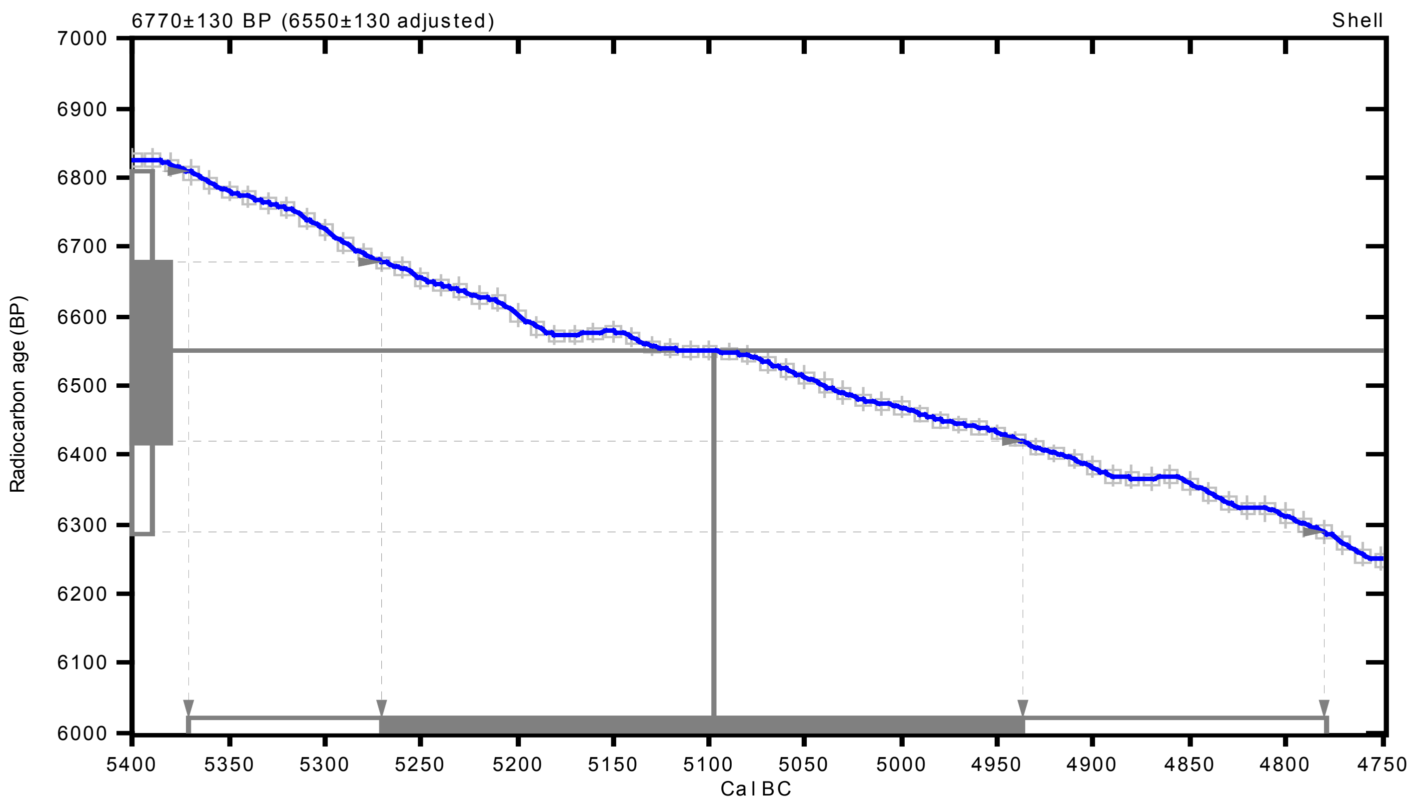
(6550±130 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal BC 5370 to 4780 (Cal BP 7320 to 6730)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 5100 (Cal BP 7050)

1 Sigma calibrated result: (68% probability) Cal BC 5270 to 4940 (Cal BP 7220 to 6890)



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(Variables: C13/C12=0.5:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197372**

