CHAPTER 9

A Land of Fire: Anthropogenic Burning on the Central Coast of California

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Native American land stewardship practices in California increasingly have come to the attention of natural resource management agencies such as the National Park Service, California State Parks, Bureau of Land Management, California Department of Forestry and Fire Protection (CAL FIRE), National Forest Service, and others. Much of this interest stems from the desire to better understand the special relationships that native people had with California's diverse environments and their influences on the health and maintenance of plant and animal communities. Indigenous landscape management using fire exemplifies this type of relationship, but our understanding of the timing, intensity, and biotic effects of burning practices remains vague. To address these questions, we recently assembled a collaborative research team that includes archaeologists, ecologists, geomorphologists, botanists, and the Amah Mutsun Tribal Band (AMTB), operating in tandem with the University of California, Berkeley; the University of California, Santa Cruz; and the San Francisco Estuary Institute. In this paper, we present our research model, discuss model implications for natural and indigenous fire management regimes in our study area, and share some preliminary macrobotanical results from our primary archaeological data source, site CA-SMA-113 at Quiroste Valley Cultural Preserve in Año Nuevo State Park (Figure 9.1).

Quiroste Valley is located along the western edge of the San Francisco peninsula, a region known to have once supported a large native population distributed among multiple politically autonomous communities (Milliken 1995). Most of these communities were located along the interior bayshore and oak woodland valleys, or along the grassland terraces and hills of the open coast (Hylkema 1991, 2002; Lightfoot and Luby 2002; Milliken et al. 2007). With the Santa Cruz Mountain range

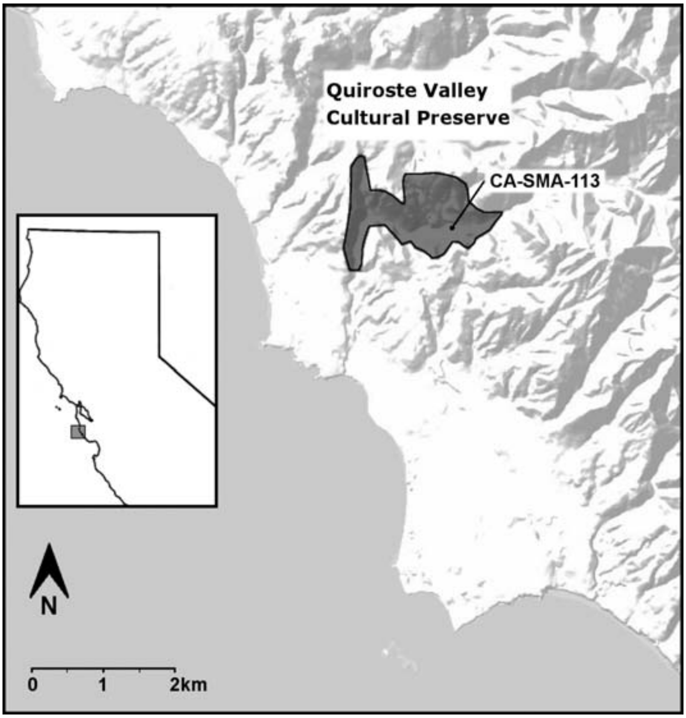

Figure 9.1 *Quiroste Valley Cultural Preserve and CA-SMA-113. Imagery courtesy of ESRI.*

separating these two geographic regions, the people lived in a landscape of great ecological diversity. They were close to marine, sandy beach, rocky shore, tidal and freshwater marsh, grassland prairie, oak grassland savanna, riparian, chaparral, mixed hardwood, and evergreen forest habitats. The mosaic distribution of productive biological communities gave a significant advantage to indigenous people, who created subsistence strategies that employed co-harvesting, long-term storage, and food exchange systems (Basgall 1987:21–52; Bean and Lawton 1973:v–xlvii; Blackburn and Anderson 1993; Fages 1937; Hylkema 2002; Milliken et al. 2007). In this densely populated region, enhancing vegetal productivity through the application of fire, along with institutionalized leadership roles and kinship/alliance systems, may have served to curb episodes of scarcity and ameliorate the effects of resource overexploitation (Anderson 2005; Bean and King 1974; Lewis 1973; Lightfoot and Parrish 2009).

Historical accounts frequently describe how native people of Central California used fire on a landscape scale. In the fall of 1769, Padre Juan

Crespi of the Portola expedition observed burned meadowlands on at least 12 different occasions as the group traveled along the open coast from Santa Cruz to San Francisco. Crespi also described dense hazel stands in some burned areas, and pointedly stated that the native people burned the meadows "for a better yield of the grass seeds that they eat (Brown 2001:565–597)." Just a few years later, while stationed at the newly established Royal Presidio of Monterey, Governor Fages prohibited landscape burning, writing that tribes ". . . are wont to cause these fires because they have the bad habit, once harvesting their seeds, and not having any other animal to look after except their stomachs, set fire to the brush so that new weeds may grow to produce more seeds, also to catch rabbits that get overcome and confused by the smoke" (Fages 1937). Further prohibitions against wildland fires by colonizing authorities beginning in the late eighteenth century greatly curtailed burning practices among California Indians (Lightfoot and Parrish 2009:94–96; Stephens and Sugihara 2006).

