

UC Merced

Journal of California and Great Basin Anthropology

Title

Vegetation Burning by the Chumash

Permalink

<https://escholarship.org/uc/item/1rv936jq>

Journal

Journal of California and Great Basin Anthropology, 4(2)

ISSN

0191-3557

Authors

Timbrook, Jan
Johnson, John R
Earle, David D

Publication Date

1982-12-01

Peer reviewed

Vegetation Burning by the Chumash

JAN TIMBROOK
JOHN R. JOHNSON
DAVID D. EARLE

THE question of whether aboriginal hunting-gathering peoples of California modified their environments by periodic burning of vegetation has been widely discussed, both by anthropologists and by geographers. Several tribes used fire in hunting, with such techniques as rabbit drives; to improve forage for game animals which would then be hunted; and to increase the availability of certain plants for direct use by humans (Lewis 1973). Bean and Lawton (1973: xxxvi) proposed that burning was part of a sophisticated technological inventory of energy extraction processes which supported the high population density and cultural complexity of aboriginal California. In their view, true agriculture was not adopted by most peoples in the state because it would have been not only unnecessary but a step backward in efficiency.

Plant geographers have suggested that the evolution and distribution of certain vegetation types in southern California have been greatly influenced by human activities, among which European introduction of plant species and grazing animals are only the most recent. It is thought by some that frequent burning by prehistoric Californians sustained a park-like landscape with grass and scattered oak trees, and that chaparral has invaded these areas since burning was suppressed after Spanish colonization in the 19th century (Aschmann 1959, 1976: 41).

Actual documentation of burning of vegetation by Indians has been confined primarily to northern California (Lewis 1973; Sampson 1944), and complaints have been voiced regarding the lack of information available about southern California Mission groups or about pre-European practices (Bean and Lawton 1973: xxi-xxii; O'Connell 1974: 118). Aschmann (1959) had assumed from plant distributions that these coastal groups did burn the local vegetation, but he could produce no documentation from early Spanish historical sources. Jonathan Sauer (1977: 383) also stated that there was no historical evidence of vegetation burning by the Chumash.

Historical accounts describing burning in early times by Indians on the southern California coast are indeed extant, although they are not widely known. They suggest that purposeful burning of some types of native vegetation was a regular occurrence among the Chumash Indians of the Santa Barbara Channel region during the late 18th century, that the practice was suppressed in the Mission Period, and that it had long faded from cultural memory by the late 19th and early 20th centuries when ethnographic data were collected from Chumash survivors.

The early accounts of vegetation modification by the Chumash are significant because they provide information useful in reconstructing the pre-Hispanic landscape. This knowledge is valuable to foresters, botanists, geographers, and ecologists, as well as to anthropologists and archaeologists.

The Chumash are of particular interest

Jan Timbrook, Santa Barbara Museum of Natural History, 2559 Puesta del Sol Rd., Santa Barbara, CA 93105. John R. Johnson and David D. Earle, Dept. of Anthropology, Univ. of California, Santa Barbara, CA 93106.

because of their high population density, sedentary existence, and complexity of socio-political organization which was far closer to the chiefdom level than to the band (Anderson 1978: 6). As a relatively complex nonagricultural group, the Chumash example can serve as a way of evaluating Bean and Lawton's hypotheses about environmental manipulation and cultural complexity in aboriginal California (1973: xxxv - xxxvii). It may also provide important comparative evidence for discussions of similar human behavior in different times and places on a worldwide basis.

It is therefore the purpose of this paper to call attention to the ethnohistoric evidence which shows that the Chumash did deliberately use fire in ways which may have had pronounced long-term environmental effects, and to demonstrate that encouragement of growth of certain plant resources was the principal reason for the practice of burning.

THE COASTAL CHUMASH ENVIRONMENT

The ethnohistoric accounts are concerned with the coastal portion of Chumash territory, roughly from the mouth of the Santa Clara River in Ventura County on the south, north to the Santa Maria River at the border between Santa Barbara and San Luis Obispo counties. Much of this area is a low, flat plain a mile or so in width, lying between the waters of the Santa Barbara Channel and the steep slopes of the Santa Ynez Mountains, which rise to an elevation of over 4000 feet within about five miles of the coast. To the west, the landscape trends more toward gently rolling hills dissected by small seasonal watercourses. Turning northward from Point Conception, the terrain again flattens out into broad plains with extensive sand dunes near the shore.

The climate of this area is Mediterranean, with warm dry summers and mild rainy winters. Precipitation averages about 12 to 17

inches along the coast, more at the higher elevations. Marine air moderates temperatures in this coastal area, so that prolonged freezing is rare. Winter temperatures of 40° to 50°F. are typical. Early summer is characterized by fog; the hottest months are August and September, when temperatures are commonly 75° to 90°F. (Smith 1976: 3-4).

The vegetation in this area today has been much altered by recent human activities (Smith 1976: 15; Heady 1977: 499). Outside settled areas, the coastal plain is covered with a mixture of introduced grass species, particularly *Avena*, *Bromus*, and *Hordeum*, and broadleaved introduced weeds such as filaree (*Erodium* spp.), fennel (*Foeniculum vulgare*), mustard (*Brassica* spp.) and milk thistle (*Silybum marianum*). In spots less heavily grazed by cattle, coastal sage scrub vegetation—particularly coyote brush (*Baccharis pilularis*), sages (*Salvia* spp.) and California sagebrush (*Artemisia californica*)—now extends all the way to the coast and is thickest on hillsides (Mooney 1977: 476). This low, soft shrub community intergrades on its upper edges with chaparral, a dense, stiff shrub cover more typical of steeper slopes and thin, rocky soils (Hanes 1977: 419). Liveoaks (*Quercus agrifolia*) are now found in rocky soils on north-facing slopes and in canyons, but formerly were more widespread in grassland-savanna or in woodland relatively free of understory (Griffin 1977: 407-409). Most of these oaks were cut for feed, firewood, and building material after European and American settlement in the 19th century (Clifton Smith, personal communication 1983). Barring human interference, the distribution of these broad vegetation types is most influenced by elevation and topography, which affect temperature and precipitation, and by the soil type and character of the geological formation on which the plants grow (Smith 1976: 21-25; Dibblee 1976; Minnich 1983: 1289; Griffin 1977: 409).

The chaparral has been extensively studied by plant ecologists because of its intimate relationship with the wildfires which occur frequently during the dry months of the year. It is often said that the chaparral community evolved with fire and has adapted to naturally occurring fires in several ways, such as sprouting from basal burls and producing seeds which germinate best after fire (Hanes 1977: 432-433). The interval between fires in any one area depends on the amount and moisture content of fuel, source of ignition, and weather conditions. Two or three decades are required to build up enough fuel for large, intense chaparral fires, but smaller ones can occur more often (Minnich 1983: 1292).

In general, abundant herbaceous cover permits burning of grassland and coastal sage scrub more often than is possible in chaparral (Minnich 1983: 1292). However, the effects and frequency of grass fires today are not necessarily comparable with those in aboriginal times before introduced weeds and heavy grazing destroyed the native grasslands (Stewart 1956: 318). Lightning strikes, which occur most often during late summer drought, are the major cause of natural fires but tend to be confined to the higher elevations (Burcham 1974: 104). Fires do not usually burn down slope (Daubenmire 1968: 214), although they have been observed to do so in southern California when fanned by Santa Ana winds (Vogl 1968: 81; J. Sauer, personal communication 1983). Since just the right combination of wind, temperature, humidity, fuel, topography, fire ignition and location must coincide, it seems likely that extensive fires in grasslands along these low plains near the coast would seldom occur under natural conditions—that is, if no humans were present.

Humans *were* present, however, and had been in the area for at least 9000 years before Europeans arrived. At the time of first inten-

sive Spanish contact in the 1770s, an estimated 15,000 Chumash people inhabited the Santa Barbara Channel coastline and offshore islands. This population was largely sedentary, and settlements of 500 to 1000 people were not unusual on the coastal plain (Brown 1967). The area north of Point Conception and the interior valleys were somewhat less thickly settled, but the population was still sizeable there as well. Chumash culture has been well described by several authors and need not be reiterated here (see Anderson 1978). Suffice it to say that the Santa Barbara Channel coast is regarded as a culture climax area and that a very large, sedentary population with complex social, political, economic, and religious organization and a high development of material culture and the arts was supported by a hunting, gathering, and fishing subsistence base (Blackburn 1975; Hudson et al. 1977, 1978; Hudson and Underhay 1978; Hudson and Blackburn 1982).

With such a large population, it would be surprising indeed if human-caused fires did not occur in grasslands along the coast (Heady 1977: 499). Village campfires must have escaped and burned out of control with some frequency. The following ethnohistoric accounts will show that grassland fires were not always accidental and sporadic, however, but deliberately and regularly initiated by humans.

CRESPI'S ACCOUNT

Fr. Juan Crespi accompanied the Portolá expedition in 1769-1770 and made detailed observations of the native culture and natural environment of the Santa Barbara Channel mainland coast (Brown 1965, 1967). The most familiar published translation of Crespi's diary, in Palou's *Historical Memoirs of New California* (Bolton 1926), is actually a composite version of the Portolá expedition. It is only partly drawn from Crespi's original diary, but with much incorporated from the

more succinct journal kept by the expedition's engineer, Miguel Costansó. There are two original holograph texts of Crespí's journals which have been translated by Alan K. Brown (n.d.) but have not yet been published. Excerpts from the translation of one of these texts which deals with vegetation burning by the Chumash are reproduced here with Dr. Brown's permission, with emphases added by the present authors.