Conventional radiocarbon age: **7180±40 BP**

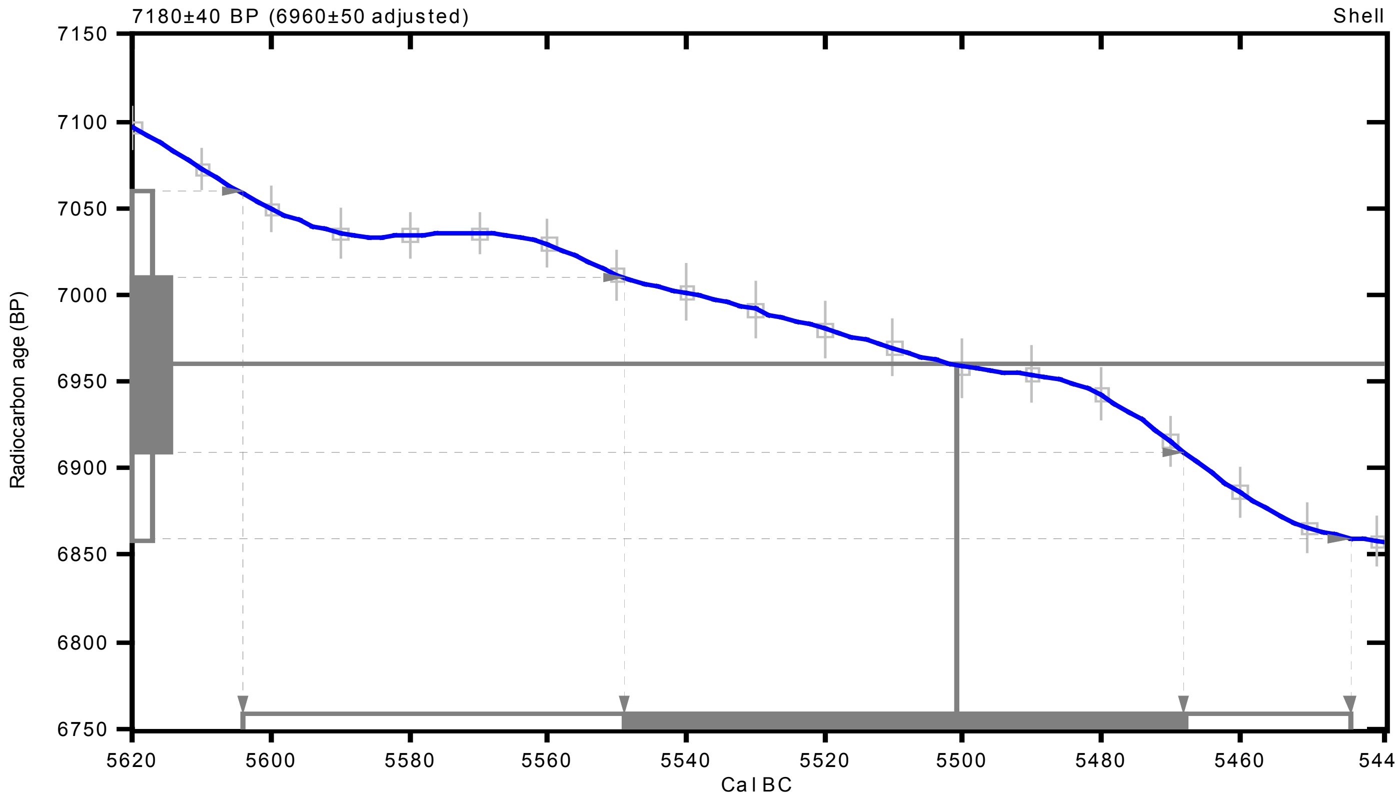
(6960±50 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal BC 5600 to 5440 (Cal BP 7550 to 7390)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 5500 (Cal BP 7450)

1 Sigma calibrated result: Cal BC 5550 to 5470 (Cal BP 7500 to 7420)
(68% probability)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-0.9:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197373**