In the 1940s, Omer Stewart, a student of Alfred Kroeber at the University of California, Berkeley, undertook the first major synthesis on indigenous fire use in California and across North America (Stewart 2002). His work inspired a generation of later scholars in the 1970s, including Henry Lewis (1973), Florence Shipek (1977), Lowell Bean (Bean and Lawton 1976), William Clarke (1952), and David Mayfield (1978), who began to address the significant role that fire played in indigenous landscape management practices across the state.

California is an ideal place to investigate anthropogenic burning and the role it played in the formation, maintenance, and conversion of multiple vegetation communities. With its Mediterranean climate that enhances vegetation production during wet, mild winters, followed by dry summers that transform this lush growth into potential fuel sources, California is a fire incubator. A diverse array of fire-adapted plants have evolved to flourish across the state. Some survive periodic fires by resprouting, whereas others maintain seed banks that can survive for decades before being activated by fires. Still others produce serotinous cones that open only with high heat (Fites-Kaufman et al. 2006; Quinn and Keeley 2006:45,70). Given the presence of fire-adapted vegetation communities, with high biodiversity and distinct adaptations to local microclimates, we think California is a perfect laboratory to examine long-term interrelationships between people, fire, and the environment.

Despite the superb opportunities for undertaking the study of anthropogenic fire in California, and its many years of scholarship, archaeologists have yet to engage systematically with the topic. A few pioneering studies have been undertaken (Gassaway 2009; Hammett 1991; Hammett and Lawlor 2004), but no concerted effort has yet been forthcoming. There is considerable debate today about the magnitude of fire management practices and the overall impact they had on the environment. Some scholars argue that by selectively using historical accounts, anthropologists have greatly exaggerated the frequency and scale of burning by Native Californians (Parker 2002; Vale 1998, 2002). We think that through our interdisciplinary research model, archaeologists can contribute meaningfully to this ongoing debate by providing critical data on the beginnings of indigenous landscape management in California and diachronic change in burning practices.

Increasingly, archaeologists also recognize the mutual benefits of active collaboration with modern descendant communities. Ethnohistoric and ethnographic accounts of indigenous burning practices are important, but the critical cultural knowledge and experience that exist in modern tribal communities can also add valuable new perspectives to collaborative investigations (Lightfoot and Parrish 2009:97,120). In modern tribes, reengagement with traditional burning practices is prevented by a lack of synthetic study and of mechanisms for application in the modern planning and regulatory environment, especially beyond reservation boundaries. As the science that drives public sector, academic, commercial, and tribal research has evolved, so too has the capacity and engagement of tribes in generating primary research and modern policy mechanisms across a host of disciplines. In addition to exploring the dynamics of temporal and spatial changes in burning practices, archaeologists are capable of providing the sorts of empirical data that these multiple parties need to guide the development of novel forms of public policy.

New methods for the management of open spaces and park lands are of keen relevance to a diverse range of scholars, government agencies, conservation organizations, and the broader public. Resource managers are grappling with questions about how local landscapes have changed over time in response to changing climate and land uses, particularly before and after European colonization. Some are considering policies and practices for managing federal and state lands that will encourage greater biodiversity, enhance the propagation of indigenous species, and reduce the risks of major firestorms. As a result, there is considerable interest in the field of restoration ecology for using indigenous knowledge to develop more accurate and efficient models of prescribed burning in local places. Central to that interest is the imperative to fashion better collaborative relationships with tribes in new and nontraditional settings.

Our research model reflects a new nexus of public, private, tribal, and academic primary research, with tangible public and tribal policy applications that can be applied on California public lands. It is a watershed/cultural landscape approach to answering important questions about basic ecosystem form and function under prolonged anthropogenic influence, including a primary focus on the role of fire in both human and ecological communities, which highlights the important contributions archaeological science can make. We are considering how this kind of information can inform contemporary environmental science and decision-making processes.

INDIGENOUS PYRODIVERSITY MANAGEMENT: A RESEARCH MODEL

Our research program is embedded in the broader theoretical perspective of historical ecology that explores the interpenetration of culture and the environment at the scale of the landscape and historical event (Balée 2006; Crumley 1994; Grossinger in press). Historical ecology is multidisciplinary in its outlook and practice and provides an ideal theoretical framework for integrating archaeology with other related fields and databases (e.g., palynology, fire ecology) that are necessary for undertaking pyrodiversity studies. Historical ecology differs from environmental history, and a number of other related disciplines, in that it focuses on documenting trends in ecological form, function, resilience, and varying responses of particular systems to disturbance, rather than a historical inventory of largely anthropogenic changes to environmental resources. It also represents the dominant theoretical approach for current studies of anthropogenic burning by nonstate societies in other areas of the world, including Amazonia, Australia, and the Pacific Northwest (Bird et al. 2005; Erickson and Balée 2006; Lepofsky and Lertzman 2008).

