

RETHINKING THE STUDY OF LANDSCAPE MANAGEMENT PRACTICES AMONG HUNTER-GATHERERS IN NORTH AMERICA

Kent G. Lightfoot, Rob Q. Cuthrell, Chuck J. Striplen, and Mark G. Hylkema

There has been little movement to systematically incorporate the study of indigenous landscape management practices into the method and theory of hunter-gatherer research in North American archaeology, despite a growing interest in this topic. The purposes of this article are twofold. One is to address why, until quite recently, archaeologists have been reluctant to engage in the current debate about the scale and ecological impact of these practices, particularly anthropogenic burning. We argue that this stems from a long tradition of viewing hunter-gatherers as passive, immediate-return foragers, as well as from the daunting methodological challenges of identifying landscape management activities using archaeological data. Our second purpose is to explore how archaeologists can make significant contributions to our understanding of past resource management practices through the creation of new kinds of collaborative, interdisciplinary eco-archaeological programs. Based on the current work of scholars in archaeological and environmental disciplines, as well as on our own implementation of such an approach in central California, we discuss the importance of maintaining mutual relationships with local tribes, the challenges of coordinating multiple data sets, and the process of rethinking our analytical methods and temporal scales for undertaking hunter-gatherer studies.

Ha habido poco movimiento para incorporar sistemáticamente el estudio de los prácticos de direcciones recursos indígenas en el método y en la teoría de las investigaciones de los cazador-recolectores en la arqueología Norte Americana, a pesar del interés creciendo en este tema. Hay dos propósitos de este artículo. Uno es abordar porqué, hasta recientemente, arqueólogos han sido reacios en dedicarse dentro del debate actual del escalo y del impacto ecológico de estos prácticos, particularmente los fuegos antropológicos. Argumentamos que este viene de una gran tradición de pensar en los cazador-recolectores como forrajeros pasivos quienes regresan inmediatamente a sus tierras ya habitadas. También viene de los desafíos metodológicos tan desalentados en identificando los prácticos de direcciones recursos usando datos arqueológicos. Nuestro según propósito es explorar cómo arqueólogos pueden hacer contribuciones significantes a nuestro entendimiento sobre los prácticos de direcciones recursos pasados por la creación de nuevos tipos de programas colaborativos, interdisciplinarios, y ecológicos. Basada en el trabajo actual de los eruditos en disciplinarios arqueológicos y ecológicos, además de nuestra implementación de tal enfoque en California Central, discutimos la importancia en manteniendo relaciones mutuales con tribales locales, los desafíos en coordinando múltiples conjuntos de datos, el proceso de repensar nuestros métodos analíticos y escalos temporales para emprender los estudios de los cazador-recolectores.

Perceptions about hunter-gatherers in North America have undergone significant transformations in the anthropological literature in recent years. Once depicted as passive foragers who simply harvested available foods and raw materials from relatively pristine ecosystems, they are now recognized as agents who actively modified and constructed local environ-

ments. Anthropologists describe diverse activities that hunter-gatherers employ to stimulate the growth and diversity of floral and faunal resources across the landscape, which include prescribed burning, tillage, pruning, seed broadcasting, transplanting, mulching/fertilizing, weeding, and irrigation, as well as the tending of clam beds and fish eggs (Anderson 2005; Blackburn and

Kent G. Lightfoot ■ Department of Anthropology, Archaeological Research Facility, University of California, Berkeley, CA 94720-3710 (klightfoot@berkeley.edu)

Rob Q. Cuthrell ■ Department of Anthropology, Archaeological Research Facility, University of California, Berkeley, CA 94720-3710

Chuck J. Striplen ■ Amah Mutsun Tribal Band, San Francisco Estuary Institute, Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720-3114

Mark G. Hylkema ■ California Department of Parks and Recreation, Santa Cruz District, Felton, CA 95018-9660

American Antiquity 78(2), 2013, pp. XX-XX
Copyright ©2013 by the Society for American Archaeology

Anderson 1993; Deur and Turner 2005; Fowler and Lepofsky 2011; Peacock and Turner 2000; Turner and Peacock 2005). In particular, the strategic use of fire is argued to be an important management tool once used to construct productive anthropogenic landscapes in many regions of North America (e.g., Boyd 1999; Hammett 1991, 1992; Lewis 1993; Patterson and Sassaman 1988; Stewart 2002). Fowler and Lepofsky refer collectively to the various activities and knowledge employed to enhance the abundance, diversity, and/or availability of local resources as “traditional resource and environmental management” (TREM [2011:286]). This article considers management practices, particularly anthropogenic burning, used by hunter-gatherers to enhance the productivity of nondomesticated plants and animals (e.g., Smith 2011).¹

Although most scholars today recognize that hunter-gatherers employed systematic burning and other management techniques to modify local habitats, there is considerable debate about the magnitude of such practices and their overall impact on the environment. Some ecologists and environmental scientists argue that the scale of environmental modification is greatly exaggerated in the current anthropological literature. Vale (1998:231, 2002:7) cautions that this perspective is creating a new “myth” or “revisionist history” about Native Americans, one in which they modified and economically enhanced vast swathes of land (see also Allen 2002; Barrett et al. 2005; Parker 2002). Vale and others believe that relatively small areas were typically altered when such management practices were employed. More importantly, they argue that major transformations in the composition and structure of plant communities often attributed to Native fire management by anthropologists can be best explained by natural, nonanthropogenic ecological processes.

Significantly, the field of archaeology has been relatively quiet throughout this debate. Although some innovative research is now taking place, particularly in the Northwest, there has been little systematic movement to incorporate TREM implications into the method and theory of hunter-gatherer research in North American archaeology. In some regions, such as California, archaeological studies of hunter-gatherers continue to be implemented with little reference to past man-

agement practices, even though they have been discussed in the local anthropological literature for many decades (e.g., Anderson 2005; Bean and Lawton 1976; Lewis 1993). This is unfortunate on two counts.

First, since the 1940s, when Omer Stewart began researching his massive synthesis of indigenous burning in North America, the majority of the anthropological research on TREM has been based on ethnohistorical and ethnographic research. Although detailed analyses of these observations have led to major contributions to our understanding of indigenous resource management strategies (e.g., Blackburn and Anderson 1993; Boyd 1999; Deur and Turner 2005; Fowler et al. 2003; Turner and Peacock 2005), there are well-recognized constraints in relying primarily on these sources to study past Native practices, particularly those originating before European contact (Deur and Turner 2005:20–28).

A particularly vexing problem is that our current understanding of TREM practices in many regions of North America has been greatly determined by the timing, methods, and impacts of European exploration and settlement. For example, along the Pacific coast of North America, early settler accounts, ethnographic observations, and tribal memories of anthropogenic burning by hunter-gatherers vary greatly (Boyd 1999; Lewis 1993). Along the central and southern California coasts—areas colonized in the late 1700s by Franciscan missionaries who implemented fire suppression policies—recollections of anthropogenic burning “had long faded from cultural memory by the late 19th and early 20th centuries” (Timbrook et al. 1993:118). In other places, there are few or no firsthand ethnographic observations of anthropogenic burning, since the earliest trained anthropologists did not go into the field until *after* the implementation of federal and state fire suppression policies that prohibited Native peoples from setting fires in wildlands (see Lightfoot and Parrish 2009:94–97). Among some tribal groups, elders can recount oral traditions of anthropogenic burning, but often they can provide few specific details of the process (e.g., on fire ignition, control, frequency, patch size, etc.) since they grew up after government fire restrictions had been implemented (Deur 2009; Lepofsky et al. 2005a:224).

The heavy reliance on ethnohistorical and ethnographic observations to make the case for TREM in the anthropological literature is an important factor in current debates about the scale and ecological impact of these practices. Some scholars have raised criticisms about the highly “selective” and “biased” use of a few historical sources to paint “careless generalizations” about the degree to which Native Americans modified local environments (Allen 2002:145, 160; Barrett et al. 2005:31–32; Vale 2002:6–7). They contend that a full evaluation of the problem will not be possible until other lines of empirical evidence, preferably involving “scientific and ecological perspectives,” are brought to bear on this issue (Allen 2002:163–166; Barrett et al. 2005:32–33). Clearly, archaeology should be a crucial component of this dialogue.