Conventional radiocarbon age: **7150±110 BP**

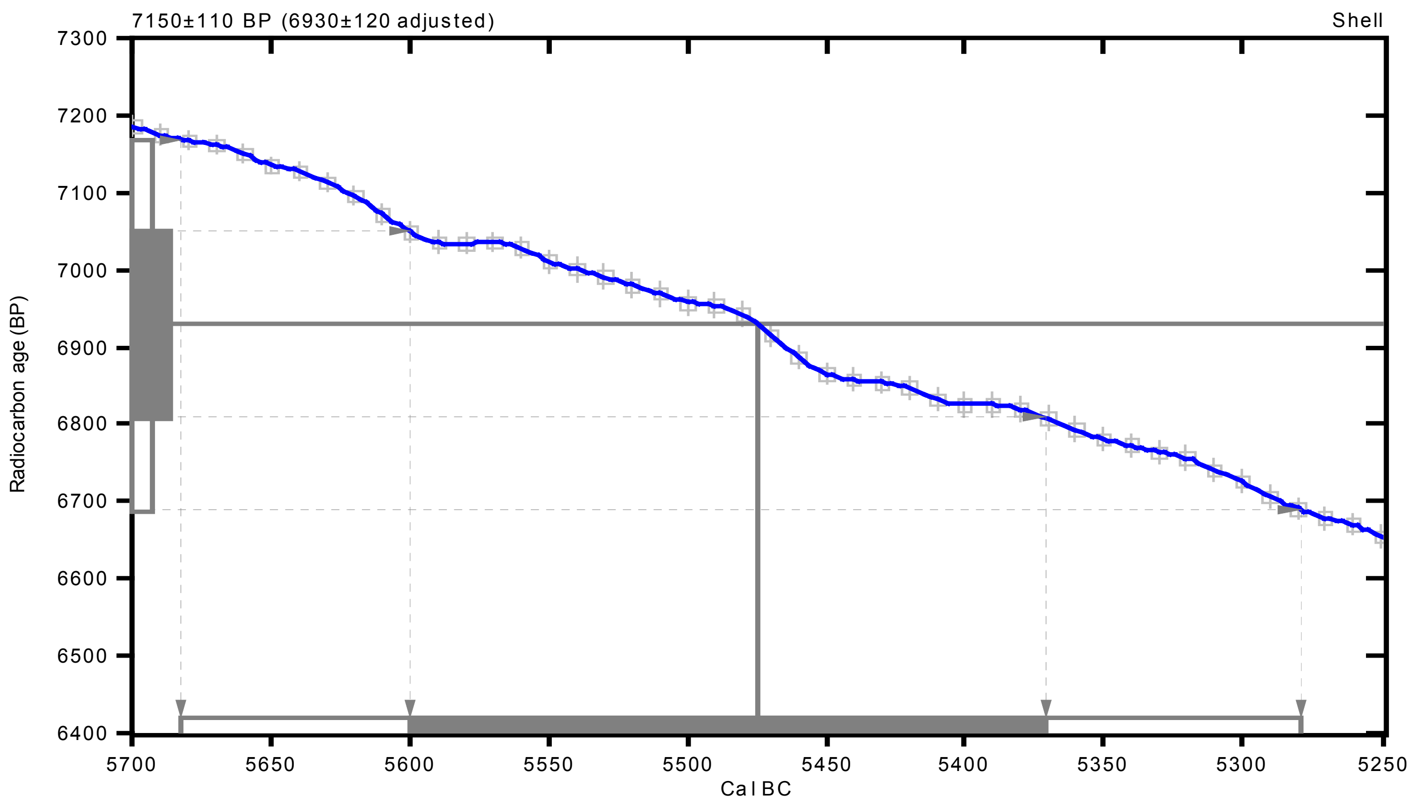
(6930±120 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal BC 5680 to 5280 (Cal BP 7630 to 7230)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 5480 (Cal BP 7420)

1 Sigma calibrated result: (68% probability) Cal BC 5600 to 5370 (Cal BP 7550 to 7320)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.8:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197374**