August 20, 1769. After setting out from camp on what later became known as Arroyo Burro Creek, near Santa Barbara, Crespí wrote:

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*; the unburned grass was so tall that it topped us on horseback by a yard.¹ All about are large tablelands with big tall live-oaks (I have never seen larger), and many sycamores as well. We have come across rose-patches in such great amounts that the plains here were full of them in many spots.

After camping the next night in the populous Goleta area, where between five and seven Chumash communities were found, the expedition set out westward toward Point Conception.

... in sight of the shore, over some low-rolling tablelands with very good dark friable soil and fine dry grasses; *in many places it had all been burnt off*. It was all flat land, excepting only some short descents into a few dry creeks. If it can be dry-farmed, all the soil could be cultivated. Shortly after we left this point, the great live-oaks at this spot dropped behind us.

On *August 24, 1769*, after camping near a large village in what may have been Tajiguas Canyon, Crespí again commented on burned vegetation:

We set out from here at San Guido, taking a due westerly course, and again going down to

the shore. We were soon stopped here, and went up to some low-rolling 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*.

After reaching the Chumash village at Gaviota Canyon, Crespí reported:

The mountains that have been alongside us during the last two days' march *are bold, rough and steep*; white-colored here and there, as though from white earth or stone, and, *where not whitish, well covered with dry grass*.

As the Portolá expedition continued its march toward Point Conception, Crespí—obviously interested in pastureland and feasibility of agriculture—repeatedly described treeless tablelands with good soil covered with fine, dry grasses. At one point he remarked:

... *the place lacks nothing but wood, of which there is none*.

On *August 27, 1769*, after leaving Chumash settlements near Point Conception, Crespí again mentioned that in some places the grassy tablelands had been burned.

Continuing northward past Chumash villages at Jalama Beach and Cañada Agua Viva, the expedition rounded Point Arguello. On *August 29, 1769*:

... we set out from the San Juan Bautista Village on a due northwest course, across level ground near the shore. We soon passed the second point, and made out still another afar off, making a sort of large bight. *We went almost all the way over salt-grass, all very much burnt off by the heathens*, with some descents to dry creeks. On going about a league and a half, we reached a stream [Honda Canyon] with a good amount of fresh water emptying into the sea, but no village nor soil of any worth upon it. The soldiers had scouted up to this point, and it was not a full day's march, *nor was there grass for the animals, as it had all been burned off*. . . . On going about three hours,

in which we must have made about two leagues and a half, we came to a hollow where the heathens had said there were some pools of water, and *although it had been burned off, there were spots that had not been and where there was good grass for the animals*; a halt was ordered here

After crossing the Santa Ynez River and continuing northward past San Antonio Creek but before reaching the plains of the Santa Maria Valley, the expedition came to a hollow in the hills. There Crespí once again noted:

. . . fine soil and *dry grass almost all of which had been burned by the heathens.*

This was the last time he mentioned grassland burning within Chumash territory on this trip.

Portolá's return journey through the Santa Barbara Channel area to San Diego took place in January, 1770. He made a second trip northward in May, 1770. Crespí's journals cover both these trips and describe the appearance of "good" grasses and wildflowers along the coastal tablelands in Chumash territory. In the spring of 1770 along the coastline north of Point Arguello, the expedition encountered fields of wildflowers such as are sometimes seen in the area today. On *May 7, 1770*:

. . . we started from the San Juan Bautista de los Pedernales village and point here, keeping on a northwesterly course over very grassy level land near the shore. We shortly passed the point here, and in the distance made out another that formed still another bight. At once after setting out, we commenced to find the *fields all abloom with different kinds of wildflowers of all colors, so that, as many as were the flowers we had been meeting all along the way and on the Channel, it was not in such plenty as here, for it is all one mass of blossom*, great quantities of white, yellow, red, purple, and blue ones; many yellow violets or gilly-flowers of the sort that are planted in gardens, a great deal of larkspur, poppy and sage in bloom,² and what graced the fields

most of all was the sight of all the different sorts of colors together. On going about a league and a half, we came down to a deep creek in a hollow where there is a good deal of grass and a good-sized stream of running water On this whole march, three leagues from the point of San Juan Bautista de los Pedernales, *we have seen not a bush nor a single heathen.*

These spectacular wildflower displays were seen in the very same area which Crespí had noted as having been burned the previous summer.

Crespí's diaries provide both excellent descriptions of the topography and vegetative cover of the Santa Barbara coastal area at the beginning of the Spanish colonial period, and very specific evidence of grassland burning by the Chumash, or "heathens." It is apparent from these descriptions that the shrub communities of coastal sage scrub and chaparral were once considerably less extensive than they are today. For example, the mountains between Tajiguas and Gaviota—or at least their lower flanks—were described as covered with grasses in August 1769, whereas dense chaparral is found there today. In addition, "not a bush" was seen in the South Vandenberg area north of Point Arguello in May, 1770; today the vegetation there is coastal sage scrub (see Smith 1976: 21-24 for a general discussion of the occurrence of these communities today). Crespí's descriptions are in fact quite consistent with the theoretical picture presented by Aschmann (1976: 41) of a park-like landscape with scattered oak trees which was sustained by frequent burning in pre-European times.

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."

Leaving aside the reasons for setting fires

for the moment, a discussion of the effects of repeated burning is in order, to account for the discrepancy between what Crespí reported and what we see in the same places today. It seems likely that the Santa Barbara coast in pre-European times was dominated by grassland and oak savanna, with perennial bunch grasses interspersed with broad-leaved native annuals (Heady 1977: 492-494). Seasonal wildflowers, such as described by Crespí, often appear to be the dominant plant cover in all natural grasslands (Burcham 1957: 27). Even where oaks are present and form a savanna or open woodland, the essential character of the community is still that of a prairie (Burcham 1957: 90).

Fires which burned in grassland would not be expected to stop at the shrub line, and may have occasionally spread up-slope into coastal sage and chaparral. While these two plant communities are adapted to fire, that adaptation is not based on burning more often than about ten-year intervals—more often for coastal sage scrub, less often for chaparral. Fires at one- to three-year intervals could be expected to burn even new growth, prevent shrub regeneration, and effectively extend the area colonized by grasses at the expense of coastal sage scrub or chaparral communities. Indian burning may also have been an important factor in maintaining the openness of oak savanna in coastal areas; mature oaks are well adapted to survive ground fires by sprouting (Griffin 1977: 408-409; Sweeney 1968: 114). Some oak species may produce more acorns as a result of thinned understory after a fire (Lewis 1973: 17).

A second ethnohistoric account, a few years after Crespí's visits, also mentions burning in grasslands. It is even more explicit in stating that fires were deliberately set by the indigenous peoples of the Santa Barbara Channel, and offers some clues as to the reasons this was done.

RIVERA Y MONCADA'S DIARY

Fernando Rivera y Moncada was the military governor of California from 1774 to 1777. On his travels throughout the territory, he frequently had contact with Indian people who had for the most part not yet been missionized. His diary has been published in Spanish (Burrus 1967), but will be quoted here in translation, with emphases added by the present authors.

On *April 24, 1776*, Rivera y Moncada stayed the night near "Mezcaltitan" at the mouth of the present Goleta Slough, which he described as the most populous part of the Santa Barbara Channel coast. The following day he journeyed eastward to just past what is now Ventura.

I passed outside the Channel. It was already dark when we stopped at the Santa Clara River. *The gentiles* [heathen Indians] *destroy and consume the pastures with their burnings* [Burrus 1967: 253].

In a later journal entry, Rivera y Moncada summarized his travels between San Gabriel and San Buenaventura in the south-eastern part of Chumash territory as follows:

Having made beforehand in this Diary extensive report of this road, [and] given information about the villages of the Santa Barbara Channel, it has seemed to me [proper] not to repeat [this], since I have not had the least novelty in my [most recent] journey. I have experienced great drought [here], therefore some of the springs along the road I have passed [are] dry; this is something that has not happened to me since I entered these lands, and in the countryside [there has been] extreme need of pasture for the animals, which in some areas has caused me difficulty in staying overnight and even in stopping at midday, due to *the horses and mules not having grass, all occasioned by the great fires of the gentiles, who, not having to care for more than their own bellies, burn the fields as soon as they gather up the*

seeds, and that [burning] is universal, although on some occasions it happens that it may be greater or less, according to the winds or calm [Burrus 1967: 310].

Rivera y Moncada's account, like Crespi's, stresses the fact that vegetation burning by the Chumash was deliberate, widespread, and affected large areas. He also indicates that fires were not necessarily controlled, and therefore they could have spread from grassland or savanna into shrublands in the foothills and mountains. Although the open parklands thus created would provide excellent forage for game animals, improved hunting is not given as the reason the Chumash set fire to pastures.

In his descriptions of the Monterey area, Rivera y Moncada explicitly stated that the heathens burned "so that new weeds may grow to produce more seeds" (Clar 1959: 5). It may be inferred from the account presented here that the Chumash were also burning to promote the growth of vegetable foods for their own consumption. The phrase "they burn the fields as soon as they gather up the seeds" indicates that seeds of grassland plants were sought-after and that burning was not done until these had been harvested. Seeds of most annual wildflowers ripen in late spring or early summer; seeds of native grasses are usually shed in June or July. This fits well with Crespi's reports of burned grasslands on his August visit, and with the usual burning of vegetation in summer or fall by other Indian groups elsewhere in California (Bean and Lawton 1973: xxi - xxii; Lewis 1973: 19; Biswell 1967: 82).