Second, by largely abstaining from the ongoing debate about the scale and ecological impact of TREM practices, archaeologists are overlooking an excellent opportunity to contribute to a series of important and broadly relevant issues concerning the contemporary management of open spaces and public lands. While various concerns have been raised about the integration of traditional ecological knowledge with modern resource management practices (Hunn et al. 2003; Nadasdy 1999), it is clear that “understanding the role of humans in ecosystem history is a fundamental first step in managing ecosystems today” (Lepofsky 2009:161). Resource managers are experimenting with new policies and practices for managing contemporary ecosystems that will enhance species richness and diversity, promote the growth of indigenous species over exotics, and reduce the risks from major firestorms. In creating the next generation of treatment protocols, there is movement in the field of restoration ecology to experiment with traditional ecological knowledge in the management, treatment, and rehabilitation of ecosystems (Anderson 2005; Clewell and Aronson 2007; Egan and Howell 2001; Fowler et al. 2003; Mason et al. 2012; Society for Ecological Restoration 2004). Questions are now being asked about the agency of Native people in shaping past fire regimes and vegetation patterns. What kinds of strategies did they employ in regards to the timing, intensity, and extent of traditional burns in specific kinds of vegetation

communities? Did these fire management practices increase species richness and decrease fuel loads over the long term? How can traditional practices, in concert with modern range and forest management protocols, provide new insights for managing wildlands today?

We believe that archaeology can make significant contributions to the study of anthropogenic burning and other management practices among hunter-gatherers that can help address these broadly relevant questions. The diachronic perspective of archaeology is well suited for providing critical information about TREM practices at the landscape scale and their implications for understanding past fire regimes and vegetation succession patterns over many centuries, spanning precontact and contact times. In this article, we follow Lepofsky (2009:162–163) in arguing that the systematic study of past TREM practices will require some rethinking in how we undertake the study of hunter-gatherer societies. Specifically, we argue that this will involve modifications in our standard procedures for undertaking archaeological research toward creating new kinds of collaborative, interdisciplinary eco-archaeological programs.

The purposes of this article are twofold. One is to address the challenges of studying traditional resource and environment management in archaeology and why we have, until quite recently, been reluctant to study these practices among hunter-gatherer societies despite their prominent discussion in the anthropological literature for more than five decades. The other purpose is to explore how archaeologists can contribute to the study of anthropogenic burning by rethinking some of our protocols in contemporary archaeological research. This latter section is based on recent work by various colleagues in archaeological and related environmental disciplines, as well as our ongoing study of historic and late Holocene hunter-gatherers in central California.

The Challenges of Studying Past Management Practices

Theoretical Issues

There is a long tradition in North American archaeology of viewing hunter-gatherer societies separately from agrarian people who intentionally

manipulated the environment to increase the productivity of specific resources using horticultural or agricultural practices (i.e., the classic forager/farmer dichotomy [Erickson 2006:241–242]). Early anthropologists, such as Alfred Kroeber (1925), drew a distinction between passive foragers, who exclusively collected available resources from the landscape (leaving only footprints), from agrarian groups, who constructed anthropogenic landscapes that were the product of direct manipulation of particular plant resources and vegetative communities. This dichotomous perspective remained a common theme in the writings of some of our most influential anthropologists into the late twentieth century (Ingold 1987:70–73; Wolf 1982:91–92).

However, this long-held view began to unravel in the archaeological literature in the 1980s, when scholars began to rethink the distinctions between hunting/gathering and agrarian societies, recognizing the broad gradient of societies that employed various forms of cultivation—used here in the broad sense to refer to any practices that enhanced the production of natural resources, not just cultigens per se (i.e., resources dependent on human intervention for their reproduction [Ford 1985; Harris 1989]). Bruce Smith's (2001) masterly overview of this subject created a pragmatic framework for placing various hunter-gatherer and agrarian societies along a continuum of food production, showing that many classic hunter-gatherers were part of a broader class of "low-level food producers" who employed various methods of cultivation (weeding, tilling, transplanting, sowing, strategic burning) to tend plants across the broader landscape but for whom the majority of important plant foods were not the products of intensive horticulture.

Employing niche construction theory, some archaeologists are now conceptualizing hunter-gatherer resource enhancement practices within a wider evolutionary framework—one that recognizes how a diverse range of life-forms modify their environments, producing new kinds of selective pressures on succeeding generations of organisms inhabiting those niches (Rowley-Conwy and Layton 2012; Smith 2007, 2011; Zeder 2012). Niche construction theory suggests that TREM activities among hunter-gatherers should not be viewed as anomalous or idiosync-

cratic but, rather, as part of broader evolutionary processes that can have long-term implications for both habitats and associated life-forms. In addition, recent research considering management practices as a broader process of "landscape domestication," in which the cultivation of wild indigenous plants and animals reconfigured the types and distributions of biological communities, is providing a new perspective for rethinking human/environmental interactions among hunter-gatherers (e.g., Balée 2006; Erickson and Balée 2006; Yen 1989).

Scholars are now making important advances in the study of hunter-gatherers and resource enhancement strategies employing archaeological and ecological data sets in such areas as the American Northwest, the Southeast, New England, the Plains, and California (e.g., Boyd 2002; Clark and Royall 1995; Gassaway 2009; Hammett 1991, 1992; Hammett and Lawlor 2004; Lepofsky and Lertzman 2008; Lepofsky et al. 2005a; Lepofsky et al. 2005b; Patterson and Sassaman 1988; Weiser and Lepofsky 2009). Yet there has been little movement to systematically incorporate the study of indigenous landscape management practices into the method and theory of hunter-gatherer research in North American archaeology. This is evident in many of the theoretical approaches employed in the study of hunter-gatherers, such as those deriving from early versions of optimal foraging models (e.g., diet breadth, patch choice, central place foraging), which have been highly influential in archaeological research (Bettinger 1991:83–111; Kelly 1995:73–110). These studies analyze hunter-gatherers as immediate-return foragers who maximize returns based on resource encounter frequency and caloric return rates. They assume that hunter-gatherers made instantaneous decisions about the procurement of resources as they were encountered during foraging activities. In highlighting the immediacy of hunter-gatherer movements, decisions, and foraging practices, these models have tended to preclude archaeologists from addressing research questions about economic activities that involved longer-term planning and delayed returns, such as the management of resource patches through fire or other cultivation methods (see critiques in Erickson 2006:243; Smith 2006:300; Zeder 2012:257–258).

Our purpose is not to criticize optimal foraging models for something they were never intended to analyze. We acknowledge that a new generation of evolutionary ecology models is now being developed to examine delayed-return economies and the transition to agriculture using a variety of concepts (e.g., future discounting, cooperation, proprietary ~~EACH~~ use rights, ideal free distribution, cultural transmission theory [Bettinger 1998, 2006; Kennett et al. 2006; Tucker 2006; Winterhalder and Kennett 2006]). As these models are refined, they should contribute greatly to the study of resource enhancement practices, but they have yet to make a major impact on mainstream hunter-gatherer research.

Another factor that has impeded archaeologists from seriously investigating landscape management practices among hunter-gatherer societies is the perceived link to more intensive agrarian practices. The cultivation methods of hunter-gatherers are often described as examples of “proto-agriculture” or “semi-agriculture” and compared with those of farmers (Anderson 2005:252–253; Bean and Lawton 1976). While not discounting the potential insights that TREM may offer in understanding the rise of agriculture, it is highly problematic to place these economic practices at an intermediary stage on an evolutionary path between hunting-gathering and agriculture (Erickson 2006:241–243; Smith 2001:25; Yen 1989:66–71). This directional evolutionary alignment has hampered archaeologists from analyzing indigenous landscape management as part of the common repertoire of “real” hunter-gatherers. Instead, it has fostered a perspective that these practices are transitional, highly situational, and relatively uncommon and that they should be analyzed as part of the broader process of agricultural adoption.

It is time that archaeologists recognize that landscape management practices may have played an important and enduring role in many North American hunter-gatherer economies. Recent syntheses indicate that many hunter-gatherer societies that maintained resource enhancement practices did so over many centuries or millennia (Diehl and Waters 2006; Lightfoot and Parrish 2009; Rowley-Conwy and Layton 2012; Smith 2006; Wills 1995). Burning, collecting, weeding, tillage,

pruning, seed broadcasting, and other cultivation methods may have been precursors to the development of agriculture in some cases, but in many other situations these methods were strategically incorporated into various hunter-gatherer life-ways to produce stable, long-term economies and social organizations that were distinct from those of agrarian societies.

Some resource enhancement strategies involved the creation of domesticated landscapes designed to enhance the productivity and richness of various suites of plants and animals (e.g., Erickson 2006:243; Yen 1989). These kinds of economies, based on the intentional transformation of a potentially broad range (gradients) of ecological communities across the landscape, differed from those of field agriculturalists who often focused on the production of a few genetically modified cultigens (Erickson 2006:243–244). Rather, in cases of landscape domestication, people typically worked at broader scales to promote the richness, productivity, and predictability of a multitude of plants and animals that could be employed for food, medicines, raw materials, and ceremonial regalia. In maintaining a flexible relationship with local resources, which were not wholly dependent on human intervention for their reproductive success, hunter-gatherers maintained their ability to choose from diverse constellations of resources from season to season and year to year depending on local environmental and social conditions. Shipek (1993:381) also notes that the timing and organization of labor for these kinds of economies may have been more evenly distributed throughout the year, in contrast to the intermittent, concentrated efforts of agrarian people involved in the production of field crops.

