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CHAPTER 8

PRE-EUROPEAN FIRE IN CALIFORNIA CHAPARRAL

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The vegetation of California offers richness in both structure and composition, but no type is more intimately tied to fire than chaparral. This relationship lends import to assertions that the burning activities of native peoples influenced the chaparral. However, several lines of evidence suggest that human impacts were marginal: ethnographic records are ambiguous; natural factors of lightning and vegetation flammability seem adequate to account for the known fire record; stratigraphic data suggest no change in fire history through the time period of initial European contact; and the richness of species composition implies spatial differences in fire return times, a pattern more consistent with varying environmental conditions that influence natural burning than regular human controls on ignitions. After a brief introduction, each of these four major points will be discussed in detail.

Fire and Chaparral

California's chaparral is notable both for its flammability and for the adaptations of its component species to recurring fire. As with other sclerophyllous shrublands found in the Mediterranean-climate regions of the world, both the composition of the vegetation community and the characteristics of the individual species are known to be intimately related to fire (Keeley 1987, 1991; Keeley and Keeley 1988; Moreno and Oechel 1991).

Given the linkages between chaparral and fire, any suggestion that the pre-European fire regime was controlled by people implies by extension that the chaparral was (and is) actually something of a human artifact. Such an argument has been made explicitly by anthropologist Henry Lewis:

> The strategy of fall and spring burnings involved a quite different kind of "management" of the chaparral areas by both the intensification and a dramatic shift from the seasonality of natural fires. This idea implies, of course, that the Indians played a fundamental role, not only in the maintenance of the chaparral belt, but that they were probably active in the very evolution of California's chaparral. (1973:59)

Others have responded with skepticism, asserting that the fire adaptations of chaparral are better explained by a natural fire regime:

> There is no compelling evidence that the use of fire by Indians or any other primitive man had any effect in developing the adaptations to fire exhibited by the vegetation in California. . . . [F]ires due to natural causes—chiefly lightning—which have occurred since remote geologic time, have been a significant force in determining the characteristics and adaptations of our California chaparral. (Burcham 1974:117–118)

This chapter explores the possibility that native Californians actively altered the chaparral, managing it through their use of fire. Such exploration requires consideration of several interlocking questions: How common was anthropogenic ignition? How did anthropogenic ignition differ from natural ignition (i.e., lightning)? To what degree was the frequency and extent of fire determined by ignition, as opposed to fuel load and weather conditions? How important was fire in determining species composition and characteristics? And for each of these aspects, how much spatial variability was there within the overall area dominated by chaparral?

These questions are complicated somewhat by variance among scholars regarding the delineation of the area involved. California chaparral grows on steep terrain between sea level and 2,000 meters. It is common in the Coast and Transverse Ranges and in the western foothills of the Sierra Nevada. Chaparral's common occurrence in a mosaic with other vegetation types (Keeley and Keeley 1988) complicates the already complex task of delineating vegetation boundaries (Küchler 1973). The distribution shown in Figure 8.1 is conservative; it is based on Küchler