Springtime burning would be unusual, both because of low vegetation flammability and in terms of harvesting desired food resources. It is not clear from Rivera y Moncada's accounts of the Santa Barbara Channel whether he actually saw burning in progress or merely observed its effects. He passed through eastern Chumash territory in

the midst of a severe drought. Lack of rain the previous winter would have resulted in a failure of the usual growth of new graze, which would have been particularly serious for his horses and mules if the pastures had been burned the summer before.

Small, hard seeds such as those of grasses and sage were important in the diet of many California Indian groups and were likely so for the Chumash, as will be discussed below. There is also evidence that fresh, green shoots were eagerly consumed, particularly after some months of living on stored food. This is shown in the third ethnohistoric account.

THE LONGINOS JOURNAL

Naturalist José Longinos Martínez traveled through both Alta and Baja California in 1791 and 1792. He recorded information about the flora, fauna, natural resources, and native peoples of the area, under orders from the Spanish King, Carlos III. Longinos made many valuable observations about the Chumash of the Santa Barbara Channel area, and also noted certain cultural features which seemed to be widespread or universal throughout the territory of New Spain (Simpson 1961: vii). In the following passages, emphases have again been added by the present authors.

In this part of the Santa Barbara Channel . . . if a chief merely makes an attempt to pass through another's jurisdiction, fighting and quarreling result, so great is the distrust that these nations have of one another *Their wars are frequent and always originate over rights to seed-gathering grounds, or in disputes over concubines* The gentiles living between San Diego and San Buenaventura *store up against the winter the plants that bear the most seeds* These nations [north of Santa Barbara] continually *keep on hand small baskets of seeds and other foodstuffs* In all New California from Fronteras northward *the gentiles have the custom of burning the brush*, this for two purposes: one, for catching rabbits

(brush-burning being a form of hunting); two, *so that with the first light rain or dew the shoots will come up* which they call pelillo [little hair] and *upon which they feed like cattle when the weather prevents their seeking other food* [Simpson 1961: 58-59].

Thus the Longinos journal contains specific evidence that burning was carried on by many California Indian groups, probably including the Chumash, for two purposes: for rabbit drives (as opposed to improving forage for animals to be hunted later), and for promoting the growth of green shoots to be eaten by humans. Longinos also stresses the importance of seeds in the native diet, and although the connection between burning and seed gathering is not explicit in this account, it was probably a third motive for setting fires. It is unclear whether by "brush" Longinos meant shrub vegetation, hence chaparral or coastal sage scrub in the Chumash area, or merely vegetation in general. The motive for burning in any particular area would depend on several factors including vegetation type. There are several species of native annual and perennial plants which have been called "fire followers," meaning they germinate and grow much more profusely after an area has been burned (Smith 1956). Many of these are grassland species and produce seeds which were used by California Indian peoples, a fact which will be discussed in more detail below.

By the time of Longinos' visit in the late 18th century, Spanish colonization and missionization of the California Indians were already well under way. The Chumash and others were increasingly denied the right to continue many of their traditional practices, including vegetation burning, under the new administration. This is the subject of another historical document.

ARRILLAGA'S PROCLAMATION

The year after Longinos' visit, the first fire control regulation in Alta California was

proclaimed by Governor José Joaquín de Arrillaga, who was in Santa Barbara at the time. Arrillaga's proclamation, the accompanying letter to the Padre Presidente of the Missions, Fermín Francisco de Lasuén, and Lasuén's reply are quoted in their entirety from Clar (1959: 8-10), with emphases added.

Arrillaga's letter to Lasuén, dated May 31, 1793:

Because of various complaints that have reached me about the serious damage that results from the fires that are set each year in the pastures by Christian and Gentile Indians, and having been informed not only by various officials but also by different mission fathers that the aforesaid damage is true, I have taken measures to publish the enclosed proclamation which I am passing into your hands with the entreaty and charge that you please inform all the mission fathers that they are to contribute for their part to the observance of such a just proclamation not only by warning the Christian Indians, and particularly the old women, not to become liable for such offense, but also by threatening them with the rigors of the law, trying in case of fire to clear the way for corporals of the guard to have Christian Indians help them to cut off with all possible determination the fire that may threaten their vicinity, to which end I authorize to the comandantes whatever may be expedient in carrying out this order. Also I should notify you that on my way here from San Diego, at the Missions of San Juan Capistrano and San Gabriel, having called the natives together, I instructed them in the presence of the reverend mission fathers about this my proclamation and the penalties that would be incurred by infractions of it. I shall do the same at the missions on the way to Monterey, for I should like to see my wishes, which are directed toward the common good, partly if not wholly carried out.

May Our Lord Keep You, Most Reverend Father.

Mission Santa Barbara, May 31, 1793.

José Joaquín de Arrillaga

The proclamation:

DON JOSE JOAQUIN DE ARRILLAGA,
CAPTAIN OF CAVALRY, INTERIM GOVERNOR
AND INSPECTOR COMANDANTE OF UPPER AND LOWER CALIFORNIA.

With attention to the *widespread damage which results to the public from the burning of the fields, customary up to now among both Christian and Gentile Indians in this country, whose childishness has been unduly tolerated*, and as a consequence of various complaints that I have had of such abuse, I see myself required to have the foresight to *prohibit for the future (availing myself, if it be necessary, of the rigors of the law) all kinds of burning, not only in the vicinity of the towns, but even at the most remote distances, which might cause some detriment, whether it be by Christian Indians or by Gentiles* who have some relationship or communication with our establishments and missions. Therefore I order and command all comandantes of the presidios in my charge to do their duty and watch with the greatest earnestness to take whatever measures they may consider requisite and necessary to *uproot this very harmful practice of setting fire to pasture lands*, not omitting any means that may lead to the achievement of the purpose which I propose in this order, to which effect they will publish it in their respective jurisdictions with particular charge to the corporals of the guard, commissioners, and magistrates of the towns that they exercise equal vigilance in trying to *advise the Christian Indians and the Gentiles of the neighboring rancherías about this proclamation and impressing upon them that those who commit such an offense will be punished*, and in case some burning occurs, they are to try immediately to take the most appropriate means to stop the fire, or failing that, to direct it into another direction which may result in less damage, apprehending the violators, of whatever class or sex, who would be *punished in accordance with the degree of malice there may be on the part of the offenders*; and in order that there may be no obstacle to the observance of this order, I beg and charge the Reverend Fathers, priests of the missions, that they do their part in instructing the Christian Indians

not to commit such transgression. And *in order that it come to the attention of all and that nobody may allege ignorance, I order that this decision of mine be published by proclamation in the presidios as well as the missions and towns of this province which is in my charge, making it be known to all classes of Indians, Christians as well as Gentiles, and repeating its publication annually, with the full understanding that whatever lack of observance may be noticed in this matter (which is) of such great interest will be worthy of the most severe punishment.*

Given in Santa Barbara, May 31, 1793.

José Joaquín de Arrillaga

On June 2, 1973, Fr. Lasuén replied to the Governor from Mission San Carlos:

My dear sir: I have received the proclamation which you sent me dated the 31st of last month, ordering the prevention by all possible means of the *horribly destructive fires which are experienced every year in this country*. Two days ago, after it was published here, I sent it to Mission Santa Cruz with a little corollary of mine for the other two missions of the north, advising that in all three a copy be made and put in the archives and that its publication be repeated annually as you direct. I will do the same (with God's help) in the future with the rest of the missions. *In all of them all possible efforts have been made with the greatest earnestness toward the remedy of this conspicuous damage*, and from now on, by virtue of your opportune proclamation, they will be continued with greater hope for the desired effect. The mission fathers of the missions at which you have stopped must have been very grateful to you for *having deigned to instruct the Indians yourself in the obligation of abstaining from such excess and the punishment they will incur if they do not comply*. That exhortation will no doubt give great weight to our own and will perhaps make them effective. I wish to thank you now for being of a mind to extend the same favor to the remaining missions. And with the mission fathers of all (the missions) I repeat that I am at your

disposition. God keep you in his Holy Grace.

Very sincerely yours

Father Fermín Francisco de Lasuén

The Governor's letter and proclamation were issued in Santa Barbara, indicating that grassland fires were considered a major problem in coastal Chumash territory. It is further noteworthy that old women were particularly implicated in the setting of such fires; women were the principal gatherers of seeds.

Fire suppression was not merely confined to proclamation, but was diligently put into practice. This is illustrated by another historic document of seven years later.

MISSION QUESTIONNAIRE

In 1798 a questionnaire was sent out to presidio comandantes inquiring about the treatment of California Indians by the Spanish padres, in response to accusations of cruelty which had been made by a former missionary at San Miguel (Bancroft 1886: 587-596; Engelhardt 1930: 566-600). The replies by Felipe de Coycochea, comandante of the Santa Barbara Presidio, were especially irksome to the missionaries, so they in turn prepared their own responses to the questionnaire. The replies made to two of the questions by Fr. Gregorio Fernández at Mission La Purísima are of interest (Fernández 1800). This mission was near Lompoc, in the northwest portion of Chumash territory, not far from the Point Arguello area visited by Crespi in 1769 and 1700.

Question 10. What types of diversions do the neophytes [baptized Indians] enjoy? What excursions are they allowed, so that they may gather seeds? For what length of time?

Answer. The neophytes are permitted all kinds of diversions which are popular among them. Likewise, half the year, or almost one-half the year, is granted them for gathering their wild seeds, in the various seasons.

Question 12. What sorts of punishments are

meted out to the neophytes? Differentiate for the sexes. For what sort of transgressions are they punished? Do the fathers have shackles, chains, stocks, and lockups, or whether they only make use of the means of punishment available to the members of the guard.