Still another factor that has hampered archaeologists from seriously investigating TREM issues is how we conceptualize resource and environmental management. As Fowler and Lepofsky (2011), Lertzman (2009), and others note, *management* can be a loaded term, which in contemporary usage may imply some form of collective control over resources and land to produce some desired future condition. It is true that some hunter-gatherer groups may have initiated collective strategies designed to enhance the overall abundance, diversity, and availability of economic resources on a landscape scale. But many other

niche construction activities may have focused on enhancing particular resources, more localized in scale and less directed toward producing broader ecological outcomes. However, the cumulative effects of many small acts over time may still have produced significant and novel anthropogenic landscape effects, as exemplified by the practice of anthropogenic burning.

People burn their environments for many different reasons. Some burning may be initiated as a form of community-level resource management to create specific kinds of habitats or successional stages (Turner and Peacock 2005:126–127). For example, Lightfoot and Parrish (2009:14–36, 94–122) argue that people may have enhanced the productivity and richness of some California ecosystems by initiating a rotational sequence of small fires, creating and sustaining patchy mosaics of vegetation stands at different stages of succession in a region. Different combinations of herbaceous plants, insects, and animals thrive in the first few years after a grassland or chaparral habitat is burned than in subsequent years (Keeley 2002:310–312; Lewis 1993). Theoretically, within a relatively small territory, a hunter-gatherer community could have created a diverse patchwork of unevenly aged habitats containing different mixes of nuts, seeds, fruits, greens, tubers, birds, and other game. By igniting small patches regularly within a multiyear rotational cycle, hunter-gatherer groups could have reaped the harvests of new-growth vegetation (and the animals attracted to it) from recently burned stands, as well as from plants in mature habitats at later successional stages (e.g., Lightfoot and Parrish 2009:100–105).

Anthropogenic burning may have also been initiated by individuals or smaller kin groups for a variety of other reasons. The proximate purposes of these fires may have been to control insects or pests, to open up pathways, to enhance a patch of specific plants, to hunt game, and so on (e.g., Lewis 1993). In some cases, these small-scale practices may have had minimal impact on the environment. However, depending on the frequency, timing, extent, and placement of fires, the consequences of these sustained acts may have resulted in the indirect production of novel and diverse successional mosaics at a broader scale. For example, Bird et al. (2008) describe how

Aboriginal Australian women burn small patches to enhance the hunting of small, burrowing prey. The intent of these burns is not to enhance plant collecting, the hunting of larger game, or the production of landscape fire mosaics per se. However, depending on the number of women involved and the frequency at which camps were moved, the outcome was the creation of a fine-grained mosaic of habitats with greater biological resource availability than that produced by natural fire regimes alone.

We believe that it behooves archaeologists to employ a more inclusive operating definition of TREM that spans a continuum of resource enhancement activities ranging from highly directed, community-based, landscape-scale practices to less coordinated, individualized, and localized scales of action involving various forms of niche construction (Smith 2007, 2011; Zeder 2012:257–259). In taking this position, we recognize that hunter-gatherer resource management practices may include a diverse range of anthropogenic activities that shaped, modified, and enhanced local environments at various scales and produced many different outcomes, some deliberate and others less directed or even inadvertent.

Methodological Issues

It is one thing to argue that past hunter-gatherers across North America may have employed resource management practices, such as anthropogenic burning (e.g., Stewart 2002). It is still another to demonstrate this using empirical data. Another major factor in why North American archaeologists have been reluctant to address indigenous management practices among hunter-gatherers is the significant challenge that is acknowledged in documenting anthropogenic burning and other resource enhancement methods in archaeological contexts.

This is certainly the case in Australia and the Amazon, where archaeologists have been at the forefront of studying the anthropogenic landscapes created through TREM practices (e.g., Black et al. 2007; Erickson 2006; Jones 1969). Landscape management practices employed by hunter-gatherers are often subtle and not prone to leave smoking guns in the archaeological record. As Bowman (1998:394–395) notes in his discussion of Tasmanian Aborigines, there is no neces-

sary relationship between the level of sophistication in anthropogenic burning skills and the complexity of associated tool kits. In fact, there appears to be little relationship between sophisticated knowledge of fire management and specific kinds of artifacts or technological innovations that will readily distinguish them from other peoples (e.g., Lewis 1991:281–282).

Furthermore, some resource enhancement practices, such as anthropogenic burning, may mimic natural disturbances, often making them difficult to distinguish from natural ecological processes (Lepofsky 2009:162; Lepofsky and Lertzman 2008:138–139; Lepofsky et al. 2005a:219). The study of fire management among hunter-gatherers involves detecting and documenting such subtle shifts in the relative densities of indigenous, economically important plant species and vegetation communities commonly found in the local region. This is in contrast to investigations of agrarian systems, which are marked by the analysis of one or a few domesticated species (sometimes foreign to the region) that can be readily identified in the archaeological record by morphological and/or genetic markers.

Collaborative Eco-Archaeological Research

Despite these formidable challenges, we believe that archaeologists can make significant contributions to the ongoing debate about the magnitude and ecological impact of anthropogenic burning. However, it will require the creation of novel interdisciplinary approaches integrating archaeological research with relevant ecological, historical, and ethnographic sources of information. As Bowman (1998:395) and Lepofsky and Lertzman (2008:130) emphasize, these types of eco-archaeological research programs are still in their infancy. We have spent several years experimenting with one such approach in our study of resource managers in central California. Specifically, we have been investigating the magnitude and frequency of anthropogenic burning in the Año Nuevo State Reserve near Santa Cruz, California (Figure 1). Based on these experiences, as well as those of others attempting to implement similar kinds of projects, we think that these eco-archaeological approaches will be most successful when they partner with tribes, develop coor-

dated programs for integrating archaeological and historical ecological research, and generate testable expectations for evaluating resource management practices using archaeological and ecological data.

Partnerships with Tribal Groups

Our investigation of anthropogenic burning and other resource management strategies has been greatly facilitated by working closely with tribal elders and scholars. In fact, we believe that these kinds of studies may provide one avenue for building the foundations of long-term collaborative research programs with tribal groups, an issue of increasing concern in North American archaeology (e.g., Kerber 2006; Silliman 2008). Descendant communities are often concerned with the state of their local environments and the health of indigenous plant and animal resources that continue to be employed as foods, medicine, and raw materials for making baskets, ceremonial regalia, and other cultural objects. It can be mutually beneficial for tribal groups to establish relationships with archaeologists as part of the study of landscape management practices, which may provide new insights for restoration treatments designed to enhance local biodiversity, habitat vitality, and the availability of traditional resources. Native elders and scholars will be critical partners in eco-archaeological studies by providing information about indigenous management drawn from their own daily activities, their oral histories and traditions, and language related to burning (Bird et al. 2005:449; Deur 2009; Lepofsky et al. 2005a; Mason et al. 2012).

Our research program in central California is being undertaken in close collaboration with members of the Amah Mutsun Tribal Band, who have a keen interest in enhancing the health and vigor of indigenous plants and animals that are still providing sources of traditional food, medicine, basket making, and dance regalia. Recently, the tribe secured an agreement with the California Department of Parks and Recreation (CDPR) designating Quiroste Valley (so named for the site's aboriginal community) as a "State Cultural Preserve" in the Año Nuevo State Reserve. Quiroste Valley, a well-drained valley tucked into the Coast Ranges a few kilometers from the coast, is rich in cultural resources and has been a major