Conventional radiocarbon age: **7250±50 BP**

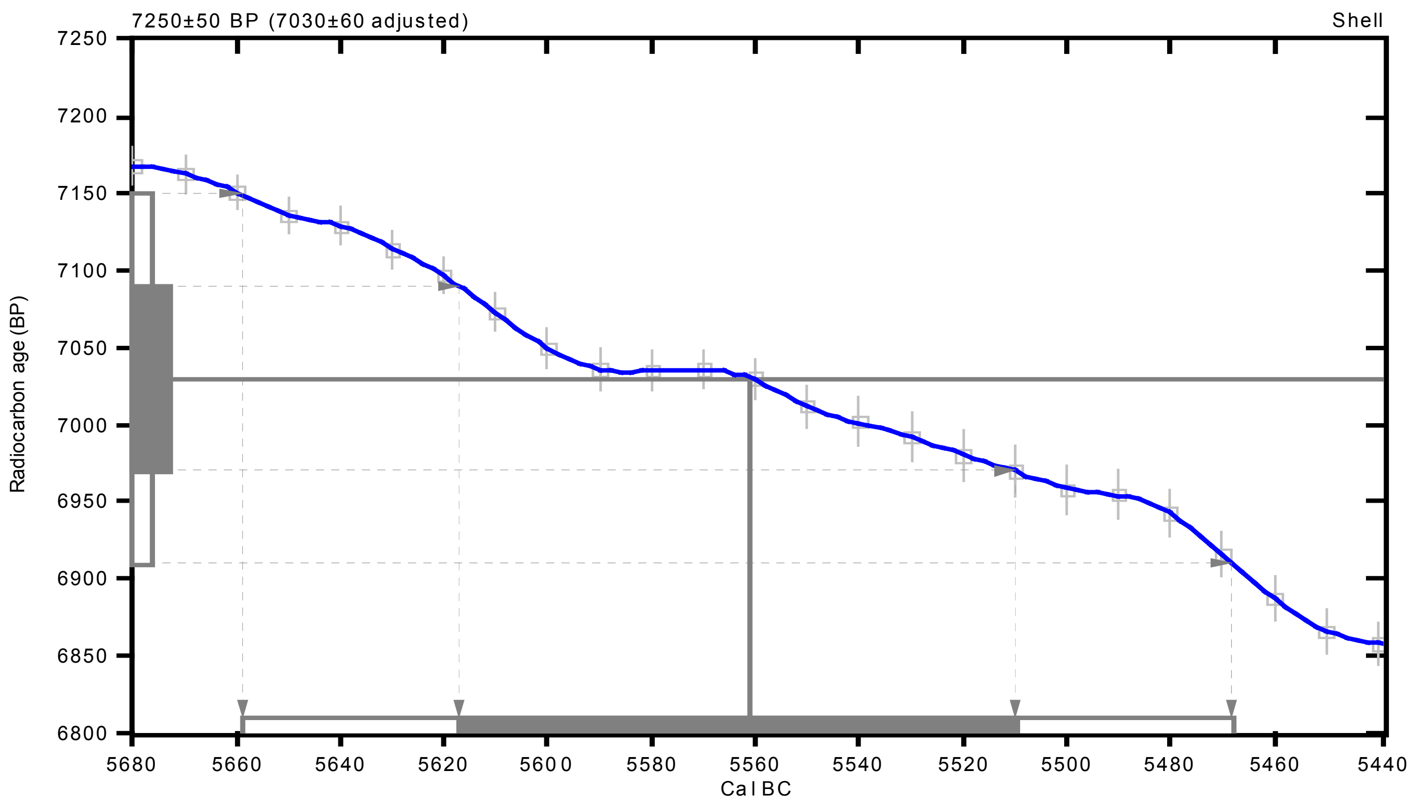
(7030±60 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal BC 5660 to 5470 (Cal BP 7610 to 7420)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 5560 (Cal BP 7510)

1 Sigma calibrated result: (68% probability) Cal BC 5620 to 5510 (Cal BP 7570 to 7460)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-3.5:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-197375**

Conventional radiocarbon age: **8260±40 BP**

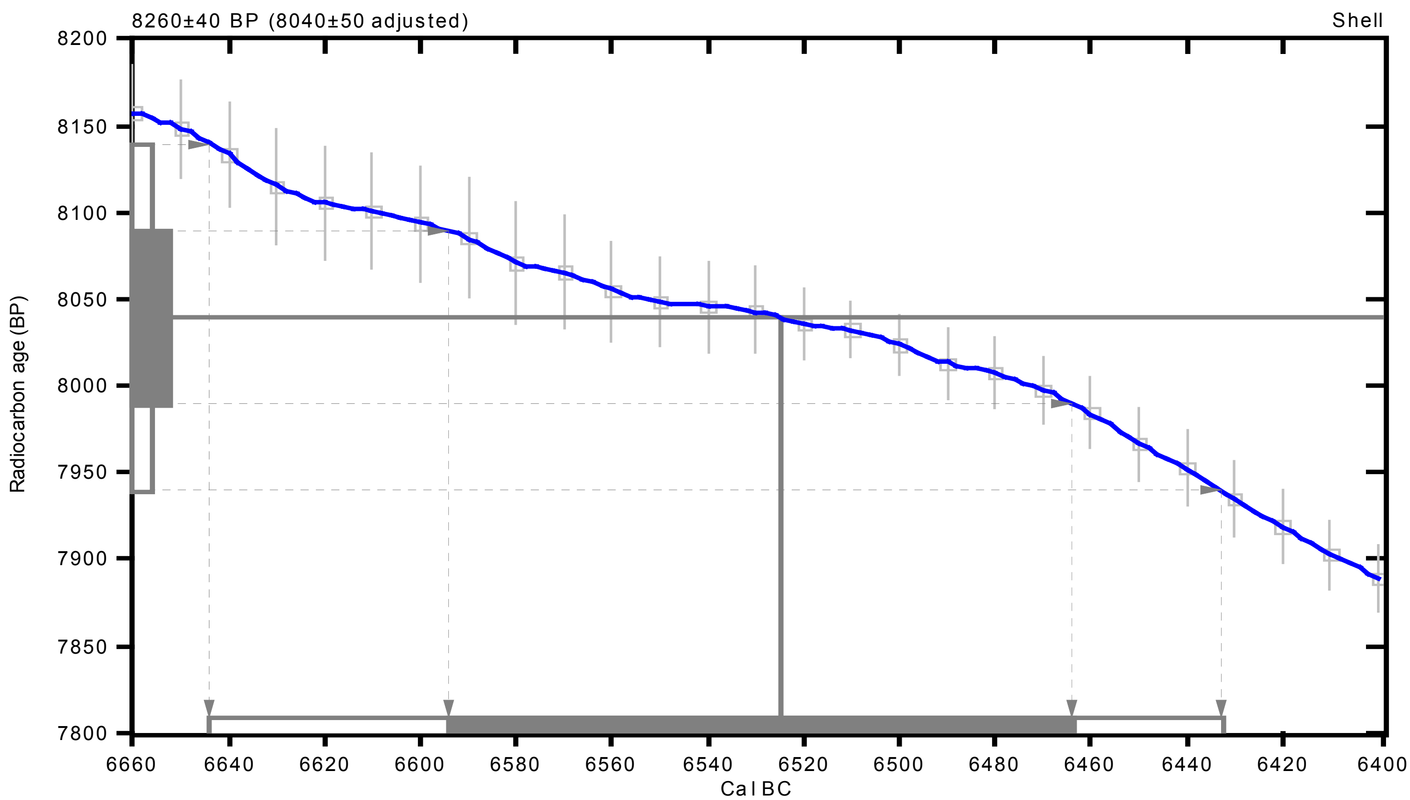
(8040±50 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal BC 6640 to 6430 (Cal BP 8590 to 8380)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 6520 (Cal BP 8480)