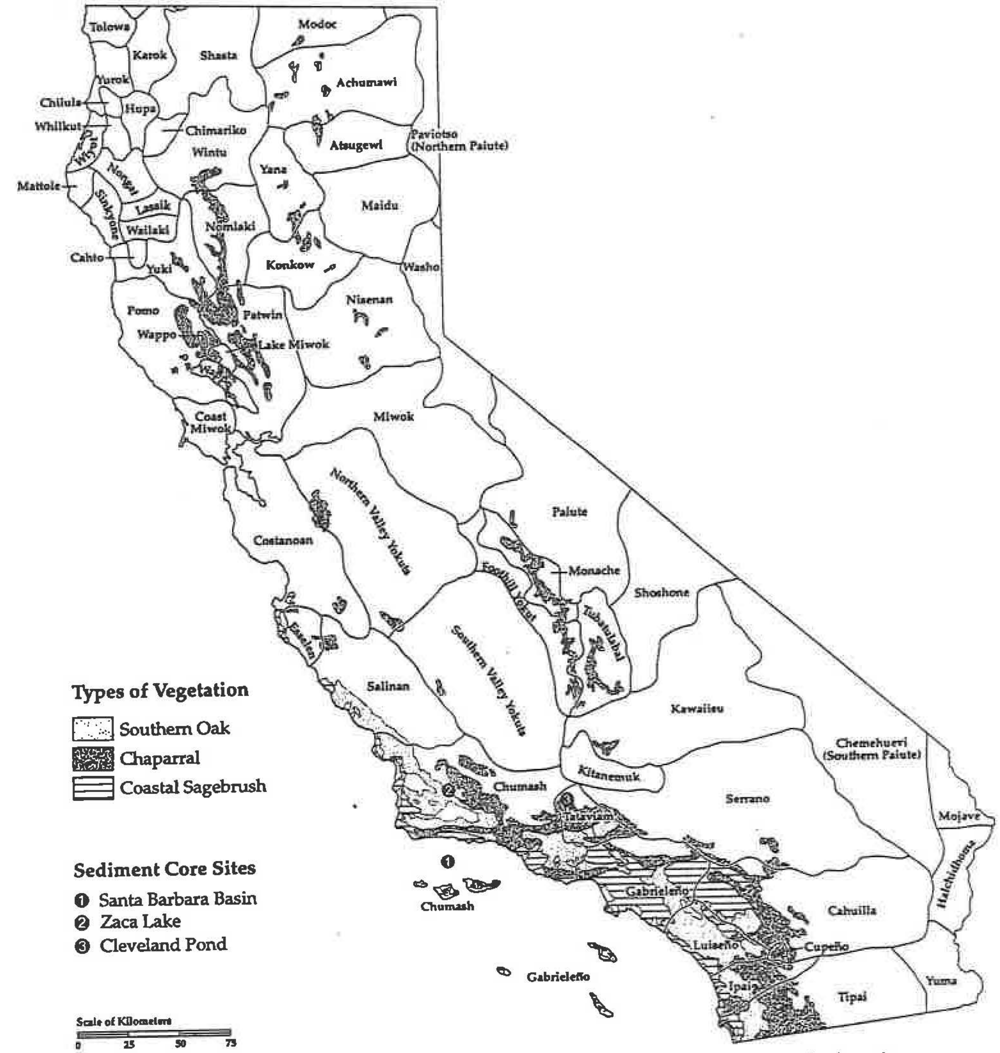

Figure 8.1. Cultural boundaries, vegetation distribution, and core sites (cultural and vegetation boundaries are from Donley et al. 1979:8, 147; sediment core locations are from Mensing 1993:31).

(1977), but covers a lesser area than the map illustrating Hanes's (1977) chapter on chaparral within that same volume. Lewis (1973) showed chaparral covering a still more expansive area, broadening the fringe around the Sacramento Valley and encompassing much of Southern California, including virtually all what Küchler (1977) mapped as coastal sagebrush and southern oak forest. Because these maps simply reflect varying degrees of cartographic generalization, none is inherently more "correct" than the others; therefore, Figure 8.1 is presented as a general guide rather than an definitive source.

Burning by Native Californians

The idea that Native Californians altered the chaparral through their use of fire is scarcely a new one. A half century ago, anthropologist Omer Stewart (1951) declared that the cessation of such burning had led to the substantial expansion of chaparral and cited Storer (1932) in support of this claim. Storer had, in fact, written about reduced burning, but in reference to fire suppression, with no mention of native burning. Because much of Stewart's article generalized about North America, it is unclear which purposes he felt were served by fire in the chaparral, although he did make reference to fire used as a tool of warfare in California and to fire as a protection from snakes for "barefoot California Indians" (Stewart 1951:320). Geographer Homer Aschmann (1959) also saw anthropogenic fire as a land-management tool with significant ecological impacts: "Above all, the Indians would burn the landscape to promote the growth of desired grasses and herbs. . . . Did it cause the degradation of a complex chaparral to the less useful chamise or coastal sage association or did it expand the oak-grassland parks?" (1959:48).

Henry Lewis and the Case for Anthropogenic Fire in Northern California

Whereas Stewart and Aschmann had made largely undocumented assertions, Lewis (1973) provided a coherent compilation of ethnohistorical evidence for native Californian burning in the northern and central parts of the state. This evidence was drawn from published records of interviews with native informants in the early twentieth century. The informants were discussing ancestral practices presumed to have been common before European and Euro-American contact. It is worth reviewing Lewis's contribution in some detail, because he provided the first data-based argument for extensive anthropogenic fire, because he inspired much of the interest and research on the topic (Blackburn and Anderson 1993), and because in the ensuing decades his work has been cited as authoritative on the topic (e.g., Aschmann 1977; Baumhoff 1978; Shipek 1989; Pyne et al. 1996).

Lewis (1973) began his description of the evidence for anthropogenic fire in the chaparral with extensive quotes from Harrington's (1932) Karok informant, who said her people used to "burn up the brush at various places, so that some good things will grow up" (Harrington 1932:63). She went on to make contradictory statements (as Lewis noted) about the timing of the fires:

> It is summer when they set fire to the brush, at the time when everything is dry, that is the time that is good to set fire, in the fall before it starts to rain. . . . they burn it any time in the summer. (Harrington 1932:64–65)

Was this informant actually discussing chaparral? Although Lewis's (1973) own map shows a substantial area of chaparral within the Karok territory, Küchler mapped no chaparral there (Figure 8.1); Baumhoff (1963), whom Lewis cites elsewhere as a source for similar information, lists less than 1.5 percent (15.1 square miles) of Karok area as chaparral. As Lewis himself noted, the "good things" growing after fire were more characteristic of coniferous forests than chaparral; they were "huckleberry bushes . . . hazel bushes . . . and the bear lilies" (Lewis 1973:51). None of the huckleberry species listed in Hickman (1993) is described as growing in chaparral. Hazel, presumably *Corylus cornuta*, used by the Karok for basket-making (Bright 1978; Anderson 1999) grows in many habitats (Hickman 1993), although in treatments of California vegetation it appears in descriptions of evergreen forest understory (Griffin 1977a; Franklin 1988) and is absent from those of chaparral (Hanes 1977; Keeley and Keeley 1988). Lewis took "bear lily" to be a reference to *Xerophyllum tenax*, another species that he noted was associated with coniferous forests. This same informant also mentioned tanbark oak and manzanita. Lewis described the former (*Lithocarpus densiflorus*) as being "effectively on the border" (1973:53) between chaparral and Douglas fir/redwood forests, but again it is generally described as occurring in various forest types (Barbour 1988; Franklin 1988), and not in chaparral (Keeley and Keeley, 1988). Many manzanita species, on the other hand, are indisputably characteristic of chaparral. Given the limited extent of chaparral in Karok territory and that most of the plants mentioned were actually atypical of chaparral, it is puzzling that Lewis used these quotes to establish chaparral burning.