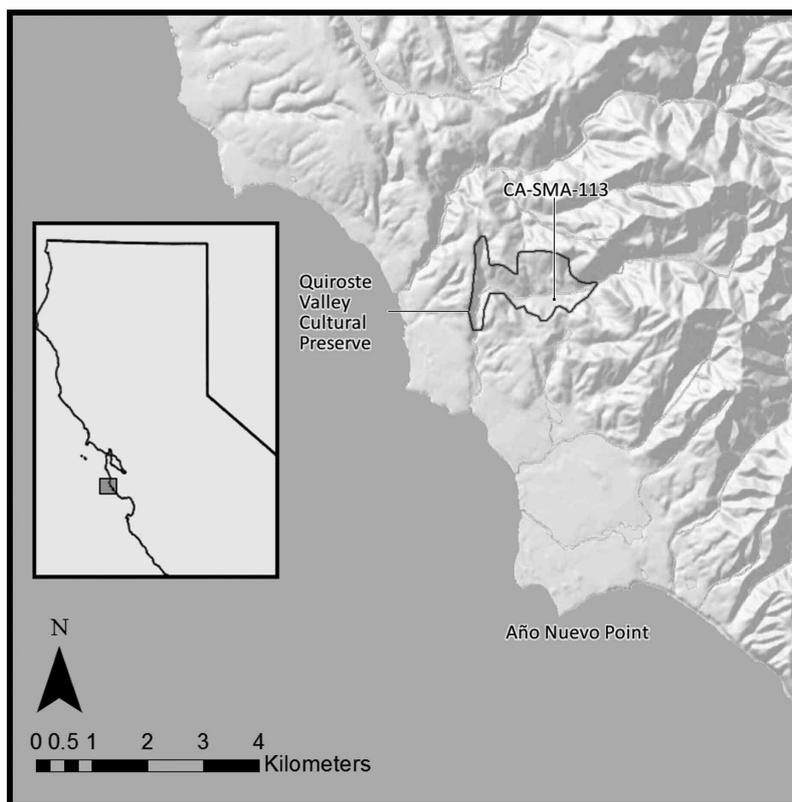


Figure 1. The Quiroste Valley Cultural Preserve study area in Año Nuevo State Reserve, California.

locus of our research (see Figure 1). In designating this area a State Cultural Preserve, CDPR will work collaboratively with the tribe in managing and restoring its floral and faunal communities. Both the tribe and CDPR are interested in melding the best of modern landscape management protocols with those from ancient practices to revive indigenous habitats in an area that is recovering from large-scale industrial logging, cattle ranching, and agriculture throughout much of the latter nineteenth and twentieth centuries.

The Integration of Archaeological and Historical Ecological Research

Another critical component for the study of indigenous resource management is to integrate the archaeological work in local regions with state-of-the-art research in historical ecology. Fire histories may be constructed using a suite of methods: dendroecology that tracks the frequency of fires through time by analyzing fire scars across the ring structures of certain species of trees; sedi-

ment cores from historic wetlands that yield accumulation rates of charcoal as proxies for past fire events, as well as pollen counts and frequencies that provide information on vegetation transformations over time; and analyses of silica phytoliths from modern soils and paleosols that can indicate significant vegetation changes in the past. There is an extensive literature about the efficacy of employing these various methods, as well as their potential constraints in documenting fire histories and ecological changes (Bowman 1998:395–400; Carle 2008:29–31; Clark and Royall 1995; Evett et al. 2007; Hotchkiss et al. 2007; McWethy et al. 2009; Whitlock et al. 2008). Document- and imagery-based historical ecology, using postcolonial spatial and narrative sources, can also provide important and highly detailed insights about local systems' responses to changing land uses and anthropogenic perturbations (Whipple et al. 2011).

In sum, it is best to employ multiple lines of evidence in building fire histories for local regions

and for understanding vegetation changes over time (Bowman 1998:404–405; Lepofsky and Lertzman 2008:139–140; Lepofsky et al. 2005a). Furthermore, in recognizing that fire regimes vary significantly over space and time, investigations of anthropogenic burning must be localized to specific areas and tribal peoples (Bird et al. 2008:14800; Black et al. 2007:478; Hallam 1979:46).

A common criticism of anthropological studies of indigenous burning is that natural ecological processes have not been adequately addressed in accounting for past fire events (Allen 2002; Parker 2002). Fire frequency is influenced by such factors as fuel buildup, fuel moisture, and ignition sources, which under nonanthropogenic conditions are controlled primarily by precipitation, temperature, and lightning (Pyne 1991; van Wagtendonk 2006). Small changes in temperatures over extended durations can have major implications for past fire regimes (Sprugel 1991:12–13). There is growing evidence that extended climatic events involving cooler temperatures (e.g., the Little Ice Age) reduced fire frequencies, while periods of warmer and drier conditions (e.g., the Medieval Climatic Anomaly) increased them (Hotchkiss et al. 2007; Sprugel 1991; Whitlock et al. 2008). Thus, in modeling the relationship of fire regimes, vegetation patterns, and archaeological remains, we must take into account the determining role that climate has played in driving the frequency, spatial extent, severity, and seasons of fires (Black et al. 2007; Hotchkiss et al. 2007; Lepofsky and Lertzman 2008; Lepofsky et al. 2005b; Whitlock et al. 2008).

Our research at Quiroste Valley has also integrated vegetation mapping, geomorphological investigations, and survey work to locate suitable ecological sites for obtaining additional lines of evidence. In our landscape-scale study with the Amah Mutsun, we detected various hunter-gatherer sites, collected wedge samples from nearby redwood stumps for dendroecological analysis, excavated a number of off-site locations to collect phytolith samples, and cored two wetlands (Skylark Pond, Laguna de las Trancas), which we are analyzing to quantify temporal changes in pollen, microscopic charcoal, macroscopic charcoal, and phytolith assemblages. By correlating palynological changes with relative densities of charcoal size fractions that represent fires at local and re-

gional scales, we will use these wetland cores to link vegetation changes to fire regimes from the early Holocene through the historic periods.

Archaeological Expectations

As noted above, it is not expected that the fire management activities of hunter-gatherers would necessarily produce readily identifiable markers in the archaeological record, such as major technological transformations, novel tools, or genetically modified plant remains. Rather, we expect to observe more subtle markers, such as increased evidence for long-term successional-stage vegetation, as well as organizational changes denoting how people were using, occupying, and modifying the local landscape. Below we outline five kinds of expectations about the relationship of fire regimes, vegetation patterns, and archaeological remains that may be useful in investigating past anthropogenic burning using an eco-archaeological approach.

Fire Regimes and Vegetation Patterns. One set of expectations concerns the delineation of what fire regimes and vegetation patterns would have looked like in a local region under nonanthropogenic conditions and under different scenarios of landscape management practices. Cuthrell et al. (2012) suggest that natural fire regimes, in which landscape fires are the result of lightning ignitions, can serve as the null hypothesis for the investigation of anthropogenic burning. Nonanthropogenic fire regimes may be modeled by incorporating data on lightning strike frequency and ignition rate with vegetation succession models (e.g., Syphard et al. 2006). In simulating the frequency rates of natural fires and how local vegetation communities may have responded to these conditions, an expected baseline model for long-term vegetation under nonanthropogenic fire regimes can be generated for a local region. The magnitude of anthropogenic burning and its overall impact on the environment can then be assessed by comparing the observed paleoenvironmental and archaeobotanical findings from the field with the baseline predictions for natural fire regimes. This can be done in several ways; two of these will serve as examples.

First, fire-return intervals from fire-scar dendroecological studies can be compared with the baseline predictions. If the observed fire-return in-

tervals from the ecological investigations are not statistically distinct from those expected for natural fire regimes, then we may conclude that there is little evidence that fire management took place. However, if observed and expected fire-return intervals do differ significantly, then the case for anthropogenic burning may be supported. Second, pollen from sediment cores and archaeobotanical remains from excavated contexts can be compared with the baseline predictions for vegetation patterns. If the observed vegetation patterns from the field studies compare favorably with those expected under natural fire regimes, then this may suggest that minimal anthropogenic burning took place, while deviation in vegetation patterns from baseline predictions would bolster the case for fire management.

One advantage of studying anthropogenic burning on the central coast of California is that natural sources of ignition (lightning strikes) are relatively rare, as the frequency of lightning in the state increases with distance from the Pacific Ocean and elevation (van Wagtenonk and Cayan 2008). In this area, recent fire ecology studies have identified fire regimes in the late Holocene with fire-return intervals at a frequency much greater than that expected from lightning strikes or natural fire occurrences alone (Greenlee and Langenheim 1990; Keeley 2002; Stephens and Fry 2005). In summarizing this literature, Cuthrell et al. (2012) note that nonanthropogenic fire regimes are characterized by fire-return intervals on the order of a century or more. The regional successional pattern for open flatlands and hill-sides is characterized by transitions from grasslands to coastal scrub shrublands and then to either mixed conifer or oak/bay woodlands, with the tempo of succession governed by local environmental conditions (Keeley 2002, 2005; McBride 1974; Williams et al. 1987). Under nonanthropogenic fire conditions, woodland and shrubland communities would thrive in areas such as Quiroste Valley. In contrast, coastal grasslands are disturbance-dependent communities, requiring regular grazing, tillage, or burning to persist. We believe that the historic large-scale grasslands along the central California coast may be the product of indigenous fire management practices characterized by frequent, small, low-intensity anthropogenic burns (Cuthrell et al. 2012; see

Weiser and Lepofsky 2009 for a case example from Washington).