Our indigenous fire management research model is multidisciplinary, incorporating approaches and datasets from paleoecology, modern fire ecology, fire scar analysis, geomorphology, and isotopic chemistry. These datasets are used in conjunction with traditional archaeological datasets, which include artifact assemblages and ethnohistoric, historic, and ethnographic information. Also critical to this model is a close working relationship with modern indigenous communities, not only to structure our approaches to research questions, but to aid in our interpretations and research logistics.

A central aspect of our approach involves determining the conditions necessary to detect the differences between anthropogenic and nonanthropogenic fire regimes, and connecting these differences with indigenous foodways and economic practices. Our research goals are to explore (1) when anthropogenic burning was initiated, (2) how burning changed the structure and composition of vegetation across the landscape and influenced landscape productivity and biodiversity, (3) how the frequency and extent of indigenous landscape management changed through time, and (4) how pyrodiversity management practices articulate with broader foodways and social practice. We present here an outline of our research model that describes its components and how they relate to one another.

Local Fire Ecology

In central California, the territories of individual tribal groups were composed of multiple environmental niches supporting vegetation communities distinct in their structure and responses to fire. Modeling the fire responses of local vegetative communities is possible through (1) published fire ecology studies, (2) historical reconstruction of fire response incorporating known fire history and historical aerial photography, and (3) historical accounts of postfire response.

Paleoecological Assessment

Botanical remains such as pollen, phytoliths, and charcoal may be preserved in accretional soil/sediment layers (such as in wetland or lacustrine environments) and in buried paleosols. Geomorphological research followed by on-the-ground testing can be used to locate these deposits, which may be sampled to reconstruct vegetation change over long time spans. Vegetation reconstruction can be supplemented through isotopic analysis of $\delta^{18}O$ values in marine shell, which reflect changes in sea surface temperature and may be used to track changes in climate (Jones and Kennett 1999; Jones et al. 2008; Kennett and Kennett 2000).

Modern and Historical Data

In many cases, the fire history of an area for the last century can be reconstructed from documentary records, and in some cases a history of recent indigenous fire management can also be developed. The timing of succession between vegetation types following fire can be tracked using historical aerial photographs and vegetation maps. In some areas of California, fire histories extending back many centuries have been constructed through fire scar dendrochronology or dendroecology (e.g., Norman 2007; Stephens and Fry 2005; Sugihara et al. 2006). These studies provide invaluable sources for estimating fire return intervals for not only recent historical times, but also for the colonial and precolonial periods of California. By integrating local fire history data with expectations for local fire responses and recent paleoecological datasets, these models can be empirically tested and refined.

Archaeobotany

Archaeobotanical remains differ in their likelihood of preservation based on structural characteristics of their anatomy and on how they were collected, processed, and discarded. Incorporating this information with archaeological site use data allows us to develop expectations for the types of archaeobotanical remains that are likely to be preserved and to use a sampling strategy that can recover an assemblage appropriate for quantitative analysis. By linking preservation pathways with local fire ecology data, we can model the extent to which we expect archaeobotanical datasets to inform fire regime reconstruction.

Anthropogenic versus Nonanthropogenic Fire Regimes

Given known ethnohistoric, ethnographic, and archaeobotanical data from the local area, models for indigenous fire management regimes can be constructed. These models also integrate fire ecology and paleoclimate data to construct expectations for changes in vegetation and resulting patterns in paleoecological and archaeobotanical datasets given different anthropogenic fire regimes and climatic conditions.

The nonanthropogenic fire regime, in which all landscape fires are the result of lightning ignitions, acts as the null hypothesis for the overall research model. Nonanthropogenic fire regimes may be simulated by incorporating data on lightning strike frequency and ignition rate with vegetation succession models (e.g., Syphard et al. 2006).

Assessment of Local Fire Regimes

Paleoecological and archaeobotanical datasets are compared with anthropogenic and nonanthropogenic fire regime models to determine the extent to which the datasets fit model expectations. Several lines of research incorporated into these models (e.g., phytolith and marine isotope analysis) are still in the early stages of development, and others carry a high degree of uncertainty due to preservation filters (e.g., macrobotanical data). Fire regime model assessment is thus a process of adjusting for best fit, rather than simple acceptance or rejection. Areas with greater uncertainty can be identified so that additional data may be collected to refine interpretations.

Fire Regimes and Social Practice

If the model suggests anthropogenic fire regimes were present in the study area, we can explore how particular aspects of the management regime articulated with social practice. For example, such topics may include (1) how mobility dynamics and sedentism changed with implementation of fire management, (2) the relationship between fire management and resource control, and (3) how incorporation of specific fire-managed resources into foodways affected processing techniques, gendered division of labor, and consumption practices. Optimality models can be useful here in outlining the potential economic consequences of different fire regimes.