1 Sigma calibrated result: Cal BC 6590 to 6460 (Cal BP 8540 to 8410)
(68% probability)



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FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)
(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

January 4, 2005

Mr. William A. Feld
Statistical Research, Incorporated
PO Box 390
Redlands, CA 92373
USA

RE: Radiocarbon Dating Result For Sample PD1343-6093

Dear William:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis went normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice is enclosed. Please, forward it to the appropriate officer or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Mr. William A. Feld | Report Date: 1/4/2005

Statistical Research, Incorporated | Material Received: 12/10/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 199066	7170 +/- 110 BP	-3.4 o/oo	7530 +/- 110 BP

SAMPLE : PD1343-6093
ANALYSIS : Radiometric-Standard delivery (with extended counting)
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal BC 6030 to 5610 (Cal BP 7980 to 7560)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-3.4:Delta-R=225±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-199066**

Conventional radiocarbon age: **7530±110 BP**

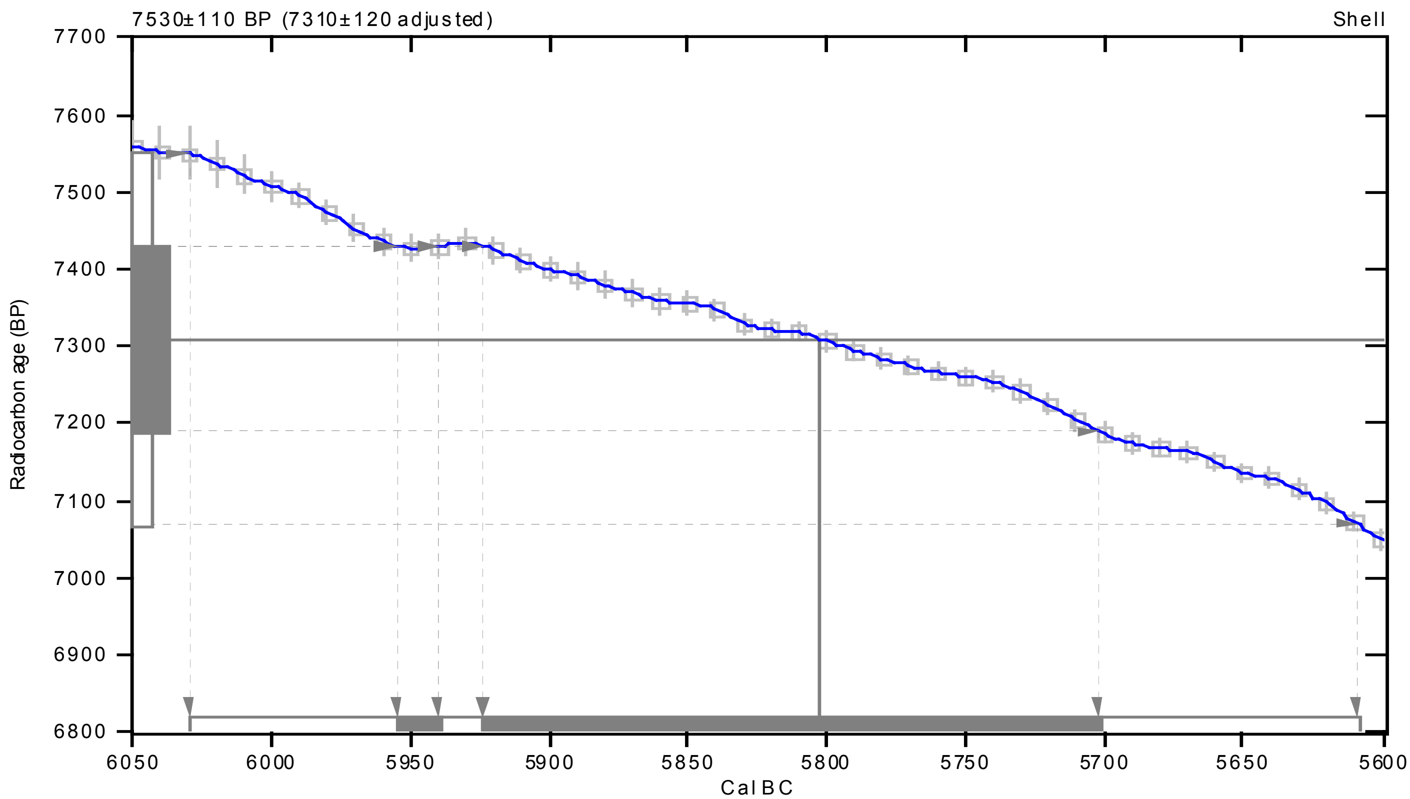
(7310±120 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal BC 6030 to 5610 (Cal BP 7980 to 7560)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 5800 (Cal BP 7750)