Foodways. The resources harvested by hunter-gatherers for foods, medicines, raw materials, and other needs represent a critical database for the study of management practices. Archaeologists can examine the suite of plants and animals processed, consumed, and deposited at sites to evaluate how they compare with the baseline expectations for resources exploited from habitats supported by nonanthropogenic fire regimes. As with paleoecological data sets, the degree of conformity to the baseline model will suggest whether fire management practices were employed. With the development of sustained burning practices, we expect to observe significant shifts in the type, diversity, and distribution of plant and animal resources used by local groups. Furthermore, we expect more of the vegetative resources utilized to be fire-dependent, fire-adapted, and/or disturbance-dependent species.

In our ongoing archaeological investigations in Quiroste Valley, particularly at CA-SMA-113, we have recovered a rich and dense assemblage of archaeobotanical remains that dates from cal A.D. 1000 to 1700. Significantly, the majority of the plant food resources used at this site were harvested from grassland communities (see Cuthrell et al. 2012). Particularly, grasses (Poaceae), tarweeds (*Madia* spp.), clover (*Trifolium* spp.), composites (Asteraceae), and other forbs form the overwhelming majority of the assemblage, while nut remains are relatively few. The results to date indicate that late Holocene people in Quiroste Valley were focusing on the exploitation of grassland and open woodland resources, consistent with our model expectations for anthropogenic burning.

Regional Settlement Systems. Anthropogenic burning practices, if implemented on a regional scale, would have posed organizational and logistical challenges for hunter-gatherers (Lightfoot et al. 2011). Members of local groups must have been mobile and flexible enough in their movements to facilitate the monitoring and management of varied resource patches across the landscape. However, they must have also been able to coordinate and disperse information about when resource patches needed to be tended and where resources were available for bulk harvesting, as well as overseeing the movement of peo-

ple across the region. Given these considerations, we are exploring whether pyrodiversity economies may have been embedded within logistically organized collector settlement systems on the central coast of California. Semisedentary residential bases represented places where members of local groups could periodically aggregate for communication and planning, undertake communal food gathering and food processing events, store bulk harvested goods, and perform mortuary practices, ceremonies, and feasts. As one component of our fire management model, we envision a regional settlement pattern that would include semisedentary residential bases dispersed across the region from which specialized task groups and family units might tend nearby habitats or bulk collect resources from patches managed through burning. These work parties may have been dispersed across the landscape during some part of the annual cycle, setting up a series of small camps and work spaces in the near and far hinterlands of the residential bases.

Bulk Harvesting. The advent of logistically organized economies that were associated with fire management should also be correlated with increasing evidence for the bulk collection of foods and potentially with innovations in mass harvesting, processing, and storage of food resources. Archaeological signatures of these kinds of innovations might include evidence for game drives (e.g., ambush sites, hunting blinds, etc.), the use of large pit ovens, changes in hunting implements, new developments in ground-stone technology used to process plant resources, evidence for feasting events, increases in the consumption of foods that could be most efficiently harvested in bulk, new and more extensive storage facilities in villages, and the establishment of outlying bulk harvesting camps.

Communal Social Organizations. The advent of some kinds of landscape management practices among hunter-gatherers may be associated with changes in the social organizations of local groups that would have facilitated game drives, aggregations of people for bulk harvesting and processing foods and raw materials, and the sponsorship of more elaborate community gatherings, dances, and feasts. Changes in communal social organizations may be detected in the archaeological record through a careful analysis of the spa-

tial layout of villages, the size and layout of house structures, and the appearance and elaboration of public architecture such as plaza space, dance houses, and storage facilities.

Rethinking Archaeological Practices

We argue that the creation of collaborative, interdisciplinary eco-archaeological programs capable of evaluating landscape management practices among hunter-gatherers will necessitate modifications in our standard procedures for undertaking archaeological research. Below we consider the implications that these kinds of programs will have for undertaking field and laboratory work, for coordinating and analyzing multiple data sets, and for examining hunter-gatherers at the scale of the *longue durée*.

Archaeological Field and Laboratory Methods

Close collaboration with tribes may necessitate some significant modifications in excavation strategies that focus on low-impact procedures, minimizing disturbances to archaeological sites but maximizing information from intact, well-dated features with higher densities of interpretable archaeobotanical and faunal remains. As outlined elsewhere (Lightfoot 2008), this kind of approach involves a greater emphasis on surface and near-surface investigations (geophysical surveys, topographic mapping, and systematic surface collections) specifically designed to delineate site overall structure and distinguish discrete features from midden deposits prior to excavation. In addition, forensic canines can be used to minimize the potential for disturbance of human burials (Lent 2007). The information gained from these techniques can then be employed, in direct consultation with tribal scholars and other members of the research team, to develop excavation strategies that are implemented with greater accuracy.

As part of this excavation strategy, archaeologists may need to modify their sampling strategies for recovering archaeobotanical and small faunal remains. In some areas, wet screening through 6- or 3-mm mesh persists as the only technique used to generate these assemblages, often resulting in impoverished and biased data sets. Cuthrell et al. (2012) advocate a systematic approach to macrobotanical and faunal sampling aimed at con-

structing data sets suitable for statistical analysis. This method involves the collection of multiple and robust flotation samples (i.e., number of identified specimens >300 per sample, often 5–10+ liters of deposit) from each interpretive archaeological context so that measures of central tendency and comparative statistical techniques can be employed to identify meaningful differences in contexts within and between sites. This stands in contrast to the widespread practices of collecting only small, judgmental flotation samples from a site, which results in extreme selection bias, and of collecting only one or a few column samples from an entire site, which precludes characterization of the overall assemblage (Lennstrom and Hastorf 1995).

Coordination of Multiple Data Sets

As outlined above, a critical component of the next generation of hunter-gatherer research is to coordinate within the study area the collection of archaeological and ecological samples, including off-site sediment samples for the extraction of phytoliths, cores from wetlands with intact pollen and charcoal records, and dendroecological samples. Most of these ecological studies tend to be done independently of the archaeological research, so integrating the research design and field and laboratory work of eco-archaeological projects will be a major step forward.

Our experience in implementing this kind of eco-archaeological approach is that it can be a significant challenge to coordinate archaeological research with the collection of fine-grained paleoecological data. The ideal scenario is to synchronize the collection of ecological samples so that they are taken systematically in the nearby hinterland of the archaeological remains of interest. But this presupposes that appropriate sources of paleoecological data will be located near relevant archaeological sites, which is not always the case. Thus, in choosing study areas for undertaking eco-archaeological studies of resource management, we must take into account not only the archaeological potential but also the potential for paleoecological data sets. To do this, we will need to undertake archival research and landscape-scale surveys to assess not only the archaeological possibilities but the presence of nearby wetlands with pollen and charcoal accumulations,

dendroecological samples, and sediment deposits that may contain intact paleosols.

Archaeology of the Longue Durée

Hunter-gatherer studies will need to take place at the scale of the *longue durée*. In constructing records of fire histories, vegetation successions, and climatic change over many millennia, it is ideal to evaluate regional conditions before and after humans first settled an area. In some cases, the initial colonization of an area (especially islands) may be marked by significant changes in fire frequencies and transformations in floral and faunal populations, which are argued to be evidence for significant anthropogenic landscape modifications (Kirch 1996; McWethy et al. 2009). However, in many cases, the evidence may be more muted and ambiguous, particularly where management practices appear to have developed in situ over many centuries. For example, there is some controversy about the patterning and quantity of charcoal accumulation that may be expected when people begin to implement a systematic program of frequent, low-intensity, small burns (Black et al. 2007:478; Hallam 1985:11–12). We believe that the best course of action is to take a diachronic perspective in examining the interrelationship among archaeological remains, past fire events, and ecological and climatic changes over centuries or millennia when these data are available.

In implementing this long-term eco-archaeological approach, the interface between prehistory and history, when indigenous management systems became entangled in colonial regimes, is of particular importance. The archaeology of colonialism should play a significant role in the study of anthropogenic burning. We can examine how landscape management practices were altered and transformed during encounters between indigenous peoples and colonizers and how these changes may have had long-term, cumulative effects among both Native and colonial cultures, fire regimes, and local ecosystems. Were significant declines in the diversity and structural complexity of habitats instigated primarily by the termination of Native burning practices, as some anthropologists have suggested? Or were they due to the implementation of fire cessation policies that no longer allowed nonanthropogenic fire

regimes to continue, as some ecologists and environmental scientists have advocated? Or were they because of other kinds of colonial landscape modifications (e.g., livestock grazing, logging, invasive plants, etc.) or a combination of all these factors (Bowman 1998:399)? Critical evaluations of these questions may provide important data for developing treatment plans for enhancing the diversity, health, and sustainability of modern ecosystems.