Answer [in part]. The misdeeds for which we fathers chastize the Indians thus are concubinage, theft, and running away. *When the transgressions are against the common good, like killing cattle, sheep, or firing pastures, which has occurred sometimes, the corporal of the guard is notified* [emphasis added].

Under the missions, the baptized Indians were permitted to continue gathering their wild seeds but prevented from setting the fires that (as will be shown below) promoted a more abundant harvest. The missionaries, military, and settlers understandably wished to discourage the grassland fires that destroyed grazing for their livestock and endangered settlements, although in some parts of California these same interests set fires in forests and chaparral to convert them to grassland (Heady 1977: 509; Pyne 1982: 416-418). Suppression of burning by the Spanish and their successors contributed to a decline in productivity of the native grassland and to encroachment of coastal sage scrub, and perhaps of chaparral, into grassland and savanna habitats (Aschmann 1976: 43-44). Invasion of European grasses, broadleaved weeds, and large herbivores, and the practice of agricultural cultivation, completed the destruction of the native grassland in coastal Chumash territory (Burcham 1957: 185-199; Heady 1977: 497-499). This drastic alteration of the environment probably contributed to a gradual abandonment of traditional seed foods by the Chumash, although certainly other factors came into play as well (Cook 1941).

Many other aspects of Chumash culture were lost under the mission system, but

vegetation burning was surely one of the first to die out, given the stringency of military enforcement. Even though some Chumash people attempted to go back to village life after the secularization of the missions in 1834, private ownership of their former lands prevented them from reviving all their old food-gathering practices. Thus, it is not surprising that the use of fire as an important hunting and gathering technique had been forgotten by the time ethnographers began interviewing Chumash survivors in the late 19th and early 20th centuries.

THE HARRINGTON NOTES

John P. Harrington, ethnographer and linguist, was the most thorough of the several anthropologists who collected data from living Chumash people. He worked in the Santa Barbara, Ventura, and Santa Ynez areas on several occasions from about 1912 until the 1950s. In what must be over 100,000 pages of field notes on the Chumash, Harrington recorded only one mention of vegetation burning and that was in an inland area. María Solares, an Ineseño woman of Yokuts-Chumash ancestry, said that:

. . . some of the Indians were burning chamiso³ one day near Mt. Pinos to hunt cottontails and jackrabbits, and the fire got beyond their control [Harrington n.d., cited by Horne 1981: 116-117].

It is uncertain whether this event involved Chumash people, since Mt. Pinos was an area jointly used by several groups, including Chumash, Kitanemuk, and Yokuts. Use of fire in this instance may have been instigated by one of these other groups, but elsewhere Harrington (1942: 6) did report that the Emigdiano Chumash used fire in driving antelopes into enclosures.

No accounts were found of burning as a hunting technique in the coastal Chumash area. Neither was burning of vegetation to promote growth of plants for human food

mentioned by any of Harrington's Chumash consultants. In fact, use of grass seeds was barely discussed by most, at least in comparison with the details provided on acorns and wild cherry pits (Timbrook 1982: 166). This may be an indication that native grasses had been substantially reduced in abundance by the late 19th century (by Harrington's consultants' lifetimes), an idea confirmed by other lines of evidence (Burcham 1957: 185-199). Plant specimens were collected in the Santa Barbara area by Chumash consultant Lucrecia García and are now preserved in the National Anthropological Archives, Smithsonian Institution. Of the 13 grass specimens, the only natives are three species of *Elymus* (observation by the senior author). Introduced grasses *Avena* and *Bromus* were said to have been pounded, leached and baked into bread in earth ovens (Craig 1967: 126). It is not clear whether the Spanish word "avena" was used by Harrington's Chumash consultants to refer to native grass species as well as to Mediterranean wild oats (*Avena* spp.).

Small seeds of flowering annuals were still remembered by Chumash people after the turn of the century (Craig 1967: 124-126). Chia (*Salvia columbariae*) is one of the best known of these, and it was frequently mentioned by Harrington's consultants as a staple food. The seeds were harvested in quantity and stored in baskets in the home. They were prepared by toasting and grinding into flour which was either eaten dry or mixed with water to form a gruel (Harrington n.d.). The question is often asked today where the Chumash got the quantities of chia they were reported to have eaten, because the plant is not common in the coastal area. *Salvia* species are among those known to occur after fire (see Table 1), and some California Indians burned chia gathering areas to improve productivity (Bean and Lawton 1973: xxi). Overgrazing and suburban development, as

well as the cessation of burning, have probably contributed to the decline in abundance of *Salvia columbariae* on the coastal side of the Santa Ynez Mountains; the plant is still found here in certain places under favorable conditions, but is not common overall.

Another species of seed plant mentioned by Harrington's consultants in Santa Barbara, Ventura, and Santa Ynez was one of the tarweeds, *Hemizonia ramosissima*, which was also prepared as pinole. Luisa Ygnacio told Harrington about 1912 that the Santa Barbara Chumash used to eat a great deal of these seeds, but by her day this food had gone out of use. She had seen it prepared just once by her mother-in-law, Mariña Ignacia, who had fixed it for José Venadero by toasting the seeds and then pounding them to flour. Luisa reported that the flour was black and dry, with a not disagreeable taste (Harrington n.d.). This plant is still common in fields along the coast (Smith 1976: 295).

Seeds of red maids (*Calandrinia* spp.) were formerly of great importance to the Chumash. Large quantities of these small, black seeds have been found in cemetery contexts in the coastal area. Excavations by Yarrow and Bowers for the 1876 Geographical Survey expedition uncovered a child burial in an olla filled with *Calandrinia* seeds—misidentified by a Mexican worker as chia—on Mescalitan Island in the Goleta Slough (Yarrow 1879: 36-37; Benson 1982: 56, 307). Phil Orr found 12 quarts of red maid seeds associated with a burial on Santa Rosa Island; these were radiocarbon dated to 600 ± 70 years B.P. (Orr 1968: 200). Similar finds have been made by other archaeologists in cemeteries on the mainland and channel islands (Ford 1887: 11-19; Orr 1968: 210; King 1969: 37; Smith 1976: 131; Abbott 1879: 78-80; Benson 1982: 84, 329).

Harrington's Chumash consultants stressed the use of red maids seeds, called "pil" in Spanish and *khutash* in Chumash, as offerings

and also as food (Harrington n.d.; Hudson et al. 1977: 55, 65; Hudson et al. 1978: 138). Red maids was one of several kinds of seeds (chia, acorns, and islay were the others) which were stored in large baskets in the home (Luisa Ygnacio in Harrington n.d.). Its importance is further indicated by the fact that its Chumash name, *khutash*, was the same as that of the Earth, which was regarded as the Indians' mother, "for she gave them their food" (Hudson et al. 1977: 37, 113). Coyote asked to be given *khutash* and ate it as he pounded it, according to one Chumash myth (Blackburn 1975: 204).⁴ Red maids, like chia, must have been much more common in coastal grasslands than it is today; *Calandrinia breweri* is much more abundant after burns and is a definite "fire follower" (Smith 1976: 131, and personal observation by the senior author). It was a food plant widely used throughout California (Heizer and Elsasser 1980: 243). The seeds were parched, pulverized, and pressed into cakes for eating (Barrett and Gifford 1933: 152-153).

Grassland plants were not only used for seeds, however. As already noted by Longinos, many kinds of green sprouts were eaten by the Chumash. Harrington's consultants mentioned several species consumed in this way. One of the most favored was clover (*Trifolium* spp.). Luisa Ygnacio said that the Indians used to eat it raw, "like a cow; not much—like we eat fruit now." When old Mariña Ignacia lay dying, she wanted to eat clover; perhaps she craved the comfort offered by a food from her childhood. Simplicio Pico of Ventura said they ate clover raw, like lettuce, and Mariña Solares of Santa Ynez said the Indians used to eat both the raw leaves and the seeds of clover (Harrington n.d.). Several species of *Trifolium* are commonly found in burns and in disturbed areas (Smith 1976: 177-180).

Harrington's notes reflect the changing Chumash diet in recent times. By the time of

his interviews in the 1910s and 1920s, most consultants were speaking of wild seeds and greens as things the old people used to eat, but which were no longer in common use. Burning as a food procurement technique was apparently unknown. Today, over half a century later, the possibility of completely understanding Chumash subsistence is even more remote. But when the ethnohistoric evidence we have presented is combined with botanical information, an interesting picture emerges.

PLANTS THAT FOLLOW FIRE

A list of the most common herbaceous plants that occur today in the coastal grasslands of the Chumash area was compiled with the help of knowledgeable local botanists.⁵ Plant species native to the area under consideration and that are known to have been eaten by the Chumash or by other California Indian peoples comprise 70 genera, as shown in Table 1. Of these 70 genera, about 35 occur after fire and an additional 15 reach their peak of abundance in areas that were burned the previous year. The latter are sometimes called "fire followers" (Smith 1956) or "pyrophytic endemics" (Hanes 1977: 433).

Plants found after grassland fires, and those that probably provided significant food resources for the Chumash, included grasses—especially perennial bunch grasses—and herbaceous plants in the sunflower, mustard, parsley, pea, buttercup, evening-primrose, sage, figwort, lily, and amaryllis families. Plant parts consumed included seeds, green leaves, shoots, and corms or bulbs.