Implementing Contemporary Vegetation Restoration and Management

A perennial challenge to contemporary resource managers is identifying a *desired future condition*, or a set of benchmark environmental indicators that, when quantitatively measured,can be used to infer the relative success of any given management application or regime. Many resource managers now accept that indigenous applications of fire had at least some influence on the mosaic of habitats encountered by colonizing forces in the late sixteenth century in California. Given the extreme scale and cost of the legacy of fire suppression in the West, many ecologists and resource managers are now turning their attention toward the collection, synthesis, and accessibility of high-quality data pertaining to historic fire regimes as an essential tool to help rehabilitate our fuel-laden watersheds and open spaces.

Data derived through the implementation of this model can improve the effectiveness of management and restoration planning and implementation. For instance, the inclusion of archaeobotanical data, historic fire regime information, mapping, and modeling historic land cover classes and their change in response to different management regimes can enhance the predictive power of management alternatives analyses. Making these data available earlier in the planning process, whether for open space management, transportation planning, or rural infrastructure construction, can help avoid impacts to important resources, and even improve the function and resilience of local ecosystems.

Since California exhibits high geographical, biological, and cultural diversity, the model must be implemented on a local scale in each study area. In some areas, reconstruction of indigenous burning practices will be less complex than in others. For example, in areas with frequent lightning-ignited fires, the difference between anthropogenic and nonanthropogenic fire regimes may be difficult to detect.

The Quiroste Valley Test Case

We chose the Quiroste Valley Cultural Preserve on the central coast of California as our initial study area. Characteristics that make Quirsote Valley (and much of the central California coast) appropriate for our study of pyrodiversity management research include: (1) sparse natural lightning, (2) straightforward patterns in vegetation succession,

(3) extensive public lands available for research, (4) documentary records of indigenous and nonindigenous land use history, (5) conifer woodlands that can provide records of fire return intervals over many centuries, and (6) multiple groups interested in collaborating on indigenous fire management. These elements facilitate the development of indigenous fire management research in its incipient phase. Once these research methods are refined through implementations in similar contexts, pyrodiversity management research will have the potential to become a broader research program throughout California.

Based on descriptions by members of the first Spanish overland expedition into central California, led by Gaspar de Portola in 1769, we believe Quiroste Valley is the location of a settlement described by the party as containing a very large hemispherical structure they referred to as "Casa Grande" (Brown 2001). Data from our primary archaeological research site, CA-SMA-113, suggest it is the probable location of Casa Grande (Figure 9.1). Despite historical disturbance, the site still contains intact deposits dated to ca. AD 1000 to 1300 (Table 9.1). We have also recovered Late Period diagnostic artifact types from disturbed and intact deposits, including Desert Side-Notched, corner-notched, and serrate obsidian projectile points. Our excavations at CA-SMA-113, conducted from 2007 to 2009, included 22 1-meter × 1-meter excavation units totaling 14.7 m^3 of archaeological sediments.

Lightning Patterns, Natural Fire Regimes, and Vegetation Succession in Central California

Lightning strike density in California varies from a regional low of 2.41 strikes/100 km^2/year in the north coast region to a high of 27.24 strikes/100 km^2/year in the southeast deserts (Figure 9.2; van Wagtendonk and Cayan 2008). In all regions, lightning occurs most frequently in the

Table 9.1 Radiocarbon Dates from CA-SMA-113 (Unit N25 W102; west wall).

Sample No.	Material	Depth, cm	Conventional Radiocarbon Age, years BP	2σ Cal Date Range, AD
CASMA-113-64	*Mytilus* shell	10–20	880 ± 40	1530–1710
01-0069-AMS	Carbon	30–40	1000 ± 40	980–1060
CASMA-113-74	*Mytilus* shell	40–50	1180 ± 40	940–1150
01-0058-AMS	Carbon	60–70	920 ± 40	1020–1210
CASMA-113-73	*Mytilus* shell	70–80	1080 ± 40	1030–1250
01-0073-AMS	Carbon	70–80	1270 ± 40	660–870

All dates collected from a 25 × 25 × 10 cm soil sample column. Inversion of dates may be caused by an intrusive pit feature in the column (Feature 4, Strata 6–8).