Conclusion

Despite many decades of debate in the anthropological literature, archaeologists have been reluctant to address questions about the magnitude and impact of resource management practices among hunter-gatherers in North America. We argue that this reticence stems from multiple factors: a long tradition of viewing hunter-gatherers as passive foragers who made minimal impacts on the environment, a tendency to link those groups with resource enhancement practices with agrarian societies, and a rather rigid definition of resource management. However, a major point of this article is to argue that archaeologists need to be more proactive in considering the possibility that a diverse range of landscape management activities may have been incorporated into the economies of Native American hunter-gatherers. Furthermore, we argue that hunter-gatherer societies that maintained landscape management practices over many centuries may be distinct in many fundamental ways from agrarian people.

This article also addresses another significant reason for the reticence of archaeologists: the difficulties of identifying landscape management practices among hunter-gatherers using archaeological data. We believe that archaeologists can make significant contributions to the ongoing debate about the magnitude and ecological impact of anthropogenic burning but that it will involve the creation of new kinds of collaborative, interdisciplinary eco-archaeological programs. This will require developing closer collaborations with Native American tribes; the coordination of archaeological research in concert with studies of past fire ecology, vegetation patterns, and paleoclimatic conditions; rethinking how excavation work is undertaken, specifically the sampling strategies

employed to recover archaeobotanical and faunal remains; and expanding the spatial and temporal scales of hunter-gatherer studies.

One approach for evaluating the magnitude and impact of anthropogenic burning among past hunter-gatherer groups is to model expected natural fire regimes and associated vegetation patterns given past environmental conditions. These expectations can be employed as a null hypothesis for evaluating the existence of anthropogenic burning. Deviations in the observed fire histories and vegetation patterns from eco-archaeological research may be indications of landscape management practices. If such management practices were being implemented, then we expect changes in fire frequency and plant communities to coincide with changes in the archaeological record. The latter may include dramatic increases in the exploitation of fire-dependent or fire-adapted species, the advent of logistically organized collector settlement practices, evidence of bulk harvesting, and changes in communal social organizations. We believe that some degree of temporal concordance should exist across these different data sets (fire histories, vegetation patterns, and archaeological findings) to generate well-supported interpretations about past landscape management practices.

The time is right for archaeologists to begin to systematically evaluate research issues about hunter-gatherer management practices. Given current concerns with restoration ecology, sustainable economies, and the role that indigenous knowledge can play in contemporary resource management, it is imperative that archaeologists get off the sidelines. In addressing this significant initiative, we propose that archaeologists create innovative eco-archaeological approaches with research objectives relevant not only to other archaeologists but also to tribal entities, government agencies, conservation organizations, and restoration ecologists. Lessons learned from this research may contribute greatly to restoration treatment plans that are being developed for the management of tribal and public lands.

Acknowledgments. We appreciate greatly the help and support from the Amah Mutsun Tribal Band and the California Department of Parks and Recreation in implementing our eco-archaeological research program in central California. We are greatly indebted to the National Science Foundation (BCS-

0912162) and the Gordon and Betty Moore Foundation for their generous support of the field and laboratory research involving hunter-gatherer resource enhancement strategies. We are very grateful for the insightful and constructive reviews of this article by Dana Lepofsky, Torben C. Rick, and other anonymous reviewers for *American Antiquity*. We are most appreciative of the excellent editorial assistance and sage comments provided by Kenneth E. Sassaman and his staff at *American Antiquity*.

References Cited

- Allen, Craig D.
2002 Lots of Lightning and Plenty of People: An Ecological History of Fire in the Upland Southwest. In *Fire, Native Peoples, and the Natural Landscape*, edited by Thomas R. Vale, pp. 143–193. Island Press, Washington, D.C.
- Anderson, M. Kat
2005 *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*. University of California Press, Berkeley.
- Balée, William
2006 The Research Program of Historical Ecology. *Annual Review of Anthropology* 35:75–98.
- Barrett, Stephen W., Thomas Swetnam, and William L. Baker
2005 Indian Fire Use: Deflating the Legend. *Fire Management Today* 65(3):31–34.
- Bean, Lowell J., and Harry Lawton
1976 Some Explanations for the Rise of Cultural Complexity in Native California with Comments on Proto-Agriculture and Agriculture. In *Native Californians: A Theoretical Retrospective*, edited by Lowell J. Bean and Thomas C. Blackburn, pp. 19–48. Ballena Press, Menlo Park.
- Bettinger, Robert L.
1991 *Hunter-Gatherers: Archaeological and Evolutionary Theory*. Plenum Press, New York.
1998 Cultural, Human and Historical Ecology in the Great Basin: Fifty Years of Ideas About Ten Thousand Years of Prehistory. In *Advances in Historical Ecology*, edited by William Balée, pp. 169–189. Columbia University Press, New York.
2006 Agriculture, Archaeology, and Human Behavioral Ecology. In *Behavioral Ecology and the Transition to Agriculture*, edited by Douglas J. Kennett and Bruce Winterhalder, pp. 304–322. University of California Press, Berkeley.
- Bird, Douglas W., Rebecca B. Bird, and Christopher H. Parker
2005 Aboriginal Burning Regimes and Hunting Strategies in Australia's Western Desert. *Human Ecology* 33:443–464.
- Bird, Rebecca B., Douglas W. Bird, Brian F. Codding, Christopher H. Parker, and J. H. Jones
2008 The "Fire Stick Farming" Hypothesis: Australian Aboriginal Foraging Strategies, Biodiversity, and Anthropogenic Fire Mosaics. *Proceedings of the National Academy of Science* 105:14796–14801.
- Black, Manu P., Scott D. Mooney, and Simon G. Haberle
2007 The Fire, Human and Climate Nexus in the Sydney Basin, Eastern Australia. *The Holocene* 17:469–480.
- Blackburn, Thomas C., and M. Kat Anderson (editors)
1993 *Before the Wilderness: Environmental Management by Native Californians*. Ballena Press, Menlo Park.
- Bowman, David M.
1998 The Impact of Aboriginal Landscape Burning on the Australian Biota. *New Phytologist* 140:385–410.
- Boyd, Matthew
2002 Identification of Anthropogenic Burning in the Paleoeological Record of the Northern Prairies: A New Approach. *Annals of the Association of American Geographers* 92:471–487.
- Boyd, Robert T. (editor)
1999 *Indian, Fire, and the Land*. Oregon State University Press, Corvallis.
- Carle, David
2008 *Introduction to Fire in California*. University of California Press, Berkeley.
- Clark, James C., and P. Daniel Royall
1995 Transformation of a Northern Hardwood Forest by Aboriginal (Iroquois) Fire: Charcoal Evidence from Crawford Lake, Ontario, Canada. *The Holocene* 5:1–9.
- Clewell, Andre, and James Aronson
2007 *Ecological Restoration: Principles, Values, and Structure of an Emerging Profession*. Island Press, Washington, D.C.
- Cuthrell, Rob Q., Chuck Striplen, Mark G. Hylkema, and Kent G. Lightfoot
2012 A Land of Fire: Anthropogenic Burning on the Central Coast of California. In *Contemporary Issues in California Archaeology*, edited by Terry L. Jones and Jennifer E. Perry, pp. 153–172. Left Coast Press, Walnut Creek.
- Deur, Douglas
2009 "A Caretaker Responsibility": Revisiting Klamath and Modoc Traditions of Plant Community Management. *Journal of Ethnobiology* 29:296–322.
- Deur, Douglas, and Nancy J. Turner
2005 Introduction: Reassessing Indigenous Resource Management, Reassessing the History of an Idea. In *Keeping It Living: Traditions of Plant Use and Cultivation on the Northwest Coast of North America*, edited by Douglas Deur and Nancy J. Turner, pp. 3–34. University of Washington Press, Seattle.
- Diehl, Michael W., and Jennifer A. Waters
2006 Aspects of Optimization and Risk During the Early Agricultural Period in Southeastern Arizona. In *Behavioral Ecology and the Transition to Agriculture*, edited by Douglas J. Kennett and Bruce Winterhalder, pp. 63–86. University of California Press, Berkeley.
- Egan, Dave, and Evelyn A. Howell
2001 Introduction. In *The Historical Ecology Handbook: A Restorationist's Guide to Reference Ecosystems*, edited by Dave Egan and Evelyn A. Howell, pp. 1–23. Island Press, Washington, D.C.
- Erickson, Clark L.
2006 The Domesticated Landscapes of the Bolivian Amazon. In *Time and Complexity in Historical Ecology: Studies in the Neotropical Lowlands*, edited by William Balée and Clark L. Erickson, pp. 235–278. Columbia University Press, New York.
- Erickson, Clark L., and William Balée
2006 The Historical Ecology of a Complex Landscape in Bolivia. In *Time and Complexity in Historical Ecology: Studies in the Neotropical Lowlands*, edited by William Balée and Clark L. Erickson, pp. 187–233. Columbia University Press, New York.
- Evelt, Rand R., Ernesto Franco-Vizcaino, and Scott L. Stephens
2007 Phytolith Evidence for the Absence of a Prehistoric Grass Understory in a Jeffrey Pine–Mixed Conifer Forest in the Sierra San Pedro Martir, Mexico. *Canadian Journal of Forestry Research* 37:306–317.
- Ford, Richard I.
1985 The Processes of Plant Food Production in Prehistoric