1 Sigma calibrated results: (68% probability) Cal BC 5960 to 5940 (Cal BP 7900 to 7890) and Cal BC 5920 to 5700 (Cal BP 7870 to 7650)



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Obsidian Source Analysis

Berkeley Archaeological XRF Laboratory
University of California, Berkeley

BERKELEY ARCHAEOLOGICAL
XRF LAB

Department of Anthropology
232 Kroeber Hall
University of California
Berkeley, CA 94720-3710
http://www.swxrflab.net

SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM CA-LAN-63, WEST LOS ANGELES COUNTY CALIFORNIA

by

M. Steven Shackley, Ph.D.
Director

Report Prepared for
Dr. John Douglass
Statistical Research, Inc.
Redlands, California

30 September 2004

INTRODUCTION

As expected for Intermediate and Archaic (Millingstone) periods in southern California, all the obsidian artifacts from these sites were produced from Inyo and Mono County sources in eastern California; the West Sugarloaf dome in the Coso Volcanic Field, Inyo County, the Mono Glass Mountain source and the Casa Diablo source in Mono County farther north.

ANALYSIS AND INSTRUMENTATION

All archaeological samples are analyzed whole. The results presented here are quantitative in that they are derived from "filtered" intensity values ratioed to the appropriate x-ray continuum regions through a least squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (McCarthy and Schamber 1981; Schamber 1977). Or more essentially, these data through the analysis of international rock standards, allow for inter-instrument comparison with a predictable degree of certainty (Hampel 1984).

The trace element analyses were performed in the Archaeological XRF Laboratory, Department of Earth and Planetary Sciences, University of California, Berkeley, using a Spectrace/ThermoNoran™ QuanX energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with an air cooled Cu x-ray target with a 125 micron Be window, an x-ray generator that operates from 4-50 kV/0.02-2.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ reduction software. The x-ray tube is operated at 30 kV, 0.14 mA, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity $K\alpha$-line data for elements titanium (Ti), manganese (Mn), iron (as Fe^T), thorium (Th), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Trace element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US.

Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Further details concerning the petrological choice of these elements in obsidian is available in Shackley (1995, 2004; also Mahood and Stimac 1990; and Hughes and Smith 1993). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1, SY-2 (syenite), BHVO-1 (hawaiite), STM-1 (syenite), QLO-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), TLM-1 (tonalite), SCO-1 (shale), all US Geological Survey standards, and BR-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). In addition to the reported values here, Ni, Cu, Zn, and Ga were measured, but these are rarely useful in discriminating glass sources and are not generally reported.

The data from the WinTrace software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 is analyzed during each sample run to check machine calibration (Table 1).

Trace element data exhibited in Table 1 and Figure 1 is reported in parts per million (ppm), a quantitative measure by weight. Source nomenclature is from Hughes (1988, 1994) Jack (1976), and Gilreath and Hildebrandt (1997).