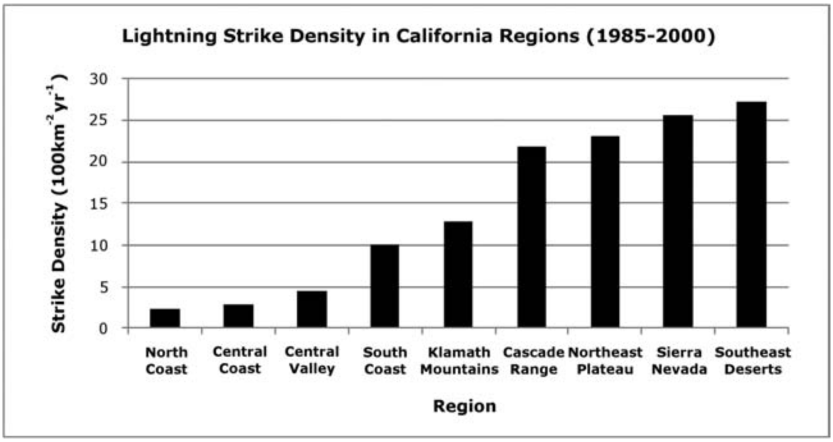

Figure 9.2 *Lightning strike density in California regions 1985–2000, based on van Wagtendonk and Cayan (2008).*

drier summer months and strike density increases with elevation (van Wagtendonk and Cayan 2008).

Based on the low density of lightning on the central California coast, several researchers have predicted that nonanthropogenic fire regimes in coastal areas would be characterized by fire return intervals of 100 years or more (Davis and Borchert 2006; Greenlee and Lagenheim 1990; Keeley 2002, 2005). The likelihood of ignition may be highly dependent on local weather patterns at the time of occurrence, so it is difficult to estimate ignition rates from strike density alone (van Wagtendonk and Cayan 2008). Using fire records, Keeley (2005) compiled data on human and lightning induced ignitions for three Bay Area counties for the period 1945 to 2002. The estimated ignition rate for this area was 0.034 ignitions/100 km^2/year, or about 1.15 percent of lightning strikes, based on the regional average. Keeley (2005) suggested that lightning-ignited fires might be smaller in extent than anthropogenic fires, since they tend to ignite at higher elevations where ridgelines act as natural firebreaks.

Contemporary vegetation in nonagricultural areas of the central California coast of is characterized by herbaceous rangelands, north coast scrub shrublands, and mixed conifer forests cut by riparian corridors and interspersed with wetlands, hardwood woodlands, and maritime chaparral. On the central coast, grasslands are disturbance-dependent communities, requiring regular grazing, tillage, or burning to persist (Keeley 2002, 2005). In the absence of disturbance, grasslands around Quiroste Valley convert to north coast scrub vegetation communities dominated by coyotebrush (*Baccharis pilularis*), poison oak (*Toxicodendron diversilobum*), and blackberry (*Rubus ursinus*).

Grassland to shrubland conversion is variable in rate, but can begin in as little as five to 10 years (Williams et al. 1987). Except in areas where edaphic or biotic conditions limit recruitment, central coast scrublands are predicted to be replaced by woodlands in the absence of fire (Ford 1991; Ford and Hayes 2007). In the area around Quiroste Valley, Douglas fir (*Pseudotsuga menziesii*) invades north coast scrub; in more xeric areas, scrublands are succeeded by live oak (*Quercus agrifolia*) and bay (*Umbellularia californica*) woodlands (Ford and Hayes 2007; McBride 1974). Douglas fir is not a fire-resilient species, and even light fires can cause 50 percent mortality in Douglas fir stands (Ryan et al. 1988), suggesting Douglas fir forests could be converted to grasslands after only a few fires.

In the central coast area, it is unlikely that large areas of shrubland could have been converted to grassland by lightning fires, since this vegetation type is most fire prone in the fall, after the summer lightning season has passed (Keeley 2005). The predicted nonanthropogenic fire regime is characterized by century-scale fire return intervals that allow mixed conifer forests to persist as climax communities over much of the region. We have observed the predicted successional pattern in Quiroste Valley, where large tracts of grasslands have converted to dense north coast scrub and Douglas fir forests since the mid-1970s.

Indigenous Plant Food Resources and Fire Management on the Central Coast

Around Quiroste Valley, a nonanthropogenic fire regime would have likely produced a landscape dominated on lower slopes and terraces by mixed conifer forests, seral scrublands, and riparian corridors, with herbaceous plant communities limited to the coastal strand and wetlands. With the exception of California blackberry (*Rubus ursinus*; berries) and lupine (*Lupinus* spp.; seeds), north coast scrub is depauperate in plant food resources. Riparian corridors contain many plant food resources such as salmonberry (*Rubus spectabilis*; berries), buckeye (*Aesculus californicus*; nuts), and nettles (*Urtica dioicia*; greens; Bocek 1984). Local wetlands contain stands of cattail (*Typha* spp.; roots, stems, inflorescences) and tule (*Schoenoplectus acutus*; rhizomes) year-round. In valleys further inland, redwood forest likely would have dominated, with an understory containing tanoak (*Notholithocarpus densiflorus*; nuts), hazel (*Corylus cornuta*; nuts), and huckleberry (*Vaccinium ovatum*; berries). Drier uplands would likely be composed of chaparral and mixed hardwood woodlands containing manzanita (*Arctostaphylos* spp.; berries), chinquapin (*Chrysolepis chrysophylla*; nuts), and several types of oak (*Quercus* spp.; nuts).