Grasses that may have been of most importance before the introduction of weedy species include California brome (*Bromus carinatus*), ryegrasses (*Elymus condensatus*, *E. glaucus*, and *E. triticoides*), meadow barley (*Hordeum californicum*), coast range melic (*Melica imperfecta*), bluegrass (*Poa scabrella*),

needlegrasses (*Stipa pulchra*, *S. lepida*, and *S. cernua*), and perhaps others (Heady 1977: 495-496; Wayne Ferren, personal communication 1982). Several of these species have seed heads which shatter easily when ripe, so that harvesting with a seedbeater, as the Chumash did, would be quite efficient (Bean and Lawton 1973: xxxiv; Craig 1967: 125).

Bunch grasses produce more seeds if leaf growth is sufficient to manufacture food reserves which are stored in the roots of the plant (Burcham 1957: 226). Burning would remove dead thatch and enrich the soil, thereby promoting plant growth and seed production (Daubenmire 1968: 211; Horton and Kraebel 1955: 254). The optimal burning interval for bunch grasses varies between species and geographical locations (Daubenmire 1968: 250-254). Indians in some parts of California are said to have burned grasslands every year to improve the following year's seed harvest (Stewart 1951: 320). In the area under consideration, it is thought that bunch grasses would thrive and produce a good seed crop if burned every 3 to 5 years (Wayne Ferren, personal communication 1982). However, an annually burned stand of *Stipa pulchra* on Las Tunas Road in Santa Barbara was reported to be one of the finest stands of bunch grass in the vicinity (Wells 1962: 96).

Fire commonly favors forbs over grasses in both annual and perennial grasslands, so that herbs fill in the interstices between grass plants (Daubenmire 1968: 249). Broadleaved annuals which were of greatest significance to the Chumash for their seeds were chia (*Salvia columbariae*) and red maids (*Calandrinia* spp., especially *C. breweri*). The probable abundance of these plants in the coastal grasslands of Chumash territory was discussed above, and both occur most abundantly after fires. Seeds of several members of the sunflower family, particularly tarweeds (*Hemizonia* and *Madia* spp.), were also a significant resource. Many other seed plants were probably used to

Table 1

**COMMON HERBACEOUS PLANTS OF COASTAL GRASSLANDS IN CHUMASH
TERRITORY, WITH THEIR USES BY CALIFORNIA INDIANS**

Plant Genus	Family	Plant Parts Used by	
		Chumash	California Indians
Achillea	Asteraceae	roots, leaves	roots, leaves
Agoseris	Asteraceae	(SEEDS, LEAVES)	
Agropyron	Poaceae		SEEDS
Allium	Amaryllidaceae	BULBS	SEEDS, BULBS, LEAVES
Amaranthus (some I)	Amaranthaceae	(SEEDS, LEAVES)	SEEDS
Ambrosia	Asteraceae	leaves	leaves
Amsinckia	Boraginaceae	(SEEDS)	SEEDS
Anagallis (I)+	Caryophyllaceae	(leaves)	
Anthemis (I)	Asteraceae		leaves
Apiastrum +*	Apiaceae		STALKS
Apium (I)	Apiaceae	STALKS	
Aster	Asteraceae	(SEEDS)	
Astragalus	Fabaceae		FRUIT
Atriplex (some I)	Chenopodiaceae		SEEDS
Avena (I)+	Poaceae	SEEDS	SEEDS
Bloomeria +	Amaryllidaceae	(BULBS)	BULBS
Brassica (I)	Brassicaceae	LEAVES	SEEDS, LEAVES
Bromus (some I)+	Poaceae	SEEDS	SEEDS
Calamagrostis	Poaceae		SEEDS
Calandrinia +*	Portulacaceae	SEEDS	SEEDS, LEAVES
Calochortus +*	Liliaceae	BULBS	BULBS
Calystegia +*	Convolvulaceae		stalks, leaves
Camissonia +*	Onagraceae		SEEDS
Carex +	Cyperaceae		roots, leaves
Castilleja	Scrophulariaceae	(SEEDS)	SEEDS
Caucalis	Apiaceae		roots
Chaenactis +*	Asteraceae		SEEDS, leaves
Chenopodium (some I)	Chenopodiaceae	SEEDS, LEAVES, roots	SEEDS, LEAVES, roots
Chlorogalum +	Liliaceae	LEAVES, roots, leaves	ROOTS, LEAVES, roots, leaves
Chorizanthe +	Polygonaceae	(whole plant)	
Cirsium	Asteraceae	STALKS, LEAVES	STALKS, LEAVES
Clarkia +	Onagraceae		SEEDS
Collinsia +	Scrophulariaceae		
Conyza (I)+	Asteraceae	leaves	leaves
Croton	Euphorbiaceae	stems, leaves	stems, leaves
Cryptantha +*	Boraginaceae	(SEEDS)	
Cucurbita	Cucurbitaceae	fruit	SEEDS, fruit
Cyperus	Cyperaceae		SEEDS
Datura	Solanaceae	roots, seeds, leaves	roots, seeds, leaves
Daucus +*	Apiaceae	(roots)	ROOTS
Delphinium +	Ranunculaceae		LEAVES, FLOWERS
Dichelostemma +	Amaryllidaceae	BULBS	BULBS
Dodecatheon +	Primulaceae		ROOTS, LEAVES
Elymus +*	Poaceae	stems	SEEDS, stems
Epilobium +	Onagraceae		(SEEDS)
Eremocarpus	Euphorbiaceae		leaves

Table 1 (cont'd.)

Plant Genus	Family	Plant Parts Used by	
		Chumash	California Indians
Erigeron +	Asteraceae		roots
Eriogonum +	Polygonaceae	stems	STEMS, leaves, roots, stems
Erodium (I)	Geraniaceae	(SEEDS, LEAVES)	
Erysimum +	Brassicaceae		
Eschscholzia	Papaveraceae		LEAVES, FLOWERS, roots
Festuca +*	Poaceae		
Foeniculum (I)	Apiaceae	(STEMS)	
Fritillaria	Liliaceae		BULBS
Galium +	Rubiaceae		seeds
Gilia +*	Polemoniaceae		SEEDS
Gnaphalium +	Asteraceae	leaves	leaves
Grindelia	Asteraceae	whole plant	LEAVES, STEMS
Haplopappus +	Asteraceae		SEEDS, STEMS
Helenium	Asteraceae	whole plant	whole plant
Helianthus	Asteraceae		SEEDS
Hemizonia +	Asteraceae	SEEDS	SEEDS
Hesperocnide +	Urticaceae		
Heterotheca	Asteraceae	(SEEDS)	stems
Hordeum (some I)+	Poaceae	(SEEDS)	SEEDS
Hypochoeris (I)+	Asteraceae	LEAVES	
Juncus +	Juncaceae	stems	SHOOTS, SEEDS, stems, leaves
Lasthenia	Asteraceae		SEEDS, LEAVES
Layia +	Asteraceae	SEEDS	SEEDS
Lepidium +	Brassicaceae	SEEDS	SEEDS
Linanthus +	Polemoniaceae		whole plant
Linaria (some I)+	Scrophulariaceae		
Lomatium +	Apiaceae	ROOTS, roots	LEAVES, STEMS, ROOTS, roots
Lotus +*	Fabaceae	stems	LEAVES
Lupinus +*	Fabaceae	FRUIT, SEEDS	LEAVES, FLOWERS, whole plant
Madia +	Asteraceae		SEEDS
Malacothrix +*	Asteraceae		
Malva (I)	Malvaceae	SEEDS, LEAVES	leaves
Marah +	Cucurbitaceae	(LEAVES), seeds	SEEDS, roots, seeds
Marrubium (I)	Labiatae	leaves	leaves
Matricaria	Asteraceae	leaves	leaves
Melica	Poaceae		
Mimulus +	Scrophulariaceae		LEAVES, whole plant
Mirabilis	Nyctaginaceae		leaves
Monardella	Labiatae		LEAVES, STEMS, leaves, flowers
Montia +	Portulacaceae	LEAVES, SEEDS	STEMS, LEAVES, flowers
Muhlenbergia +*	Poaceae	stalks	stalks
Navarretia +	Polemoniaceae		whole plant
Nicotiana +	Solanaceae	leaves	leaves
Oenothera +	Onagraceae		LEAVES
Opuntia ^A (+)	Cactaceae	STEMS, FRUIT	STEMS, FRUIT
Orthocarpus	Scrophulariaceae		
Oryzopsis (I)	Poaceae		SEEDS
Oxalis (some I)	Oxalidaceae		leaves

Table 1 (cont'd.)

Plant Genus	Family	Plant Parts Used by	
		Chumash	California Indians
Paeonia +*	Paeoniaceae	roots	roots, seeds
Penstemon +	Scrophulariaceae		roots, stems, leaves
Perezia +*	Asteraceae	leaves	leaves
Phacelia +*	Hydrophyllaceae	(LEAVES) ^B	leaves
Plagiobothrys +	Boraginaceae		SHOOTS, FLOWERS
Plantago (some I)	Plantaginaceae	leaves	
Platystemon +	Ranunculaceae		LEAVES
Poa +	Poaceae		SEEDS
Polypogon (some I)	Poaceae		
Pteridium	Pteridiaceae	whole plant	SHOOTS, roots
Ranunculus +	Ranunculaceae		SEEDS
Raphanus (I)	Brassicaceae	(SEEDS, LEAVES)	
Rumex (some I)	Polygonaceae	LEAVES, SEEDS, STEMS, roots	LEAVES, SEEDS, roots
Salvia +	Labiatae	SEEDS, (SHOOTS), leaves	SEEDS, leaves
Sanicula +	Apiaceae		LEAVES, roots
Scrophularia	Scrophulariaceae	leaves	leaves
Senecio +	Asteraceae	(SEEDS)	
Sidalcea +	Malvaceae		PART UNSPECIFIED
Silene +*	Caryophyllaceae		part unspecified
Sisymbrium (I)	Brassicaceae		LEAVES
Sisyrinchium	Iridaceae		
Solidago	Asteraceae	leaves	leaves
Sonchus (I)	Asteraceae	LEAVES	
Stellaria +	Caryophyllaceae	(LEAVES)	
Stipa +	Poaceae		(SEEDS)
Thysanocarpus +	Brassicaceae		SEEDS
Trifolium +	Fabaceae	LEAVES, SEEDS	LEAVES, SEEDS
Urtica	Urticaceae	stems	LEAVES, stems
Xanthium	Asteraceae	LEAVES, leaves	
Zigadenus +	Liliaceae	leaves	leaves

(I) introduced (non-native) plant

+ plants that occur after fire (one or more species)

* plants that are most abundant after fire (one or more species)

Food uses of plants are listed in capital letters, non-food uses in lowercase letters.