Discussion

The presence of Inyo and Mono County, California obsidian in southern California Intermediate and Archaic period sites is typical (Hughes and True 1985). The one biface produced from obsidian originally procured from Mono Glass Mountain exhibits a quality not generally found today at that dome. I have seen good quality Mono Glass Mountain obsidian, but it is relatively uncommon. Much of the glass at the source today is more vitrophyric than this specimen.

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Table 1. Elemental concentrations for archaeological samples. All measurements in parts per million (ppm).

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
1	1045	315	9177	245	20	43	127	49	West Sugarloaf
2	899	291	9422	235	13	50	151	40	West Sugarloaf
3	886	326	6751	174	9	25	91	24	Mono Glass Mtn
4	803	294	8824	247	16	52	134	48	West Sugarloaf
5	818	251	9593	247	14	50	138	46	West Sugarloaf
6	795	258	9598	272	17	49	141	56	West Sugarloaf
7	892	283	8722	245	10	55	138	51	West Sugarloaf
8	957	318	9044	251	10	53	139	40	West Sugarloaf
9	1036	303	8990	246	16	51	133	45	West Sugarloaf
10	918	311	9541	274	10	61	146	56	West Sugarloaf
11	807	259	9161	263	11	53	141	53	West Sugarloaf
12	1102	284	9808	137	90	19	170	7	Casa Diablo
RGM1-S1	1524	315	13169	144	108	23	218	8	standard

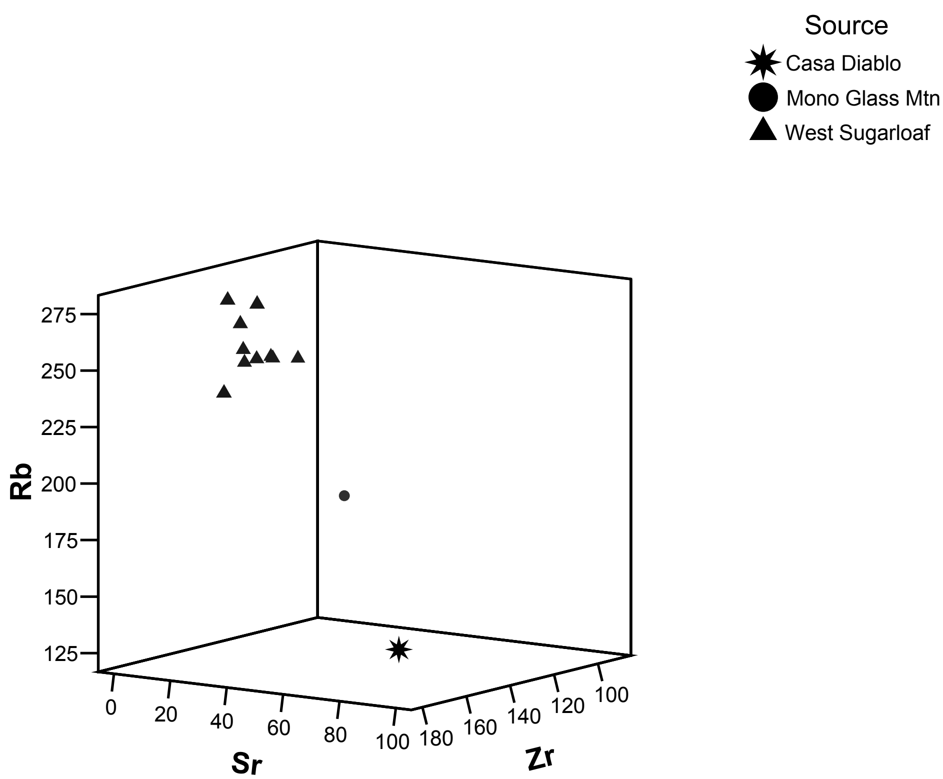

Figure 1. Rb, Sr, Zr three-dimensional plot of the archaeological specimens. Assignment to West Sugarloaf dome in the Coso Volcanic Field based on compositional ranges reported by Hughes (1988).

Obsidian Hydration Analysis

Origer's Obsidian Laboratory

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October 26, 2004

John G. Douglass, Ph.D., RPA
Project Director
Statistical Research, Inc.
P.O. Box 390
Redlands, California 92373

Dear John:

I write to report the results of obsidian hydration band analysis of 12 specimens from site CA-LAN-63. This site is within the West Bluff project area that sits on the bluff top overlooking the Ballona wetlands on the west side of Los Angeles. This work was completed following source determinations made by Steve Shackley who forwarded the specimens to us on your behalf.