The next native group discussed by Lewis were the Pomo, for whose customs he referenced Stewart (1943) and Kniffen (1939). According to Lewis, "In discussing both redwood forest and chaparral areas of the northern Pomo, Stewart notes that 'the brush was burned at intervals, making hunting much easier than at present'" (Lewis 1973:53–54). But if one reads Stewart's statement in its entirety, one gets a different impression:

> The plants in the redwood forests yielded tan-oak acorns, iris fiber, and berries; the forest was also hunting territory.

> The brush was burned at intervals, making hunting much easier that [sic] at present. Redwood bark was used for houses. (Stewart 1943:34)

The entire paragraph seems to refer to redwood forest, and the clearing of brush within that forest. Nor is there mention of chaparral in the preceding or following paragraphs, suggesting that the reference to burning was more far-reaching. This pattern holds true for the remaining references to Pomo fire in Stewart's (1943) monograph: "In Latcupda the clearings in the forests were kept free of brush by annual burning" (48) and "The usual openings in the trees, kept free from brush by burning, furnished them bulbs and grass seeds" (51). These statements all seem more consistent with firing of forest understory than of chaparral.

The applicability of Kniffen's statements about Pomo burning to the chaparral is also equivocal. In his statements (which Lewis quoted extensively) about Redwood Valley in the Russian River watershed, he described chaparral as occupying middle to high elevations:

> An association of live oak, black oak, and Oregon oak graded with altitude into a chaparral composed mainly of scrub oak, manzanita, buckbrush, and chamise, with frequent additions of madroña, Christmas berry, and the like. (Kniffen 1939:373)

But his reference to burning seems to describe lower elevation:

> Acorn gathering lasted until late November. That the gathering might be easier, all the dry weeds and brush were annually burned after the seed gathering was over, so that there remained no underbrush in the *valley or on the lower hillsides.* (Kniffen 1939:378; italics added)

Although Lewis concluded that "the pattern of autumn burning in the chaparral areas was clearly stated" (1973:57), comparison of these statements suggests that fires were set in the oaks, below the chaparral. Indeed, the chaparral of the hillside was valued as well, making it unlikely that the Pomo would deliberately extend fire up to elevations where it would destroy a significant food resource: "The first of the important crops was the manzanita berry. . . . [T]he manzanitas of the hillsides, so conspicuous in the chaparral, were communal property" (Kniffen 1939:378).

Similar questions arise for the Yurok and Tolowa, who, like the Karok, had equivocal contact with chaparral. Baumhoff (1963) classified more than 6 percent of the territory for each group (45.4 and 60.5 square miles, respectively) as chaparral, but Küchler (1977) mapped the same area as a mosaic of forest types, with no chaparral. Lewis (1973) quoted sources to the effect that both groups set fires to facilitate hunting and that the Tolowa specifically burned brush to keep clearings open in which grass would thrive, attracting deer. Lewis acknowledged that it was unclear whether either instance referred to chaparral, but thought it a reasonable assumption, since clearings in chaparral were known to be primary game areas. There appears to be no means of either proving or disproving these assumptions.

In the Sierran foothills, the Nisenan did clearly occupy an area inclusive of chaparral. Beals (1933) emphasized the importance of fall fire drives through brush in deer hunting, and Lewis's assumption that this was chaparral is not unreasonable. Beals also described fire use in preparation for tobacco planting: "Burn ground clear in winter, scatter seeds in ashes in spring" (1933:356). Lewis assumed that for burning to have been done in winter it must have been "Below the snowline and probably within the chaparral belt" (1973:56). But the existence of such a "belt" is questionable: most of this area is actually ponderosa pine forest and blue oak foothill pine forest, albeit with an understory inclusive of chaparral species and areas of interspersed chaparral (Küchler 1977). Of course, in any given locale the regime of anthropogenic fire may have helped to determine whether chaparral components like ceanothus and manzanita were dominant species or understory shrubs, or were entirely absent. Similarly, Lewis cited a source indicating that the Miwok planted tobacco in the spring on burnt ground; Lewis assumed this to be spring burning in chaparral, but the informant he cites does not specify the vegetation type, whether the burns were new or old, or whether the Miwok set the fires or exploited areas that had naturally burned.

Lewis also included grasshopper burning by the Wintu in his enumeration of chaparral fires, based on Du Bois's (1935) description. But the latter is quite specifically a reference to grassland, not chaparral:

> The grassy area was encircled by people who sang and danced as they whipped the grass and drove the grasshoppers into a center ring. The grass within the narrowed circle was then fired. (Du Bois 1935:14)

The Shasta used fire in hunting deer, but again Lewis's application of the available information to chaparral was purely speculative. He quotes Holt:

> . . . on the more open hills on the north side of the river, where the white oaks grew. When the oak leaves began to fall fires were set . . . in the late fall . . . they had the big

> drive, encircling the deer with fire. (Holt, quoted in Lewis 1973:55)

Lewis asserted that "'the open hills on the north side of the river' would also be the areas of concentrated chaparral cover" (1973:55), but without any explanation as to why. He speculated that "white oak" was actually a reference to Oregon oak (*Quercus garryana*), which does indeed sometimes occur in stands of chaparral although commonly in other vegetation types (Griffin, 1977b). It is unclear why Holt's informants would have specified oaks if they were part of a dense scrubby mix; it seems at least as likely that the vegetation referred to was oak woodland or savanna (which would also have been an easier environment in which to control fire behavior).