Information that is not certain is enclosed in parentheses

Sources: Smith 1976; Heizer and Elsasser 1980; Sweeney 1956; Clifton Smith, personal communication 1983; Mary Junak, personal communication 1982; Harrington n.d.

^A*Opuntia* is thought to regenerate after fire (L. Benson 1969:168-170).

^B*Phacelia* leaves reported by Curtis (1959:141) as having been eaten raw, but this seems unlikely as they cause severe dermatitis in some persons.

a lesser degree.

Green shoots and leaves of clover (*Trifolium* spp.), miner's lettuce (*Montia perfoliata*), pigweed (*Amaranthus* spp.), and goosefoot (*Chenopodium* spp.), and probably other spe-

cies as well, were eaten by the Chumash in historic times. It is questionable whether these ever formed a significant portion of the diet, and as a seasonal food consumed in small amounts, greens were probably more import-

ant for enjoyment than for actual calories or vitamin content.

Another plant type of great importance to the Chumash, although not mentioned specifically in the ethnohistoric accounts of grassland burning, is that which forms underground bulbs or corms. Several members of the lily and amaryllis families produce such bulbs and are often seen in great profusion in savanna and chaparral the spring after a fire. This is in part a matter of increased salience when surrounding vegetative cover has been burned off, but the bulbs also sprout more vigorously and more of them flower the first year after a fire (Keeley et al. 1981: 1615). Because seedlings of these plants thrive in the more open post-fire vegetation, regular burning over a period of time would probably favor bulb-forming species (J. Sauer, personal communication 1983). Two such species, brodiaea (*Dichelostemma pulchellum*) and mariposa lily (*Calochortus* spp., especially *C. catalinae*), were harvested in huge quantities by the Chumash and many other California Indian groups (Harrington n.d.). Increased bulb production would be a beneficial side effect of fires set for other purposes rather than an immediate goal in itself, since it would be a gradual, long-term development.

Certain other plants used for purposes other than food are also encouraged by fire. Some are medicinal; others are basketmaking or construction material. Since the ethnohistoric accounts emphasize burning in connection with food species, these other plants will not be discussed in this paper, but they are included in the list of grassland plants in Table 1.

DISCUSSION

Contrasting views of the effects and frequency of fires before and after European arrival have been put forth in the literature. Some of the major points merit discussion here.

It has been stated that lightning was a far more important cause of fire in prehistoric California than humans were; that California Indians lacked both the labor force and the technological skills necessary to do the physical job of burning large tracts of vegetation in a systematic or purposeful manner; and that like all early peoples they regarded fire with a mixture of fear, reverence, and awe (Burcham 1974: 106, 111). The evidence presented in this paper clearly shows that these statements do not apply to the Chumash Indians and coastal grasslands within their territory. The documents quoted also answer questions about the reasons fires were set, address criticisms that insufficient use has been made of pre-20th-century accounts to assess the impact of aboriginal burning in California, and counter statements that fire suppression is exclusively a 20th-century policy.

Some have argued that the Chumash did not deliberately burn chaparral (e.g., Horne 1981: 111-123). The ethnohistoric documents quoted here should not be interpreted as conflicting with Horne's argument. We believe that grass fires could have readily spread into chaparral and had significant effects on the density and boundaries of that community, at least on the coastal side of the Santa Ynez Mountains. However, no evidence has been found to indicate that the Indians actually set fires in the chaparral itself. We cannot say for certain whether anthropogenic fires affected chaparral in interior Chumash territory; this may have been the case if inland valley grasslands and savannas were also burned, and Arrillaga's proclamation indicates they might have been. But regular burning may have had more significant effects on the distribution of coastal sage scrub than on chaparral (Richard Minnich, personal communication 1983).

Charcoal deposits in the Santa Barbara Channel have been interpreted to show that fires were less frequent prehistorically, or at

least that there was less net burning per unit area, per unit time (Byrne et al. 1977: 366). These data are still being analyzed. We suggest that even if precipitation and wind deposited burned material in the sea in a regular, predictable pattern after every fire, grassland burning would not produce enough ash and charcoal to be visible in the varved cores from the Santa Barbara Channel floor. Other recent research has shown that fires were probably more frequent but smaller before suppression policies were enacted in the last century (Minnich 1983). That grassland fires were frequent and widespread in early historic times is indicated by the explorers' comments about burned fields and by the necessity of a proclamation by the governor and military enforcement to stop the Indians from "firing the pastures." We suspect that the practice was one of some antiquity, but further archaeological investigation is needed to demonstrate this. Close observation of the effects of escaped campfires may have led the Chumash to experiment with deliberate burning of grasslands.

The increase in extent and density of chaparral since European colonization of southern California has been noted by many authors, and two contradictory sorts of explanations of this observed phenomenon have been offered. On the one hand it is said to be the result of more frequent fires in recent times (Burcham 1974: 219-220), and on the other as the result of fire suppression (C. Sauer 1952: 17; Lewis 1973; Aschmann 1976: 41; Stewart 1951: 318; Minnich 1983). In the botanical literature, the debate still rages over the successional status of chaparral and its relation to coastal sage scrub and grassland after fire (Hanes 1977: 447; Mooney 1977: 476-478; Axelrod 1978: 1119, 1127). The ethnohistoric evidence shows that fires were more frequent in Mission and pre-Mission times, at least in grasslands. It can be argued that although some shrubs sprout

after fires, if they were burned often enough they might be thinned out and eventually killed. While destructiveness of any one fire would depend on temperature and humidity conditions, a long regime of regular burning could increase the spacings between shrubs—areas that are normally occupied by herbs and grasses (Sweeney 1968: 118; Hanes 1977: 433; Heady 1977: 501). Eventually, then, the shrubs would die out and the vegetation type in any one spot would be completely modified. Fire is widely used as a means of maintaining grass dominance in environments where in its absence woody vegetation would overwhelm grass; woody species that do not sprout from their roots can be either eliminated or reduced to a thin stand of small individuals by repeated burning (Sampson 1944; Daubenmire 1968: 248; Heady 1977: 501). This process would be more likely to occur in coastal sage scrub than in chaparral (Richard Minnich, personal communication 1983).

Decreased fire frequency should allow seeds normally brought in from adjacent shrub communities by animals or by natural dispersal mechanisms a chance to grow and shade out grasses and herbs (Sauer 1952: 17; Sweeney 1956: 171). The result should then be recolonization, or "secondary succession" (Burcham 1957: 220), of areas that had been maintained as grassland by burning, but that were actually better suited to chaparral or coastal sage scrub in terms of their soils and topography.

Perhaps future analysis of charcoal and pollen deposits in sloughs and marshes along the Santa Barbara coast will provide more information about the relative abundance of plant species and communities in prehistoric times.

The evidence presented here strongly suggests that the Chumash understood the connection between fire and the growth of certain useful plants, and that their principal

reason for setting fires was to encourage the growth of seed plants, bulbs, and green shoots for human consumption. Of these food resources, seeds were most important in Chumash diet because of the quantities that could be obtained and because they could be stored for long periods of time. It is our opinion that the Chumash could have obtained the large quantities of chia and red maids seeds found as burial accompaniments and reported in the ethnographic literature only by burning the coastal grassland and savanna.

Fires were set in late summer after seeds were collected, but probably no attempt was made to burn the entire coastal plain every year. In fact, it might not be possible to burn such a large area so often. Fires require a certain amount of fuel for their spread; plant growth, and therefore fuel build-up, is related to rainfall. Fires in grassland and coastal sage scrub are at present larger after wet winters, but are more likely to spread into chaparral after dry winters (Minnich 1983: 1291). Crespi's description of grass burned in some places and not in others supports the idea that some patches were burned one year, others the next. This would allow enough time for dry fuel to accumulate and support a fire, so that the optimal burning of each patch every few years was probably achieved.

The ethnohistoric evidence is less clear on the acquisition of animal foods as a motive for setting fires among the Chumash. If the coastal Chumash were using fire in game drives—and it is not certain that they were—it was most likely for hunting small animals such as rabbits or rodents, which are abundant in grassland (Burcham 1957: 189). Deer do not aggregate in herds suitable for hunting with fire, but the Chumash would surely have taken advantage of any opportunity to hunt deer and smaller game attracted by increased green forage resulting from fires. The usual methods of bow hunting with the aid of deer disguises would be most appropriate in grass-

land-chaparral ecotones where shrubs and herbs sprouting after fires provide succulent browse for the animals (Wirtz 1974: 17; Bell 1974; Lewis 1973: 28), and also provide both camouflage and ease of movement for the hunter.