- North America. In *Prehistoric Food Production in North America*, edited by Richard I. Ford, pp. 1–18. Anthropological Papers No. 75. Museum of Anthropology, University of Michigan, Ann Arbor.
- Fowler, Catherine S., Pauline Esteves, Grace Goad, Bill Helmer, and Ken Watterson
2003 Caring for the Trees: Restoring Timbisha Shoshone Land Management Practices in Death Valley National Park. *Ecological Restoration* 21:302–306.
- Fowler, Catherine S., and Dana Lepofsky
2011 Traditional Resource and Environmental Management. In *Ethnobiology*, edited by E. N. Anderson, Deborah Pearsall, Eugene Hunn, and Nancy Turner, pp. 285–304. Wiley-Blackwell, New York.
- Gassaway, Linn
2009 Native American Fire Patterns in Yosemite Valley: Archaeology, Dendrochronology, Subsistence, and Culture Change in the Sierra Nevada. *Society for California Archaeology Proceedings* 22:1–19.
- Greenlee, Jason M., and Jean H. Langenheim
1990 Historic Fire Regimes and Their Relation to Vegetation Patterns in the Monterey Bay Area of California. *American Midland Naturalist* 124:239–253.
- Hallam, Sylvia J.
1979 *Fire and Hearth: A Study of Aboriginal Usage and European Usurpation in South-Western Australia*. Australian Institute of Aboriginal Studies, New Series No. 13. Canberra.
1985 The History of Aboriginal Firing. In *Fire Ecology and Management in Western Australian Ecosystems*, edited by J. R. Ford, pp. 7–20. WAIT Environmental Studies Group Report No. 14. Western Australian Institute of Technology, Perth.
- Hammett, Julia E.
1991 Ecology of Sedentary Societies Without Agriculture: Paleoethnobotanical Indicators from Native California. Unpublished Ph.D. dissertation, Department of Anthropology, University of North Carolina, Chapel Hill.
1992 The Shapes of Adaptation: Historical Ecology of Anthropogenic Landscapes in the Southeastern United States. *Landscape Ecology* 7:121–131.
- Hammett, Julia E., and Elizabeth J. Lawlor
2004 Paleoethnobotany in California. In *People and Plants in Ancient Western North America*, edited by Paul E. Minnis, pp. 278–366. Smithsonian Books, Washington, D.C.
- Harris, David R.
1989 An Evolutionary Continuum of People–Planting Interactions. In *Foraging and Farming: The Evolution of Plant Exploitation*, edited by David R. Harris and G. C. Hillman, pp. 11–26. Unwin Hyman, Boston.
- Hotchkiss, Sara C., Randy Calcote, and Elizabeth A. Lynch
2007 Response of Vegetation and Fire to Little Ice Age Climate Change: Regional Continuity and Landscape Heterogeneity. *Landscape Ecology* 22:25–41.
- Hunn, Eugene S., Darryll R. Johnson, Priscilla N. Russell, and Thomas F. Thronton
2003 Huna Tlingit Traditional Environmental Knowledge, Conservation, and the Management of a “Wilderness” Park. *Current Anthropology* 44(Suppl.):S79–S103.
- Ingold, Tim
1987 *The Appropriation of Nature: Essays on Human Ecology and Social Relations*. University of Iowa Press, Iowa City.
- Jones, Rhys
1969 Fire-Stick Farming. *Australian Natural History* 16:224–228.
- Keeley, Jon E.
2002 Native American Impacts on Fire Regimes of the California Coastal Ranges. *Journal of Biogeography* 29:303–320.
2005 Fire History of the San Francisco East Bay Region and Implications for Landscape Patterns. *International Journal of Wildland Fire* 14:285–296.
- Kelly, Robert L.
1995 *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways*. Smithsonian Institution Press, Washington, D.C.
- Kennett, Douglas J., Atholl Anderson, and Bruce Winterhalder
2006 The Ideal Free Distribution, Food Production and Colonization of Oceania. In *Behavioral Ecology and the Transition to Agriculture*, edited by Douglas J. Kennett and Bruce Winterhalder, pp. 265–288. University of California Press, Berkeley.
- Kerber, Jordan E. (editor)
2006 *Cross-Cultural Collaboration: Native Peoples and Archaeology in the Northeastern United States*. University of Nebraska Press, Lincoln.
- Kirch, Patrick V.
1996 Late Holocene Human-Induced Modifications to a Central Polynesian Island Ecosystem. *Proceedings of the National Academy of Science* 93:5296–5300.
- Kroeber, Alfred L.
1925 *Handbook of the Indians of California*. Bulletin 78, Bureau of American Ethnology, Smithsonian Institution. U.S. Government Printing Office, Washington, D.C.
- Lennstrom, Heidi A., and Christine A. Hastorf
1995 Interpretation in Context: Sampling and Analysis in Paleoethnobotany. *American Antiquity* 60:701–721.
- Lent, Susan
2007 Forensic Dogs Help Preserve Native American Burial Ground. *California Transportation Journal* 3(2):16–17.
- Lepofsky, Dana
2009 The Past, Present and Future of Traditional Resource and Environmental Management. *Journal of Ethnobiology* 29:161–166.
- Lepofsky, Dana, Douglas Hallett, Ken Lertzman, Rolf Mathewes, Albert McHalsie, and Kevin Washburn
2005a Documenting Precontact Plant Management on the Northwest Coast: An Example of Prescribed Burning in the Central and Upper Fraser Valley, British Columbia. In *Keeping It Living: Traditions of Plant Use and Cultivation on the Northwest Coast of North America*, edited by Douglas Deur and Nancy J. Turner, pp. 218–239. University of Washington Press, Seattle.
- Lepofsky, Dana, and Ken Lertzman
2008 Documenting Ancient Plant Management in the Northwest of North America. *Botany* 86:129–145.
- Lepofsky, Dana, Ken Lertzman, Douglas Hallett, and Rolf Mathewes
2005b Climate Change and Culture Change on the Southern Coast of British Columbia 2400–1200 cal. B.P.: An Hypothesis. *American Antiquity* 70:267–294.
- Lertzman, Ken
2009 The Paradigm of Management, Management Systems, and Resource Stewardship. *Journal of Ethnobiology* 29:339–355.
- Lewis, Henry T.
1991 Technological Complexity, Ecological Diversity, and Fire Regimes in Northern Australia: Hunter-Gatherer, Cowboy, Ranger. In *Profiles in Cultural Evolution*, edited by A. Terry Rambo and Kathleen Gillogly, pp. 261–288. Anthropological Papers No. 85. Museum of Anthropology, University of Michigan, Ann Arbor.