In the valley of the Pit River, Lewis cited Kniffen's description of the Madesi subgroup of the Achumawi:

> The heavy precipitation results in a dense and varied vegetational cover. With the pine and fir of the hills are the manzanita, dogwood, yew, ash, maple and oak of the valley. What would have been a dense undergrowth was prevented by annual spring burnings following the retreating snow. (Kniffen 1929:314)

This is a difficult statement to interpret, as it refers to dense growth in one sentence and its absence in the next. But the reference to manzanita suggests that some chaparral components were reduced by deliberate burning in a setting where they might otherwise have had at least some prominence.

In his summation regarding native Californian burning of the chaparral, Lewis (1973) emphasized the seasonality he perceived in anthropogenic fire:

> The patterns of fall, and, secondarily, spring burning involve, not simply an intensification of the natural pattern of fires, since lightning fires occur during the summer and early fall, but, rather, a pronounced departure from the seasonal distribution of natural fires. (Lewis 1973:58)

He went on to conclude that the overall pattern of anthropogenic fire in the chaparral represented a "carefully managed environment of plants and animals" (Lewis 1973:59).

This detailed review of Lewis's argument is not intended to denigrate his work. In fact, he provided a compelling argument that native Californians did indeed set frequent fires in the northern part of the (future) state. The concern here is whether those fires were set in the chaparral.

BOX 8.1. Breakdown of chaparral burning patterns ascribed to native Californians by Lewis (1973). Groups are included if published works have identified them as burning chaparral; the final column gives this author's assessment of the likelihood that the fires were actually in chaparral, based on the evidence discussed in the text.

Tribe	*Purpose for burning*	*Burning season*	*Applicability to chaparral*
Karok	Promote favorable growth	Summer or fall	Uncertain
Pomo	Facilitate hunting and acorn gathering	Fall	Unlikely
Yurok	Facilitate hunting	Unstated	Unlikely
Tolowa	Facilitate hunting	Unstated	Unlikely
Nisenan	Deer hunting drives and tobacco cultivation	Fall and winter	Uncertain
Miwok	Tobacco cultivation	Unstated	Uncertain
Wintu	Grasshopper hunting	Unstated	Very unlikely
Shasta	Dear hunting	Fall	Uncertain
Achumawi	Unstated	Spring	Likely

In this regard, the foregoing discussion of his data suggests that he fell short of proving his theory that the chaparral had been substantially managed through the deliberate use of fire (Box 8.1).

Evidence for Anthropogenic Fire in Southern California

Timbrook et al. (1982) have collected extensive historical evidence of fires in the coastal region near Santa Barbara; they argue that these were deliberately set by the Chumash so as to increase and maintain the extent of grassland at the expense of chaparral and coastal sage. Several herbaceous species (most notably chia, *Salvia columbariae*) served as sources of edible seeds; hence, maximizing grassland would presumably have been a means to guarantee food supplies (Timbrook 1986).

The evidence is drawn from the written accounts of early Spanish explorers. Among the accounts most cited by Timbrook et al. and others (e.g., Stewart 1951; Aschmann 1959; Shipek 1989) are those of Fr. Juan Crespi, who accompanied the Portolá expeditions along the southern and central California coast in 1769 and 1770. Fr. Crespi's diary is available in a published translation (Bolton [1927] 1971), but Timbrook et al. (1982) rely on an unpublished translation which they consider more reliable; I use their version where possible.

Several of Crespi's journal entries from 1769 mention fire, and some specifically attribute it to the native population:

> [Northwest of San Juan Capistrano, July 24] After traveling a short distance in it we came to two good villages, whose people were all very friendly. We greeted them in passing, and they made us their speech, of which we understood nothing. We traveled through this valley for about two leagues; it is of good land, but they had burned all the grass. (Bolton [1927] 1971:137)

> [West of Santa Barbara, August 20] We went over land that was all of it level, dark and friable, well covered with fine grasses, and very large clumps of very tall, broad grass, burnt in some spots and not in others. (Timbrook et al. 1982:166)

> [West of Goleta, August 21] . . . some low-rolling tablelands with very good dark friable soil and fine dry grasses; in many places it had all been burnt off. (Timbrook et al. 1982:166)

> [East of Gaviota, August 24] . . . tablelands that end in high bold cliffs near the sea, but are all very good dark friable soil, well covered with very fine grasses that nearly everywhere had been burnt off by the heathens. (Timbrook et al. 1982:166)

> [Between the Santa Ynez and Santa Maria rivers, August 29] . . . fine soil and dry grass almost all of which had been burned by the heathens. (Timbrook et al. 1982:167)

Timbrook et al. take these descriptions as evidence that areas now covered by chaparral (e.g., near Gaviota) were maintained as a grassy, parklike landscape by frequent fire. Furthermore,

> It is also clear that what Crespí saw was the result of fires which were set deliberately in grasslands by the Indians, rather than escaped campfires or lightning-caused fires, since he speaks of grass being "burnt off by the heathens." (Timbrook et al. 1982:167)

This assertion sounds reasonable, but the evidence is not as definitive as the statement makes it out to be. None of the Crespi journal entries actually describes seeing natives set fires or even gives the source of his belief that they set the fires. In at least one instance (the July 24 entry), the "information" cannot have come from the native people themselves, since he specifically notes his group's inability to understand the native language. Because there are enough instances in American history of Whites erroneously ascribing "negative" practices to Native Americans, one wishes that Crespi, or any of the other eighteenth-century diarists, had specified why they assumed "heathens" were responsible for the fires.