CONCLUSIONS

Increased plant food yield and improved hunting were probably both seen by the Chumash as good reasons for burning vegetation. Both involve the significant process of performing an activity at one point in time in order to obtain desired results at another point in the future, some months or a year away. That the Chumash regularly engaged in long-term time reckoning and advance planning is shown by their development of a calendar system based on astronomical observations keyed to cycles of earth and sky (Hudson and Underhay 1978). As mentioned above, the Chumash could have developed the idea of burning to increase plant and animal resources from observing the effects of escaped fires near their settlements. It is arguable that, for the Chumash at least, Bean and Lawton's hypotheses about the rise of cultural complexity in aboriginal California can be taken one step farther: burning was not an "energy extraction process" in the sense of exploiting something that already existed, but truly a food production technique more efficient than agriculture in this ecological setting. Indians were allowed to continue gathering wild seeds in Mission times because agriculture could not support the neophyte population (Coombs and Plog 1974).

The probable effects of regular burning on the vegetation of coastal Chumash territory over a long period of time have significant implications for attempts at reconstruction of the aboriginal environment, both here and elsewhere. The grassland and savanna which dominated the landscape of the Santa Barbara plains and foothills when the Spanish explor-

ers first arrived have now been replaced by coastal sage scrub as well as much non-native vegetation, and chaparral has apparently increased its density and extent, since grassland burning has been suppressed for nearly 200 years. A similar situation may have prevailed in the Santa Maria and Santa Ynez valleys as well, although specific data are lacking for these interior grasslands. On the other hand, in some places—for example the San Gabriel River to the south—very thick vegetation was described by Crespi in the same areas where chaparral is found today (Burcham 1957: 94). Pollen records indicate that chaparral and coastal sage scrub have only dominated the local landscape for the last 2300 years, having succeeded coniferous forest and oak woodland; this trend may have been related to human activities as well as to climate changes (Heusser 1978: 673; Schlesinger et al. 1982: 76). The point is that archaeologists and others should be very cautious in assuming that plant resources available to the inhabitants of any site hundreds or thousands of years ago were the same as those found in the same area today.

Vegetation burning by hunter-gatherers was a widespread practice in many parts of the world, from Europe to Australia (Sauer 1952; Stewart 1951, 1956; Lewis 1973; Gould 1980: 81-82; Pyne 1982: 66ff.). In the midwestern United States, tall-grass prairies were maintained by natural fires or those set by Indians, and with fire suppression by settlers and increased grazing the prairies were later colonized by trees (Stewart 1951). The pampa of Argentina is also thought to have been a culturally-induced vegetation type (Schneider 1927).

It has been said that the extensive records of Indians setting fire to fields and forests throughout North America should make it apparent that this activity was an important ecological factor in the development and maintenance of many types of so-called

“natural” vegetation (Stewart 1951: 319; Day 1953; Sauer 1952: 12; Daubenmire 1968: 211), and that the general effect of their use of fire was to replace forests with grasslands (Pyne 1982: 69; Sauer 1950). The practice of vegetation burning by the Chumash should be added to the list of important ecological factors in southern California.

ACKNOWLEDGEMENTS

We thank the following people for providing information and for commenting on the manuscript (and hope that they will not be held responsible for any errors in interpretation we may have made): Fr. Virgilio Biasiol, David Brokensha, Alan K. Brown, Frank Davis, Wayne R. Ferren, Ray Ford, Richard I Ford, Michael Glassow, John W. Johnson, Mary Junak, Chester King, Harry Lawton, Richard A. Minnich, Karen Osland, Jonathan Sauer, Clifton Smith, Phillip Walker, and Richard S. Whitehead.

NOTES

1. “. . . clumps of very tall, broad grass . . . so tall that it topped us on horseback by a yard” surely refers to giant wild rye, *Elymus condensatus*. The grasses described as “very fine” are unidentified, but could be *Stipa pulchra*. Saltgrass, *Distichlis spicata*, is reported for the Guadalupe Dunes. Effects of burning may have differed with grass species and habitat involved (Frank Davis, personal communication 1983).

2. Identifications of the wildflowers listed by Crespi are difficult because he applied the names of common Spanish garden plants to unfamiliar plants he found growing in California (Alan Brown, personal communication 1983). The authors have discussed the matter with Dr. Brown, who translated the passage, and feel the following identifications are probably the best:

“yellow violets or gillyflowers”—*Viola pedunculata*, although “gillyflower” (Spanish “aleli”) may refer to *Dianthus*.

“larkspur”—possibly *Delphinium*, but more likely *Lupinus*.

“poppies”—Spanish “cardosanto” refers to prickly poppy, *Argemone*, in Mexico. That plant would

not be found near Point Arguello, so Crespí may have been trying to describe California poppy (*Eschscholzia californica*). But the two species are not similar in appearance, and the senior author feels Spanish "cardo," thistle, may have referred to *Cirsium brevistylum*, which is common in the area Crespí visited (Smith 1976: 282).

"sage"—probably chia (*Salvia columbariae*) rather than any of the woody species, since "not a bush" was seen.

3. "chamiso" can mean just brush in general, or a particular shrub species, *Adenostoma fasciculatum*. This plant does not grow near Mt. Pinos, so Mariá probably meant just bushy vegetation or perhaps basin sagebrush (*Artemisia tridentata*).

4. The identification of *qutaš* as chia in the text (Blackburn 1975: 207) is incorrect since many consultants refer to chia *and khutash*. The Barbareño Chumash word for chia is *'ilepesh* (Harrington n.d.).

5. Mary Junak (Santa Barbara Botanic Garden), Wayne Ferren (University of California, Santa Barbara, Herbarium), Clifton Smith (Santa Barbara Museum of Natural History).

REFERENCES

- Abbott, C. C.
1879 Mortars and Pestles. Report of the United States Geographical Surveys West of the 100th Meridian, Vol. VII: 70-92. Washington: United States Government Printing Office.
- Anderson, Eugene N., Jr.
1978 A Revised, Annotated Bibliography of the Chumash and Their Predecessors. Socorro: Ballena Press Anthropological Papers No. 11.
- Aschmann, Homer
1959 The Evolution of a Wild Landscape and its Persistence in Southern California. *Annals, Association of American Geographers* 48(3): 250-251.
1976 Man's Impact on the Southern California Flora. Symposium Proceedings: Plant Communities of Southern California, June Lattig, ed., pp. 40-48. California Native Plant Society Special Publication No. 2.
- Axelrod, D. I.
1978 The Origin of Coastal Sage Vegetation, Alta and Baja California. *American Journal of Botany* 65:1117-1131.
- Bancroft, Hubert H.
1886 History of California, Vol. I. 1542-1800. San Francisco: The History Company.
- Barrett, S. A., and E. W. Gifford
1933 Miwok Material Culture. *Bulletin of the Milwaukee Public Museum* II (4).
- Bean, Lowell J., and Harry W. Lawton
1973 Some Explanations for the Rise of Cultural Complexity in Native California, with Comments on Agriculture and Protoagriculture. In: *Patterns of Indian Burning in California: Ecology and Ethnohistory*, by Henry T. Lewis, pp. v-xlvii. Ramona: Ballena Press Anthropological Papers No. 1.
- Bell, Margaret M.
1974 Chaparral Fuel Modification and Wildlife. In: *Symposium on Living with Chaparral, Proceedings*, Murray Rosenthal, ed., pp. 167-172. San Francisco: Sierra Club.
- Benson, Arlene S.
1982 The Noontide Sun: The Fieldnotes and Unpublished Manuscripts of the Rev. Stephen Bowers. Master's thesis, California State University, Northridge.
- Benson, Lyman
1969 The Native Cacti of California. Stanford: Stanford University Press.
- Biswell, H. H.
1967 The Use of Fire in Wildland Management in California. In: *Natural Resources: Quality and Quantity*, S. V. Ciriacy-Wantrup and J. J. Parsons, eds., pp. 71-86. Berkeley: University of California Press.
- Blackburn, Thomas C.
1975 December's Child: A Book of Chumash Oral Narratives. Berkeley: University of California Press.
- Bolton, Herbert E., ed., tr.
1926 Historical Memoirs of New California, by Francisco Palou. Berkeley: University of California Press.
- Brown, Alan K.
n.d. Unpublished Translation of Portions of Crespí's Journals. On file at Santa Barbara Mission Archive Library, Reference Files MS. 720.
1965 The Various Journals of Juan Crespí. *The Americans* 21(4):375-398.
1967 The Aboriginal Population of the Santa Barbara Channel. Berkeley: University of