In this nonanthropogenic fire regime landscape, summer-ripening berries and fall-ripening nuts would likely have been the primary seasonal resources. Other plant foods, such as wetland geophytes, would have remained visible on the landscape and available for harvest throughout the year. Because forests would tend to provide mainly seasonal resources, while the coastal areas would have contained reliable resources such as shellfish, fishes, and wetland geophytes year-round, we might expect long-term habitation sites to be located on or near the coastal strand. Sites located inland might tend to be shorter-term logistical camps used to harvest seasonal plant food resources, which may have been transported to long-term habitation sites for storage. We would expect the archaeobotanical assemblages of all of these sites to contain few herbaceous seed foods, and we would expect most seeds to be taxa that can grow near the coastal strand. We would expect nut resources to be present in contexts deposited in all seasons, since they can be stored year-round.

The large tracts of anthropogenic coastal grasslands encountered by the Spanish on their initial forays into Alta California contained a rich assemblage of seasonal plant foods that would have altered the pattern of food procurement described here. Modern grasslands near Quiroste Valley contain several native grasses with large seeds and compact inflorescences that would have facilitated gathering. Local forbs with edible seeds include coast tarweed (*Madia sativa*), clover (*Trifolium* spp.), and dock (*Rumex* spp.). Geophytes probably would have been much more common in open grasslands than in the understories of dense scrub or mixed conifer forests, providing a reliable multiseason food resource.

Without extensive grasslands on the coast, the period between midsummer and early fall may have been a lean time for plant foods. Berries and geophytes would have been available, but these would be difficult to access in dense scrub and perhaps sparse in forest understories. Grasslands provided a reliable source of storable mid-summer to early fall food resources including the above plants and animals attracted to them. Under these conditions, long-term habitation sites may have shifted inland to have more direct access to grassland resources, placing them equidistant from coastal resources and upland nut resources. The potential for multiseason site occupation would be expected to increase, since stored nuts from the previous fall would not need to last through the entire summer. Thus, stored grass and forb seeds may have reduced the need for summer residential mobility, particularly in years of lean nut harvest.

Under an anthropogenic fire regime, we expect grassland seed foods to be represented in higher density in macrobotanical samples. Short-term summer-deposited discard contexts are expected to contain few nut resources compared with seed resources. Landscape type conversion also suggests the possibility of new types of logistical seed-gathering camps. At these locations, seed gathering may have been followed by landscape burning associated with game drives. If so, the ecofact assemblage might contain exclusively remains of grassland plant taxa and fire-driven fauna such as lagomorphs and rodents.

SYSTEMATIC SAMPLING STRATEGY FOR ARCHAEOBOTANICAL REMAINS

Although multiple archaeological datasets may be linked with fire management practices, the archaeobotanical assemblage provides the most direct evidence of the types of plants people used for food and economic purposes. Here, we will discuss the requirements for a macrobotanical sampling strategy aimed at informing indigenous fire management practices and relating these to broader social practice.

Since the advent of flotation in the 1960s, macrobotanical analysis has become an integral component of archaeological research throughout the United States. However, unlike the sampling strategies for other archaeological datasets (e.g., lithics and faunal remains), flotation sampling has yet to be used systematically in many research projects, due largely to factors of cost and analysis time. For studies of indigenous landscape management, we argue that a systematic approach to macrobotanical sampling aimed at constructing robust datasets suitable for statistical analysis is key.

Long-term habitation sites such as CA-SMA-113, occupied through multiple seasons for decades to generations, are most likely to contain a representative assemblage of the range of plants people used for food and raw materials. Our initial fieldwork at the site used geophysical survey techniques to define the overall site structure. Our goal was to identify the spatial distribution of discrete cultural features, such as hearths and pits. Excavations units were placed to explore these geophysical anomalies, which resulted in the recovery of data from several discrete contexts.

We used distinct sampling methods for arbitrary contexts (lacking stratigraphic boundaries) and discrete contexts (defined by natural boundaries). In arbitrary contexts, we collected 5- or 10-liter "scatter" samples from each 10-cm level. These are collected by aggregating small amounts of deposit collected throughout the level. These were chosen over "bulk" samples (collected from a single location) because they converge to overall mean values for taxon density more efficiently than bulk samples (Lennstrom and Hastorf 1992; Pearsall 2000). Collecting multiple samples from each arbitrary context allows us to use parametric statistics to estimate a mean and range of error for the density of each recovered taxon. These error ranges can be used to determine whether differences in taxon density are more likely to reflect actual differences or to be the result of chance. We recommend collecting at least 10 samples from each type of arbitrary context, reducing the standard error of the mean. A total of 159 flotation samples were collected from CA-SMA-113 using this sampling methodology.