- 1993 Patterns of Indian Burning in California: Ecology and Ethnohistory. In *Before the Wilderness: Environmental Management by Native Californians*, edited by Thomas C. Blackburn and M. Kat Anderson, pp. 55–116. Ballena Press, Menlo Park.
- Lightfoot, Kent G.
2008 Collaborative Research Programs: Implications for the Practice of North American Archaeology. In *Collaborating at the Trowel's Edge: Teaching and Learning in Indigenous Archaeology*, edited by Stephen W. Silliman, pp. 211–227. University of Arizona Press, Tucson.
- Lightfoot, Kent G., Edward M. Luby, and Lisa Pesnichak
2011 Evolutionary Typologies and Hunter-Gatherer Research: Rethinking the Mounded Landscapes of Central California. In *Hunter-Gatherer Archaeology as Historical Process*, edited by Kenneth E. Sassaman and Donald H. Holly, pp. 55–78. University of Arizona, Tucson.
- Lightfoot, Kent G., and Otis Parrish
2009 *California Indians and Their Environment: An Introduction*. University of California Press, Berkeley.
- Mason, Larry, Germaine White, Gary Morishima, Ernesto Alvarado, Louise Andrew, Fred Clark, Mike Durglo, Sr., Jim Durglo, John Eneas, Jim Erickson, Margaret Friedlander, Kathy Hamel, Colin Hardy, Tony Harwood, Faline Haven, Everett Isaac, Laurel James, Robert Kenning, Adrian Leighton, Pat Pierre, Carol Raish, Bodie Shaw, Steven Smallsalmon, Vernon Stearns, Howard Teasley, Matt Weingart, and Spus Wilder
2012 Listening and Learning from Traditional Knowledge and Western Science: A Dialogue on Contemporary Challenges of Forest Health and Wildfire. *Journal of Forestry* 110:187–193.
- McBride, Joe R.
1974 Plant Succession in the Berkeley Hills, California. *Madrono* 22:317–380.
- McWethy, David B., Cathy Whitlock, Janet M. Wilmshurst, Matt S. McGlone, and Xun Li
2009 Rapid Deforestation of South Island, New Zealand, by Early Polynesian Fires. *The Holocene* 19:883–897.
- Nadasdy, Paul
1999 The Politics of TEK: Power and the “Integration” of Knowledge. *Arctic Anthropology* 36(1–2):1–18.
- Parker, Albert J.
2002 Fire in Sierra Nevada Forests: Evaluating the Ecological Impact of Burning by Native Americans. In *Fire, Native Peoples, and the Natural Landscape*, edited by Thomas R. Vale, pp. 233–267. Island Press, Washington, D.C.
- Patterson, William A., and Kenneth E. Sassaman
1988 Indian Fires in the Prehistory of New England. In *Holocene Human Ecology in Northeastern North America*, edited by George P. Nichols, pp. 107–135. Plenum, New York.
- Peacock, Sandra L., and Nancy J. Turner
2000 “Just Like a Garden”: Traditional Resource Management and Biodiversity Conservation on the Interior Plateau of British Columbia. In *Biodiversity of Native America*, edited by Paul E. Minnis and Wayne J. Elisens, pp. 133–179. University of Oklahoma Press, Norman.
- Pyne, Stephen J.
1991 *Burning Bush: A Fire History of Australia*. Henry Holt, New York.
- Rowley-Conwy, Peter, and Robert Layton
2012 Foraging and Farming as Niche Construction: Stable and Unstable Adaptations. *Philosophical Transactions of the Royal Society B (Biological Sciences)* 366:849–862.
- Shipek, Florence C.
1993 Kumeyaay Plant Husbandry: Fire, Water, and Erosion Management Systems. In *Before the Wilderness: Environmental Management by Native Californians*, edited by Thomas C. Blackburn and M. Kat Anderson, pp. 379–388. Ballena Press, Menlo Park.
- Silliman, Stephen W. (editor)
2008 *Collaborating at the Trowel's Edge: Teaching and Learning in Indigenous Archaeology*. University of Arizona Press, Tucson.
- Smith, Bruce D.
2001 Low-Level Food Production. *Journal of Archaeological Research* 9:1–43.
- 2006 Human Behavioral Ecology and the Transition to Food Production. In *Behavioral Ecology and the Transition to Agriculture*, edited by D. J. Kennett and B. Winterhalder, pp. 289–303. University of California Press, Berkeley.
- 2007 Niche Construction and the Behavioral Context of Plant and Animal Domestication. *Evolutionary Anthropology* 16:188–199.
- 2011 General Patterns of Niche Construction and the Management of “Wild” Plant and Animal Resources by Small-Scale Pre-Industrial Societies. *Philosophical Transactions of the Royal Society B (Biological Sciences)* 366:836–848.
- Society for Ecological Restoration
2004 *The SER International Primer on Ecological Restoration*. Society for Ecological Restoration International, Tucson.
- Sprugel, Douglas G.
1991 Disturbance, Equilibrium, and Environmental Variability: What Is “Natural” Vegetation in a Changing Environment? *Biological Conservation* 58:1–18.
- Stephens, Scott L., and Danny L. Fry
2005 Fire History in Coast Redwood Stands in the Northeastern Santa Cruz Mountains, California. *Fire Ecology* 1(1):2–19.
- Stewart, Omer C.
2002 *Forgotten Fires: Native Americans and the Transient Wilderness*. Edited with an introduction by Henry T. Lewis and M. Kat Anderson. University of Oklahoma Press, Norman.
- Syphard, Alexandra, Janet Franklin, and Jon Keeley
2006 Simulating the Effects of Frequent Fire on Southern California Coastal Shrublands. *Ecological Applications* 16:1744–1756.
- Timbrook, Jan, John R. Johnson, and David D. Earle
1993 Vegetation Burning by the Chumash. In *Before the Wilderness: Environmental Management by Native Californians*, edited by Thomas C. Blackburn and M. Kat Anderson, pp. 117–149. Ballena Press, Menlo Park.
- Tucker, Bram
2006 A Future Discounting Explanation for the Persistence of a Mixed Foraging–Horticulture Strategy Among the Mikea of Madagascar. In *Behavioral Ecology and the Transition to Agriculture*, edited by Douglas J. Kennett and Bruce Winterhalder, pp. 22–40. University of California Press, Berkeley.
- Turner, Nancy J., and Sandra L. Peacock
2005 Solving the Perennial Paradox: Ethnobotanical Evidence for Plant Resource Management on the Northwest Coast. In *Keeping It Living: Traditions of Plant Use and Cultivation on the Northwest Coast of North America*, edited by Douglas Deur and Nancy J. Turner, pp. 101–150. University of Washington Press, Seattle.
- Vale, Thomas R.
1998 The Myth of the Humanized Landscape: An Example from Yosemite National Park. *Natural Areas Journal* 18:231–236.

- 2002 The Pre-European Landscape of the United States: Pristine or Humanized? In *Fire, Native Peoples, and the Natural Landscape*, edited by Thomas R. Vale, pp. 1–39. Island Press, Washington, D.C.
- van Wagtenonk, Jan W.
 2006 Fire as a Physical Process. In *Fires in California's Ecosystems*, edited by Neil G. Sugihara, Jan W. van Wagtenonk, Kevin E. Shaffer, Joann Fites-Kaufman, and Andrea E. Thode, pp. 38–57. University of California Press, Berkeley.
- van Wagtenonk, Jan W., and Daniel R. Cayan
 2008 Temporal and Spatial Distribution of Lightning Strikes in California in Relation to Large-Scale Weather Patterns. *Fire Ecology* 4(1):34–56.
- Weiser, Andrea, and Dana Lepofsky
 2009 Ancient Land Use and Management of Ebey's Prairie, Whidbey Island, Washington. *Journal of Ethnobiology* 29:184–212.
- Whipple, Alison, Robin M. Grossinger, and Frank W. Davis
 2011 Shifting Baselines in a California Oak Savanna: Nineteenth Century Data to Inform Restoration Scenarios. *Restoration Ecology* 19:88–101.
- Whitlock, Cathy, Jennifer Marlon, Christy Briles, Andrea Brunelle, Coin Long, and Patrick Bartlein
 2008 Long-Term Relations Among Fire, Fuel, and Climate in the North-Western US Based on Lake-Sediment Studies. *International Journal of Wildland Fire* 17:72–83.
- Williams, Kimberly, Richard J. Hobbs, and Steven P. Hamburg
 1987 Invasion of an Annual Grassland in Northern California by *Baccharis pilularis* ssp. *consanguinea*. *Oecologia* 72:461–465.
- Wills, Wirt H.
 1995 Archaic Foraging and the Beginning of Food Production in the American Southwest. In *Last Hunters—First Farmers: New Perspectives on the Prehistoric Transition to Agriculture*, edited by T. Douglas Price and Anne B. Gebauer, pp. 215–242. School of American Research Press, Santa Fe, New Mexico.
- Winterhalder, Bruce, and Douglas J. Kennett
 2006 Behavioral Ecology and the Transition from Hunting and Gathering to Agriculture. In *Behavioral Ecology and the Transition to Agriculture*, edited by Douglas J. Kennett and Bruce Winterhalder, pp. 1–21. University of California Press, Berkeley.
- Wolf, Eric
 1982 *Europe and the People Without History*. University of California Press, Berkeley.
- Yen, Douglas E.
 1989 The Domestication of Environment. In *Foraging and Farming: The Evolution of Plant Exploitation*, edited by David R. Harris and Gordon C. Hillman, pp. 55–75. Unwin Hyman, Boston.
- Zeder, Melinda A.
 2012 The Broad Spectrum Revolution at 40: Resource Diversity, Intensification, and an Alternative to Optimal Foraging Explanations. *Journal of Anthropological Archaeology* 31:241–264.

Note

1. Some may question whether we should categorize such groups with diverse cultivation techniques as hunter-gatherers anymore; yet the concept still serves a heuristic purpose in delineating those people who minimized their reliance on formal domesticates (i.e., foods entirely dependent on humans for their propagation and survival).

Submitted March 26, 2012; Revised June 18, 2012;

Accepted September 26, 2012.