Other, similar, late-eighteenth-century diarists also provide evidence for Timbrook et al. The journals of Fernándo Rivera y Moncada and José Longinos Martínez refer to burning by heathens (or "gentiles") in much the same terms used by Crespi. They also cite proclamations from the 1790s that prohibited "the burning of the fields, customary up to now among both Christian and gentile Indians" (Timbrook et al. 1982:171). It is unclear, however, to what extent the latter reflect "native" practices, given that there was by then extensive European contact.

Taken together, these historical sources leave little doubt that the Spanish found a landscape in which grass fires were common in the coastal region near and north of Santa Barbara. Two corollary possibilities have been inferred but not proven: that the fires were set and "managed" by the Chumash and that they prevented the growth of chaparral—chaparral that has subsequently expanded during two centuries of fire exclusion (Aschmann 1976; Timbrook et al. 1982).

Historical evidence for burning in southern California is not limited to the Santa Barbara region (Bean and Lawton 1973). An early, oft-cited example is a diary (of uncertain authorship) from the expedition headed by Juan Rodríguez Cabrillo and Bartolomé Ferrelo in 1542. In October of that year, they described Santa Monica Bay:

> On the following Sunday, the 8th of said month, they drew near to the mainland in a large bay which they called Bay of Los Fumos, (Bay of Smokes), because of the many smokes which they saw on [around] it. (Bolton 1916:24–25)

Sixty years later, another diary of unknown authorship, from the expedition lead by Sebastián Vizcaino, attributed fires near San Diego to the native Californians:

> The Indians made so many columns of smoke on the mainland that at night it looked like a procession and in the daytime the sky was overcast. (Bolton 1916:79–80)

More than two centuries later, Crespi also noted burns in the San Diego area:

> We ascended a little hill and entered upon some mesas covered with dry grass, in parts burned by the heathen for the purpose of hunting hares and rabbits which live there in abundance. (Bolton [1927] 1971:132)

The problem remains, however, that none of these journals provides a source for the assumption that native Californians set the fires, let alone for assumptions regarding their motives.

The emphasis on historical evidence in southern California has derived in large part from the unavailability of the type of ethnographic sources used by Lewis in the north (Timbrook et al. 1982). In his 1973 monograph, Lewis had said that he omitted the southern part of the state because ethnographic evidence was lacking for "the major tribal groups within the woodland-grass and chaparral belts of the central and southern coastal range—mainly the Costanoan, Salinan, and Chumash" (1973:14).

Ethnographic evidence, however, is not entirely absent. In a paper based on interviews with an elderly Tipai informant, Spier (1923) reported:

> A hot day is chosen for a rabbit hunt (inyaigEaRX). A group from one locality, of indiscriminate gentile affiliation, surround and set fire to a patch of brush to drive the animals out, hallooing the while.
>
> Nets are set over the runways with cords which, passing through the meshes as draw strings, are entined in the bushes. When many are hunting together they drive the rabbits into these purse nets; but when there are only few, they set fire to the brush to drive the rabbits. (Spier 1923:337)

Nor is the evidence limited to a single source. Shipek (1989) described details of deliberate burning by Kumeyaay [Tipai-Ipai] peoples, based on interviews with multiple informants. Interestingly, the emphasis was on vegetation manipulation, rather than hunting. Shipek discussed two types of burning. One was burning of grasses in summer prior to broadcasting seeds of desired "grain-grasses." She concluded that chaparral had expanded into extensive areas of former grassland after Europeans forced a halt to such burning. The other was burning of chaparral as part of a detailed pattern of planting, maintaining, and harvesting edible species:

> Many shrubs, such as manzanita (*Arctostaphylos* sp.) and ceanothus (*Ceanothus* sp.), provided food and were planted in numerous eco-niches, including steep slopes, as were wild grapes (*Vitis* sp.) and various berries. Seeds of agave (*Agave* sp.) and yucca (*Yucca* sp.), plants which provided both food and fibre, were saved and tried in many locations. The seed was planted immediately before burning a slope, and germination was induced by the heat of the fire. . . . Regular burning of chaparral also improved browse for deer, thus doing double duty by providing food for meat animals. (Shipek 1989:164)

Of all the available evidence, Shipek's seems the most supportive of the notion of active, sophisticated environmental management espoused by Lewis. Not surprisingly, given its intensity, Shipek describes this kind of management as having been concentrated around homes and villages.

Overall, the ethnographic and historical evidence regarding native Californian burning of chaparral is mixed. In northern California, fire was apparently a much-used tool and was applied to facilitate both hunting and gathering activities. There is some uncertainty over the relevant vegetation types, perhaps because large stands of chaparral are not common as they are in southern California, and chaparral elements often intergrade with forest and woodland. Where chaparral occurs as a definitive unit, however, there is virtually no evidence that fire was applied to it (Box 8.1). In southern California, fires were apparently common in grasslands on the coastal terraces; given the available evidence, conclusions that they were set by native Californians (primarily Chumash) and that they reduced the extent of chaparral are purely inferential. Finally, there is specific ethnographic evidence that in southernmost California the Tipai-Ipai did burn chaparral, but these fires were apparently limited spatially to sites proximate to their homes.

Natural Ignition

For Native Californian burning to have had a significant ecological impact, two requirements need to have been met. The first, clearly, is that they set fires. The second is that the fires be different from those that would have burned absent human action. The role of natural ignition is therefore as critical to the question as the role of humans. Realistically, the only widespread natural ignition source is lightning (Pyne 1982; Pyne et al. 1996), so our attention turns to the availability of lightning ignition in the chaparral.