Procedures used by our lab for preparation of thin sections and measurement of hydration bands are described here. The specimens were examined to find two or more surfaces that would yield edges that would be perpendicular to the microslides when preparation of the thin sections was done. Generally, two parallel cuts were made at an appropriate location along the edge of each specimen with a four-inch diameter circular saw blade mounted on a lapidary trimsaw. The cuts resulted in the isolation of a small sample with a thickness of about one millimeter. The samples were removed from the specimens and mounted with Lakeside Cement onto etched glass microslides.

The thickness of each sample was reduced by manual grinding with a slurry of #600 silicon carbide abrasive on plate glass. Grinding was completed in two steps. The first grinding was stopped when the sample's thickness was reduced by approximately one-half. This eliminated micro-flake scars created by the saw blade during the cutting process. The slides were then reheated, which liquefied the Lakeside Cement, and the samples inverted. The newly exposed surfaces were then ground until proper thickness was attained.

Correct thin section thickness was determined by the "touch" technique. A finger was rubbed across each slide, onto the sample, and the difference (sample thickness) was "felt." The second technique used to arrive at proper thin section thickness is the "transparency" test where each microslide was held up to a strong source of light and the translucency of the samples was observed. Samples were reduced enough when they readily allowed the passage of light. A coverslip was affixed over each sample when grinding was completed. The slides and paperwork are on file under File No. OOL-173.

The hydration bands were measured with a strainfree 60-power objective and a Bausch and Lomb 12.5-power filar micrometer eyepiece mounted on a Nikon Labophot-Pol polarizing microscope. Hydration band measurements have a range of +/- 0.2 microns due to normal equipment limitations. Six measurements were taken at several locations along the edge of each thin section, and the mean of the measurements was calculated and listed on the enclosed data page.

Note that the data page shows measurements for 17 thin sections. This reflects the fact that five of the 12 specimens had multiple cuts at locations indicated on artifact sketches. The number "1" and "2" following the specimen identification number on the data page indicates that it is Cut 1 or Cut 2, as requested and shown on the sketches.

Please don't hesitate to contact me if you or Kathleen Hull have questions regarding this hydration work.

Sincerely,

Thomas M. Origer
Director

Submitter: J. Douglass - Statistical Research, Inc. October 2004

	Lab#	Sample#	Description	Unit	Depth	Remarks	Measurements	Mean	Source
CA-LAN-63									
	1	1-1625	Debitage			none	6.6 6.6 6.7 6.7 6.7 6.9	6.7	West Sugarloaf (x)
	2	2-1684-1	Point			none	4.2 4.2 4.2 4.2 4.2 4.3	4.2	West Sugarloaf (x)
	3	2-1684-2	Point			none	4.2 4.2 4.2 4.2 4.3 4.3	4.2	West Sugarloaf (x)
	4	3-1685-1	Biface fragment			none	3.9 4.0 4.0 4.0 4.1 4.1	4.0	Mono-GM (x)
	5	3-1685-2	Biface fragment			none	4.0 4.0 4.0 4.0 4.1 4.1	4.0	Mono-GM (x)
	6	4-1686-1	Biface			none	4.8 4.8 4.8 4.9 4.9 5.0	4.9	West Sugarloaf (x)
	7	4-1686-2	Biface			none	4.9 5.0 5.0 5.0 5.0 5.0	5.0	West Sugarloaf (x)
	8	5-1687-1	Biface fragment			none	2.5 2.5 2.5 2.6 2.7 2.7	2.6	West Sugarloaf (x)
	9	5-1687-2	Biface fragment			none	3.7 3.7 3.7 3.8 3.8 3.8	3.8	West Sugarloaf (x)
	10	6-1624	Debitage			none	6.4 6.4 6.5 6.6 6.6 6.7	6.5	West Sugarloaf (x)
	11	7-1626	Debitage			none	6.5 6.5 6.6 6.6 6.6 6.6	6.6	West Sugarloaf (x)
	12	8-1623	Debitage			none	4.7 4.8 4.8 4.8 4.9 5.0	4.8	West Sugarloaf (x)
	13	9-1576	Debitage			none	5.8 5.8 5.9 5.9 6.0 6.1	5.9	West Sugarloaf (x)
	14	10-1575	Debitage			none	6.1 6.1 6.2 6.2 6.2 6.4	6.2	West Sugarloaf (x)
	15	11-1574	Debitage			none	5.3 5.3 5.3 5.3 5.4 5.4	5.3	West Sugarloaf (x)
	16	12-1688-1	Biface			weathered	4.0 4.0 4.1 4.1 4.1 4.2	4.1	Casa Diablo (x)
	17	12-1688-2	Biface			none	4.5 4.6 4.6 4.7 4.7 4.8	4.7	Casa Diablo (x)

Lab Accession No: OOL-173 Technician: Thomas M. Origer

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