- California Archaeological Survey Reports No. 69.
- Burcham, L. T.
1957 California Range Land: An Historico-Ecological Study of the Range Resources of California. Sacramento: State of California, Department of Natural Resources, Division of Forestry.
- 1974 Fire and Chaparral Before European Settlement. In: Symposium on Living with Chaparral, Murray Rosenthal, ed., pp. 101-120. San Francisco: Sierra Club.
- Burrus, Ernest J., S.J.
1967 Diario del Comandante Fernández Rivera y Moncada. Vol. I. Colección Chimalistae de Libros y Documentos Acerca de la Nueva España, No. 24. Madrid: Ediciones José Porrúa Toranzas.
- Byrne, R., J. Michaelson, and A. Soutar
1977 Fossil Charcoal as a Measure of Wildfire Frequency in Southern California: a Preliminary Analysis. In: Proceedings of the Symposium on the Environmental Consequences of Fire and Fuel Management in the Mediterranean Ecosystem, H. A. Mooney and C. E. Conrad, eds., pp. 361-367. Washington: United States Forest Service, General Technical Report WO-3.
- Clar, C. Raymond
1959 California Government and Forestry, Vol. I. Sacramento: California Division of Forestry.
- Cook, Sherburn F.
1941 The Mechanism and Extent of Dietary Adaptation among Certain Groups of California and Nevada Indians. Ibero-Americana: 18.
- Coombs, Gary, and Fred Plog
1974 Chumash Baptism: an Ecological Perspective. In: 'Antap: California Indian Political and Economic Organization, L. J. Bean and T. F. King, eds., pp. 137-153. Ramona: Ballena Press.
- Craig, Steve
1967 The Basketry of the Ventureño Chumash. Los Angeles: University of California Archaeological Survey Annual Report 1966-1967: 82-149.
- Curtis, Freddie
1959 Arroyo Sequit: Archaeological Investigations of a Late Coastal Site in Los Angeles County, California. Archaeological Survey Association of Southern California Paper No. 4.
- Daubenmire, R.
1968 Ecology of Fire in Grasslands. *Advances in Ecological Research* 5:209-266.
- Day, G. M.
1953 The Indian as an Ecological Factor in the Northeastern Forest. *Ecology* 34:329-346.
- Dibblee, T. W.
1976 Geology of Santa Barbara County and Its Influence on Vegetation. In: A Flora of the Santa Barbara Region, California, by Clifton F. Smith, pp. 7-13. Santa Barbara: Santa Barbara Museum of Natural History.
- Englehardt, Zephyrin, O.F.M.
1930 The Missions and Missionaries of California, Vol. II. Upper California. Santa Barbara: Mission Santa Barbara (second edition).
- Fernández, Gregorio, O.F.M.
1800 Questions Sent by the Governor of California, Don Diego de Borica, to the Comandantes, and the Replies of the Fathers of Mission Purísima. Translation by Maynard Geiger, O.F.M. Manuscript on file at the Santa Barbara Mission Archive Library.
- Ford, H. C.
1887 Notes on Excavations Made in Indian Burial Places in Carpinteria. Report of the Proceedings of the Santa Barbara Society of Natural History, pp. 11-19.
- Gould, R. A.
1980 Living Archaeology. Cambridge: Cambridge University Press.
- Griffin, James R.
1977 Oak Woodland. In: Terrestrial Vegetation of California, M. G. Barbour and J. Major, eds., pp. 383-413. New York: John Wiley & Sons.
- Hanes, T. L.
1971 Succession After Fire in the Chaparral of Southern California. *Ecological Monographs* 41:27-52.
- 1977 California Chaparral. In: Terrestrial Vegetation of California, M. G. Barbour and J. Major, eds., pp. 417-469. New York: John Wiley & Sons.
- Harrington, John P.
n.d. Unpublished fieldnotes on file at National Anthropological Archives, Smithsonian Institution.

- 1942 Culture Element Distributions: XIX, Central California Coast. University of California Anthropological Records 7:1-46.
- Heady, Harold F.
1977 Valley Grassland. In: Terrestrial Vegetation of California, M. G. Barbour and J. Major, eds., pp. 491-514. New York: John Wiley & Sons.
- Heizer, Robert F., and Albert B. Elsasser
1980 The Natural World of the California Indians. California Natural History Guides No. 46. Berkeley: University of California Press.
- Heusser, Linda
1978 Pollen in the Santa Barbara Basin, California: a 12,000-Year Record. Bulletin of the Geological Society of America 89:673-678.
- Horne, Stephen P.
1981 The Inland Chumash: Ethnography, Ethnohistory and Archaeology. Doctoral dissertation, University of California, Santa Barbara.
- Horton, J. S., and C. J. Kraebel
1955 Development of Vegetation After Fire in the Chamise Chaparral of Southern California. Ecology 36:244-262.
- Hudson, Travis, and Thomas Blackburn
1982 The Material Culture of the Chumash Interaction Sphere. Vol. I: Food Procurement and Transportation. Los Altos: Ballena Press Anthropological Papers No. 25.
- Hudson, T., T. Blackburn, R. Curletti, and J. Timbrook, eds.
1977 The Eye of the Flute: Chumash Traditional History and Ritual as Told by Fernando Librado *Kitsepawit* to John P. Harrington. Santa Barbara: Santa Barbara Museum of Natural History.
- Hudson, T., J. Timbrook, and M. Rempé
1978 Tomol: Chumash Watercraft as Described in the Ethnographic Notes of John P. Harrington. Socorro: Ballena Press Anthropological Papers No. 9.
- Hudson, Travis, and Ernest Underhay
1978 Crystals in the Sky: An Intellectual Odyssey Involving Chumash Astronomy, Cosmology, and Rock Art. Socorro: Ballena Press Anthropological Papers No. 10.
- King, Linda B.
1969 The Medea Creek Cemetery (4-LAn-243): an Investigation of Social Organization from Mortuary Practices. Los Angeles: University of California Archaeological Survey Annual Report 1968-1969:23-68.
- Lewis, Henry T.
1973 Patterns of Indian Burning in California: Ecology and Ethnohistory. Socorro: Ballena Press Anthropological Papers No. 1.
- Minnich, Richard A.
1983 Fire Mosaics in Southern California and Northern Baja California. Science 219:1287-1294.
- Mooney, Harold L.
1977 Southern Coastal Scrub. In: Terrestrial Vegetation of California, M. G. Barbour and J. Major, eds., pp. 471-489. New York: John Wiley & Sons.
- Keeley, Sterling C., Jon E. Keeley, Steve M. Hutchinson, and Albert W. Johnson
1981 Postfire Succession of Herbaceous Flora in Southern California Chaparral. Ecology 61(6):1608-1621.
- O'Connell, James F.
1974 Review of Patterns of Indian Burning in California: Ecology and Ethnohistory, by Henry T. Lewis. Journal of California Anthropology 1(1):118-120.
- Orr, Phil C.
1968 Prehistory of Santa Rosa Island. Santa Barbara: Santa Barbara Museum of Natural History.
- Pyne, Stephen
1982 Fire in America: A Cultural History of Wildland and Rural Fire. Princeton: Princeton University Press.
- Sampson, A. W.
1944 Plant Succession on Burned Chaparral Lands in Northern California. Berkeley: University of California Agricultural Experiment Station Bulletin 55.
- Sauer, Carl O.
1950 Grassland Climax, Fire, and Man. Journal of Range Management 3:16-20.
1952 Agricultural Origins and Dispersals. New York: American Geographical Society.
- Sauer, Jonathan
1977 Fire History, Environmental Patterns, and Species Patterns in the Santa Monica Mountain Chaparral. In: Proceedings of the Symposium on the Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems, H. A. Mooney

- and C. E. Conrad, eds., pp. 383-386. Washington: United States Forest Service General Technical Report WO-3.
- Schlesinger, W. H., J. T. Gray, D. S. Gill, and B. E. Mahall
1982 *Ceanothus megacarpus* Chaparral: a Synthesis of Ecosystem Processes During Development and Annual Growth. *The Botanical Review* 48(1):72-117.
- Schmeider, Oscar
1927 The Pampa: a Natural or Culturally Induced Grass-land? University of California Publications in Geography 2(8):255-270.
- Simpson, Lesley Byrd, ed., tr.
1961 *Journal of José Longinos Martínez: Notes and Observations of the Naturalist of the Botanical Expedition in Old and New California and the South Coast, 1791 - 1792.* San Francisco: John Howell Books.
- Smith, Clifton F.
1956 *Botanizing on the Burn.* Santa Barbara Museum of Natural History Quarterly 31(3): 33-39.
1976 *A Flora of the Santa Barbara Region, California.* Santa Barbara: Santa Barbara Museum of Natural History.
- Stewart, Omer C.
1951 *Burning and Natural Vegetation in the United States.* *Geographical Review* 41(2): 317-320.
1956 *Fire as the First Great Force Applied by Man.* In: *Man's Role in Changing the Face of the Earth*, W. L. Thomas, ed., pp. 115-330.
- Sweeney, J. R.
1956 *Responses of Vegetation to Fire: a Study of the Herbaceous Vegetation Following Chaparral Fires.* University of California Publications in Botany 28:143-250.
- 1968 *Ecology of Some "Fire-type" Vegetations in Northern California.* *Proceedings of the Tall Timbers Fire Ecology Conference* 7:111-125. Tallahassee: Tall Timbers Research Station.
- Timbrook, Jan
1982 *Use of Wild Cherry Pits as Food by the California Indians.* *Journal of Ethnobiology* 2(2):162-176.
- Vogl, R. J.
1968 *Fire Adaptations of Some Southern California Plants.* *Proceedings of the Tall Timbers Fire Ecology Conference* 7:79-109. Tallahassee: Tall Timbers Research Station.
- Wells, Philip V.
1962 *Vegetation in Relation to Geological Substratum and Fire in the San Luis Obispo Quadrangle, California.* *Ecological Monographs* 32(1):79-103.
- Wirtz, William O., II
1974 *Chaparral Wildlife and Fire Ecology.* In: *Symposium on Living with Chaparral*, Murray Rosenthal, ed., pp. 7-18. San Francisco: Sierra Club.
- Yarrow, H. C.
1879 *Report Upon the Operations of a Special Party for Making Ethnological Researches in the Vicinity of Santa Barbara, California.* In: *Report of the United States Geographical Surveys West of the 100th Meridian, Vol. VII:* 32-47. Washington: United States Government Printing Office.