In discrete contexts, such as pit features, hearths, and ash lenses, deposits less than 10 liters in volume were collected in toto for flotation. In these cases, the archaeobotanical remains represent a population of all specimens in the context. For larger discrete contexts, we collected 10-liter scatter samples at twice the rate of arbitrary contexts. These contexts have the potential to provide more interpretable data than arbitrary contexts. For example, the contents of an ash lens may represent hearth-related activities that occurred on a time scale of weeks or months, whereas mixed midden levels may represent activities on a multi-decadal time scale. At CA-SMA-113, we collected 35 "bulk" flotation samples from discrete contexts such as ash deposits and bounded charcoal-rich areas. We also collected one eight-sample flotation column from a unit containing a pit feature.

Fine temporal resolution is required to reconstruct seasonal variation in the use of ecological resources, a fundamental issue in reconstructing fire management regimes. Discrete contexts have higher spatial resolution than arbitrary contexts, providing more detailed information on contemporaneous practices across a site. Thus, they allow us to explore the degree of heterogeneity in foodways among the people living at a site. The extent to which fire-managed resources were used throughout a community may be connected to the communality of fire management practices in general. Since burning can modify large tracts of landscape for years to come, we think it is likely that fire management decisions, such as which places to burn in a given year and when to burn them, could have been important discursive issues within a community. Implementing a high-resolution, systematic sampling strategy from the outset allows us to explore these issues archaeologically.

Preliminary Macrobotanical Results

Field crews collected a total of 202 flotation samples from CA-SMA-113. These contain a dense and rich assemblage of macrobotanical remains, often with more than 50 identifiable specimens per liter of soil. Here, we are not presenting the full suite of macrobotanical remains from samples; rather, we will focus on a small portion of the dataset: grassland-associated seed food taxa and woodland-associated nut food taxa that commonly occur in these samples. All of the flotation samples presented here were collected from Feature 4, a shallow pit approximately 1 meter × 1.5 meter in diameter with fill up to 30 cm in depth. It may represent the remains of a pit oven used for roasting geophytes and subsequently filled with hearth material and food waste. Radiocarbon dates from Feature 4 place it between ca. AD 1000 and 1200 (Table 9.1; samples 01-0058-AMS and CASMA-113-73). The dataset presented here includes five bulk flotation samples from discrete contexts and five scatter flotation samples from nondiscrete contexts in the pit fill.

Figure 9.3 presents the density of seeds from four major plant food taxon groups: grasses (Poaceae), tarweeds (*Madia* spp.), clover (*Trifolium* spp.), and composites (Asteraceae). Grass seeds are present in high densities (> 25 species/liter) in all samples. Two bulk samples with extremely high grass density (> 200 species/liter) may represent winnowing debris, where small grass seeds were burned after separation from larger seeds. Most samples also contain abundant remains of tarweeds, a fire-stimulated group of sunflower family plants whose oily seeds were commonly collected as food (Anderson 2005:263–4). Interpretation of clover seeds is less clear. Although clover is generally regarded as a greens food collected early in the year (Anderson 2005), it is possible that clover seeds were added to pinole. Alternatively, clover may have been harvested for greens alone, with the ripe inflorescences discarded in fires. Other composite seeds not yet identified to genus may or may not represent seed food remains. Although many composite seeds are edible, these seeds could have been collected incidentally along with other seed foods or windborne into fires.

Figure 9.4 presents the density of nut remains from the three most common nut food taxa in the assemblage: hazel (*Corylus cornuta*), tanoak acorn (*Lithocarpus densiflorus*), and acorn (*Quercus* spp.). Nut

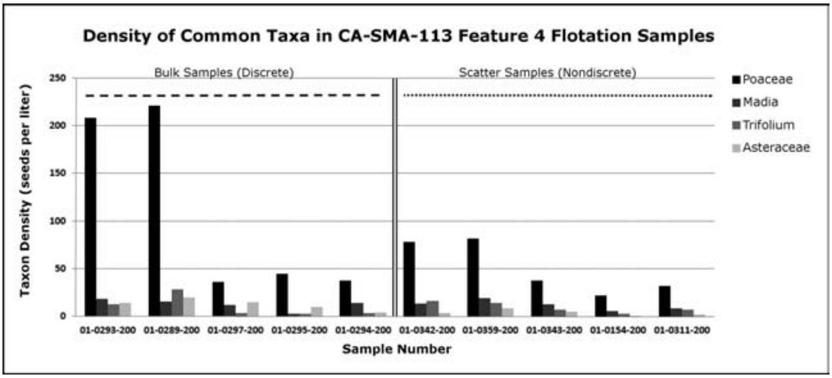

Figure 9.3 *Density (no. of seeds per liter) of common grassland-associated seed food taxa in flotation samples from pit feature (Feature 4), CA-SMA-113.*