As a starting point, we know that cloud-to-ground lightning is rare on the West Coast—indeed, rarer than anywhere else in the contiguous United States (Orville 1991; Orville and Silver 1997). Of the lightning that does occur, however, an unusually high proportion of it is positively charged (Orville and Silver 1997); this is the type of lightning that some consider most effective as an agent of ignition (Pyne et al. 1996).

Within California, lightning frequency generally increases with elevation (e.g., Wells and McKinsey 1995), making it a relative rarity at the moderate elevations within which chaparral dominates. But in his northeastern California analysis, Court (1960) has demonstrated that the occurrence of lightning does not correlate well with the occurrence of lightning-caused fire. His analysis was focused on temporal distribution (lightning fires were not clustered in the months with the most lightning), but the logic presumably applies to spatial variation as well: ignition in a given place within a given season depends not so much on the quantity of lightning strikes as on the polarity of the strikes and on the fuel conditions where the strikes occur. And although lightning may be rare in the low to middle elevations where chaparral is found, it does still occur with some regularity (e.g., Wells and McKinsey 1995). As Burcham has noted:

> Within those general areas where lightning does occur, it is highly sporadic. It varies greatly in frequency and intensity from one year to another; in the time of year when it does occur; and in its distribution over an area. (1974:104)

Minnich (1987) provided a detailed argument that prior to Euro-American fire suppression chaparral fires also resulted from lightning strikes at higher elevations: lightning ignited fires in higher-elevation forests, where they smoldered until weather and fuel conditions allowed them to spread downslope into chaparral.

If lightning frequency does not provide a reliable guide to the occurrence of lightning fires, we must turn to actual fire records. Keeley (1982) analyzed the distribution of California wildfires in records from the U.S. Forest Service (USFS) for the decade of the 1970s. He cited 19 percent of the lightning fires in that decade as having occurred in chaparral. Many of California's wildfires are not included in Keeley's USFS data, because they occur within lands under the jurisdiction of the California Department of Forestry and Fire Protection (CDF, formerly California Division of Forestry). Table 8.1 shows records for those lands. The CDF records unfortunately do not specify the same detail of fuel type, so Table 8.1 shows the frequency of lightning fire in "brush" for the 1990s. Not all the fires in that category were in chaparral (some were likely in sagebrush and coastal sage), but it can be safely assumed that a large proportion were.

It is clear from these data that while the majority of California's lightning fires are at higher elevations, a substantial number do occur in the chaparral. Certainly the raw numbers, if not the percentages, would be

TABLE 8.1. Occurrence of lightning fire in brush within CDF jurisdictions (data from California Department of Forestry and Fire Protection records).

Year	*Number of lightning fires in brush*	*Percent of total lightning fires*
1990	73	12.8
1991	30	9.4
1992	95	13.9
1993	13	8.6
1994	40	8.9
1995	25	16.2
1996	53	15.9
1997	41	16.3
1998	36	15.2
1999	77	16.9
TOTAL	483	13.4

higher if it were not for the role of humans. The majority of California wildfires are started by humans; indeed, in data for CDF fires in the 1970s (Keeley 1982) and 1990s (unpublished CDF data), scarcely 5 percent of total fires were ignited by lightning. This is largely because human ignition (accidental or deliberate) is ubiquitous in the modern California landscape, and many fuel accumulations that might otherwise have been ignited by lightning are consumed by human-caused fires.

The role of fuel accumulation is of critical importance here. Most vegetation types become more flammable with time: a stand that has gone longer without burning becomes easier to ignite. In the case of chaparral, this trend is particularly important, although with an exception. The exception is that in the immediate postfire period woody chaparral shrubs are replaced by herbaceous species and subshrubs that may be easily ignited (Zedler et al., 1983; but note that this phenomenon may be dependent on exotic herbaceous annuals that were absent from the pre-European landscape). Within a few years, however, these more flammable species are crowded out by the reestablishment of chaparral shrubs, which are themselves relatively nonflammable for as much as two decades, after which they become significantly more fire-prone with age (Figure 8.2; Philpot 1977; Minnich and Dezzani 1991).

The importance of chaparral stand age to flammability has spurred some debate over the impact of fire suppression on fire magnitudes. Minnich and colleagues have argued that frequent fires in the pre-Euro-

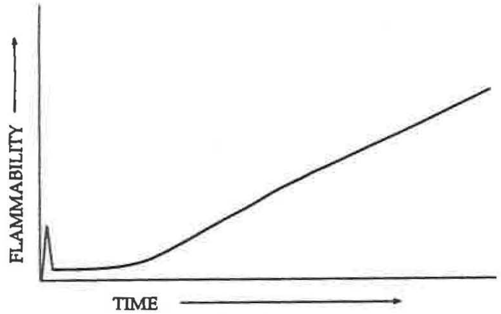

Figure 8.2. Change in flammability of a chaparral stand with time since previous fire.

pean era maintained a mosaic in which many patches were immature (hence nonflammable) chaparral that acted as natural firebreaks and limited fire size; they assert that fire suppression has allowed the expansion of mature (highly flammable) stands and resulted in larger fires (Minnich 1983, 1998; Minnich and Dezzani 1991; Minnich and Chou 1997). Keeley et al. (1999) have challenged that view, noting that the largest chaparral fires in California occur when desiccating downslope foehn winds blow. They argue that under the influence of such winds, any vegetation will burn, and the age of stands becomes irrelevant to fire spread. Of note, both these views stress factors other than ignition as being key. Minnich emphasized that fuel load was key, with lightning a sufficient combustion source:

> Over the several decades necessary for chaparral to mature, thunderstorms are sufficiently numerous for lightning to be a ubiquitous source of combustion. Although native Americans and early European settlers also set fires deliberately or accidentally, human acceleration of burning in chaparral is unlikely given its nonflammability during the first decades of succession. (1983:1292)

Keeley et al., while emphasizing weather rather than fuel load, agreed on the adequacy of lightning:

> Large catastrophic wildfires in brush-covered regions of California are often driven by high winds. . . . Today, people ignite most of these fires; however, in their absence, lightning storms that typically occur just weeks before the autumn foëhn winds would have provided a natural source of ignition. (1999:1831)

In sum, specific studies of fire ecology, fire history, and fire behavior

in California chaparral suggest that this vegetation would burn periodically, even in the absence of a human role. There are disagreements on the relative impacts of stand age and fire weather on the size of the fires, but both theory and data suggest that some scale of fire would burn a given stand on timescales of decades to centuries.

Stratigraphic Evidence

If native Californians were responsible for the fires that burned chaparral in the past, then the frequency of fire should have decreased with the arrival of Europeans, who forbad such burning (and in many instances decimated the native populations). Thus any record allowing a comparison of fire frequency before and after European arrival should help to clarify the importance of anthropogenic fire. The best (perhaps only) way to reconstruct fire frequency over centennial to millennial timescales is by the analysis of charcoal preserved in radiocarbon-dated sediment cores (Millspaugh et al. 2000). Similarly, if vegetation has changed in response to altered fire regimes, the changes should be apparent in pollen preserved within the same or similar sediments (Clark and Royall 1996).

Unfortunately, there are few sedimentary records available that shed light on the California chaparral. The best available information of this type is from the Santa Barbara region. One site in that area (Santa Barbara Basin; see Figure 8.1) provides a charcoal record of nearby fires (Byrne et al. 1977; Mensing 1993; Mensing et al. 1999) and along with two other sites (Zaca Lake and Cleveland Pond) has also yielded pollen data reflecting vegetation change (Mensing 1993, 1998).

Mensing et al. (1999) analyzed charcoal in a core from Santa Barbara Basin, representing 560 years of deposition from the coastal plain and western Transverse Ranges (which have extensive chaparral cover). They reported that large fires had occurred in all centuries of their record, with small fires also common. There was no significant change in the occurrence of large fires between the pre-European period (when presumably native Californian—locally Chumash—burning was prevalent) and the (Spanish) Mission and subsequent periods. Mensing et al. concluded that what variation they did see in charcoal concentrations and inferred fire frequency was better correlated with climatic variability (large fires coming just after transitions from fuel-growing wet periods to fuel-drying droughts) than with human history.

The pollen record also seems to suggest that the ecological impacts of Chumash fires were limited in scale. Mensing (1998) reported on pollen trends in the Santa Barbara Basin core and in a core from Zaca Lake that he calculated conservatively to extend at least two centuries before Spanish settlement. His pollen record does not show the increase of chaparral taxa (*Rhamnaceae/Rosaceae*) that should appear if the cessation of Native burning allowed chaparral expansion at the expense of grassland (cf. Dodge 1975; Timbrook et al. 1982). Indeed, at Santa Barbara Basin, chaparral pollen declined slightly in the last century. Similarly, a core farther east at Cleveland Pond reveals no increase of chaparral at or following the transition from unhindered native burning to the Mission period (Mensing 1993). With regard to the pollen record from all three sites, Mensing concluded:

> In the case of Santa Barbara [i.e., the region], fires in the coastal grassland were probably more frequent in the immediate pre-European period as a result of burning by Indians. . . . However, there is no evidence that frequently set Indian fires substantially altered the boundary of chaparral vegetation. Even if fires escaped into the chaparral, as they must have sometimes, this caused no expansion of coastal sage scrub and grassland into chaparral areas. (1993:116)

Fire Regimes and Chaparral Fire Ecology

Ultimately, our concern is for the ecological impacts of anthropogenic fire, rather than with proving or disproving its occurrence. So the final question is whether the characteristics of California chaparral can be adequately explained by a natural fire regime or instead depend on factors that would have been unique to anthropogenic fire.

A natural regime of lightning-caused fires would presumably have been characterized by a high degree of spatial and temporal variation in the distribution of burns. Given the relative rarity of lightning in the California chaparral, the ignition variable alone would have favored more frequent fires near topographic prominences that would be likely lightning targets, with longer fire intervals in the declivities less likely to be struck. That picture is complicated by the impacts of fuel maturation (Minnich and Dezzani 1991), meteorological conditions (Keeley et al. 1999), and climatic variation (Mensing et al. 1999) upon the occurrence and size of fires. The net result would have been a heterogeneous, uneven-grained mosaic characterized by varied stand ages and sizes. All stands would presumably burn eventually, but the length of time between fires would be variable, as would the size of the burns. Fires would have been seasonally concentrated in the summer and autumn, when fuels were dry and thunderstorms likely; and large fires would have been limited to the latter season, when foehn winds were common.

By contrast, a landscape in which anthropogenic fire dominated would presumably have burned more consistently and frequently. Aschmann (1977) estimated a doubling of fire frequency, Shipek described "regular burning of chaparral" (1989:164), and Timbrook et al. (1982) suggested that fires were set at the grassland/chaparral ecotone at 1- to 3-year intervals. If, as most authors suggest, fires were used with great care to control their impacts, they were probably set in conditions that favored low-intensity fire to prevent their spreading beyond control. The size of the fires is less clear. Lewis (1973) suggested that anthropogenic fires would generally be small in area, a view implicitly supported by Shipek's (1989) descriptions of careful and precise fire usage. On the other hand, the fires must have been reasonably large to have the significant ecological impacts claimed by many authors (e.g., Stewart 1951; Lewis 1973; Dodge 1975). Descriptions of seasonality are inconstant for anthropogenic fires; every season has been mentioned in one account or another. Even within Lewis's (1973) paper emphasizing spring and fall fires, his sources mention burning at every season of the year (Box 8.1).