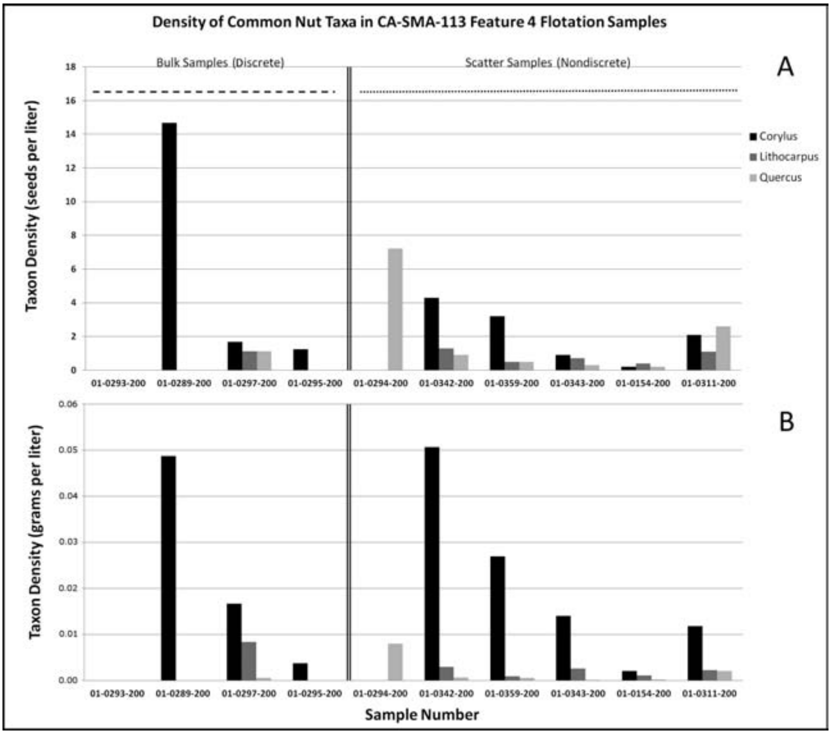

Figure 9.4 *Density (A = count per liter; B = grams per liter) of common nutfood taxa in flotation. samples from Pit Feature (Feature 4), CA-SMA-113.*

remains usually have a count density of less than five specimens per liter and weight densities of less than 0.05 g/liter for hazel and less than 0.005 g/liter for acorn. Hazel is represented at higher density both by count and weight than acorns in most samples. As noted above, Padre Juan Crespi described dense, burned hazel stands while traveling up the coast in 1769 (Brown 2001). The high density of hazel remains at this site suggests people on the coast may have been managing hazel stands for food early in the Late Period. Hazel may even have been the primary staple nut food at the site. Alternatively, people may have shelled and processed acorns away from site CA-SMA-113, resulting in infrequent exposure of acorn shells to fire at the site.

Bulk samples collected from discrete contexts are more variable in overall macrobotanical density and in relative taxon composition than scatter samples from nondiscrete deposits, supporting the idea that the discrete deposits represent shorter-term and more heterogeneous practices. But in all samples, count density of seed food taxa is much higher than nut food taxa, generally by an order of magnitude or more. The high proportion and consistently high density of seed food taxa throughout the Feature 4 macrobotanical assemblage suggests site inhabitants were using grassland habitat plant foods intensively and regularly. Given our model expectations for very limited grassland communities under nonanthropogenic fire regimes, the preliminary data from macrobotanical analysis tends to support the hypothesis that landscape burning was practiced during the early part of the Late Period.

CONCLUSIONS

California is an exceptional place to examine the various strategies of anthropogenic burning employed by native people, and the degree to which these landscape management practices influenced the formation, maintenance, and conversion of vegetation communities across the state. We believe that archaeologists can play a crucial role in examining the long-term interrelationships between people, fire, and the environment across the state. As outlined in this paper, archaeologists can begin to address the magnitude of past fire management practices and the overall impact they had on the environment. Given California's high biodiversity, localized multiclimates, distinctive topographies, and densely packed native polities across the landscape, it is clear that archaeological investigations of anthropogenic burning will need to take place at the scale of the local region.

This paper outlines a research program for the study of anthropogenic burning in central California. We emphasize that archaeological research will need to be undertaken in a diachronic and multidisciplinary framework that includes paleoecology, modern fire ecology, dendroecology, geomorphology, and isotopic chemistry. In our case study, we model the expectations for anthropogenic burning in Quiroste Valley, and consider how the resultant paleoecological and archaeobotanical datasets will differ from those created under natural fire regimes. We then consider different expectations for how indigenous people may have used plant resources under natural versus anthropogenic fire regimes.

A significant finding of our modeling program is that anthropogenic burning in the study area will tend to create and maintain grassland vegetation communities, in contrast to those communities supported by natural fire regimes (shrublands and conifer forests). In evaluating these expectations for the people inhabiting CA-SMA-113 in Quiroste Valley, we implemented a systematic sampling program for collecting macrobotanical samples from arbitrary and discrete contexts. Analysis of these samples indicates native people were extensively involved in the exploitation of grassland taxa. These preliminary findings suggest that native Californians used fire management to convert resource-poor coastal shrublands and woodlands to productive grassland/shrubland mosaics in late prehistoric times in one area of the central California coast. We are currently assessing this interpretation by using other lines of evidence that concern the region's fire history, vegetation successions, and macrobotanical remains from additional archaeological sites.

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