Fire ecology research over the past 25 years has revealed an enormous variety of fire-related adaptations in California chaparral species. Woody taxa range in reproductive strategy from "obligate-sprouters" (e.g., *Cercocarpus betuloides*) that only regenerate vegetatively to "obligate-seeders" (e.g., *Arctostaphylos glauca*) that reproduce only from seed; there are also species capable of producing both resprouts and seedlings (e.g., *Adenostoma fasciculatum*). Beyond this, some species' seeds will germinate only when exposed to a fire-related stimulus (heat for some, charred wood for others), whereas others are unresponsive to fire cues but require the moist conditions following winter rains (Keeley 1991, 1992). There is also variation among both seeds and sprouts in the degree of fire intensity through which they can retain their viability (Odion and Davis 2000).

This diversity of adaptations is, apparently, best explained by an environment in which fire is inevitable but unpredictable—that is, in the kind of landscape described above for a natural fire regime. Keeley (1977) and Keeley and Zedler (1978) have suggested that obligate-seeders in the chaparral evolved because occasional fire intervals greater than 100 years bestowed a competitive advantage as stands aged and individual shrubs died. Under this scenario, seeds would remain to germinate when the stand eventually did burn, but there would be few live shrubs remaining to serve as a source of competing sprouts. Keeley and Zedler concluded "chaparral is adapted to both short and long fire-free periods. *This is undoubtedly a reflection of the unpredictability of fire* in the environment" (1978:159, italics added).

Zedler (1977) also argued that some chaparral species cannot survive indefinitely in stands that burn at short intervals. He observed that *Cupressus forbesii* required 40 years to mature sufficiently to provide enough seed to ensure its representation in the postfire seed pool. Thus its continued presence (and occasional prominence) in the chaparral indicates that at least some chaparral stands must go several decades between fires, and that it is not a newcomer to the chaparral indicates that this fire cycle must have been prevalent in the pre-European period. And although reproduction of sprouters has traditionally been thought to be favored by fire (e.g., Hanes and Jones 1967), Keeley (1992) has more recently suggested that some obligate sprouters may also require long fire-free intervals for successful reproduction.

The low intensity of "controlled" fires would also have militated against the success of some chaparral species. Riggan et al. (1988) reported that low-intensity fire fails to trigger successful germination by obligate-seeding *Ceanothus* species and noted that because of resultant changes in fuel composition repeated low-intensity fire could become self-perpetuating, permanently "degrading" the chaparral composition. The widespread occurrence of *Ceanothus*-dominated chaparral thus suggests an environment in which low-intensity anthropogenic fire, at least those consciously set, has been rare.

All these studies lend support to the notion of a multifaceted chaparral landscape that owes its diversity of species and species' adaptations to a fire regime in which burns are quite irregular, temporally and spatially. Although virtually all species require fire, many of them actually need long intervals between fires for conditions to develop that will allow for successful postfire regeneration. As noted earlier, this accords most closely with the characteristics of a lightning-dependent fire regime.

Conclusions

What, then, can we conclude from the disparate types of evidence, and the disparate conclusions, that have been published regarding native Californian fire in the chaparral?

There is little doubt that native Californians did make extensive use of fire. There is, however, considerable doubt as to the extent of its use and impacts in the chaparral. In northern California, anthropogenic fire appears to have been far more common in other vegetation types; most of the descriptions that have been cited as evidence of chaparral burning do not hold up under scrutiny. In southern California, it seems equally apparent that at least the margins of chaparral *were* affected by anthropogenic fire. Repeated (arguably anthropogenic) burning of grasslands must have meant at least some fire along the grassland/chaparral ecotone, and the Tipai-Ipai apparently did deliberately burn within the chaparral, albeit on a limited spatial scale. But again, there is no evidence that the bulk of the chaparral landscape was subject to a human-modified fire regime. There is no ethnographic evidence to support such a regime, the characteristics of the vegetation are better explained by a lightning-dependent fire regime, and the limited stratigraphic evidence available indicates that both fire frequency and the chaparral vegetation itself remained unchanged through the transition from the pre-European to the colonial periods.

It would be reasonable to summarize the impact of native Californian fire in the following terms: a variety of Native cultures made sophisticated use of fire, both to favor edible species and to facilitate (directly or indirectly) hunting. The scale of fire use was so limited, however, that the bulk of the chaparral as we know it evolved under a natural, lightning-dependent fire regime. Undoubtedly, anthropogenic fire did have some ecological impacts, but those impacts were spatially limited to the immediate surroundings of population centers and to the preexisting (i.e., quasinatural) ecotones. Because of the limited spatial extent of anthropogenic burning, the overall chaparral environment was unchanged by the cessation of native burning, as evidenced by the static nature of the stratigraphic record.

This conclusion should not be seen as derogatory of the environmental management skills of native Californians. Rather, it recognizes the sophistication of the pre-European population: they saw advantages in manipulating their environment and had the skills to do so, but they chose to do it where it would be to their specific advantage, rather than indiscriminately burning an entire landscape.

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