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Author
Jordan, Timothy A.

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Ecological and Cultural Contributions of Controlled Fire Use by Native Californians: A Survey of Literature

TIMOTHY A. JORDAN

Prescribed burning of the countryside was widely practiced by Native Californians. The application of fire as a tool of land management resulted in greater environmental resources that served as food, forage for game, basketry and other plant material products, and medicines. Fire provided many benefits to the environment by stimulating plant growth, providing nutrients to the soil, eliminating plant competition and insect infestations, and controlling overgrowth. Because of their fire management activities, California Indian groups were able to support larger populations and greater population densities than hunter-gatherer subsistence methods would have otherwise been able to accomplish.

There is extensive literature on the subject of fire use in Native Californian land management reaching back to the 1920s, though the foundations for analysis of this topic were laid only in the 1970s. The more recent sources propose that Native Californians used fire as a tool of land management to sustain the populations that existed prior to Euro-American contact. Much of this work draws from ethnohistorical data and places significant emphasis on encouraging game populations. Ecological studies are also relevant to this study.

Archaeological data further supports the hypothesis that Native Californian groups used fire as a means of environmental management. These studies offer scientific evidence showing that forests experienced frequent, low-intensity fires during aboriginal times which were likely attributable to human ignition, either through records of fire-scars, charcoal and pollen deposits in the earth, material remains, or environmental effects which could not have been produced otherwise.

Timothy Jordan is a recent graduate of San Francisco State University's Department of Anthropology. He currently resides in Vacaville, California.

More recent research examines how fire disturbances would have directly affected plant species in aboriginal times. This research is comprehensive. It draws from ethnohistory, ethnography, anthropology, ecology, and places a strong emphasis on fieldwork, thereby taking earlier approaches a step further by seeking to understand how the environment's reaction to fire proved to be beneficial to the Native populations and the plant resources they were cultivating. This essay will provide a brief history of the literature regarding the use of fire for land management in Native California, illustrating the ways in which theory pertaining to this issue has changed over the past twenty-five years as well as to show changes in the methodology with which this topic has been approached. In addition, this essay will discuss the ecological effects that resulted from the application of fire by Native Californians.

RESEARCH ON THE USE OF CONTROLLED FIRES AS ENVIRONMENTAL MANAGEMENT TOOL

Omer Stewart, in an early article on the subject of indigenous burning, states that "the influence of burning on vegetation is well known, [but] it is not ... fully understood." Stewart proposes that burning by Native peoples greatly influenced the vegetation present at the time of Euro-American contact and that its effects can still be seen today in the American landscape. In fact, fire is described as "the critical factor in determining the 'natural' vegetation observed by the first Europeans."[1] Tall-grass prairies were created and maintained by the use of fire. Stewart cites Shantz, who explained that, "fires have in all probability protected the grassland from the encroachment of the forests. Aided by high winds ... fires swept with great rapidity across ... the prairies and plains.... Trees and shrubs are killed by fires and as a consequence the grasses are able to maintain themselves on land which would support a good forest growth if the trees were adequately protected." Many of the grasslands were becoming covered with chaparral, as cattle grazing reduced the grasses necessary to carry a fire. Stewart cited Storer, who reported "the restriction of burning in forests, and especially chaparral areas, [is] leading in some instances to replacement of grassland by chaparral."[2]

Stewart contended that Indians must have been burning the landscape prior to Euro-American contact to create the diverse terrain found in California. He stated, "Indian burning ... was almost universal" and over two hundred ethnohistorical accounts that mention the practice have been found. Cabeza de Vaca described in 1528 how fire was being used to flush game from bushes (see p. 5 of this article); to encourage the growth of desirable plants, specifically bushes that were a food source; as an aid in warfare; and simply to facilitate travel by keeping overgrowth down.[3]

In 1968 Robert Daubenmire released an ecological study regarding grassland fires. Daubenmire reported, "in recent years botanists have come to realize that a surprisingly large portion of natural vegetation owes much of its character to the frequency of man-induced fires." Daubenmire emphasizes that "wherever plants grow close enough together to carry a conflagration, fire can be a significant component of the biotic environment."[4] Prior to this

study it was believed that fire was not beneficial to the environment. Daubenmire found that "fire is not always detrimental, and under the right circumstances desirable effects can be maximized with undesirable influences prevented." These maximized desirable effects proved useful in providing more food and plant material to tribes. Native tribes learned at a very early point in their inhabitancy of California that there were "advantages of the use of vegetation fires in driving game animals to their destruction, or bringing in succulent new growth to attract grazers and facilitate their slaughter."[5]

GROUNDBREAKING RESEARCH BY LEWIS, AND BEAN AND LAWTON

In 1973 Native Californian fire use and the resulting effects on the environment were directly addressed by Henry T. Lewis, who proposed that Native Californians did not just use fire to drive game from bushes, but also to improve grass, chaparral, and forest environments.[6] Lewis acknowledged that Native peoples must have been well aware of the ecological effects of fire, be it the result of natural or man-made ignition, since such disturbances affected day-to-day subsistence. Tribes would have to adapt quickly to fire disturbances or else risk the survival of the group.

Lewis criticizes Stewart's reliance on ethnohistorical references to support his theories regarding Native Californian burning, as those accounts did not explain the relationship of Native peoples to the environment. In his article, Lewis "makes use of both general ecological theory and specific environmental field studies to reconstruct certain patterns of aboriginal behavior in selected habitats." Previous work on this subject only notes that Native Californians were using fire. However, "to simply note that Indians used fire to modify their environments is no more an ecological generalization than to note that all farmers use plows. Instead, to be ecological it must be shown how the aboriginal use of fire was a factor within a system of environmental relationships and that it functioned in a number of ways."[7]

Lewis found that if "regular grass fires are maintained mature blue oaks are not adversely affected ... [and] the production of both acorns and lea[ves] increased as a result of the reduced competition from the thinned understory of brush." Burning disturbances actually increase oak productivity and the supply of acorns available for consumption. Acorns "provided the main subsistence resource for all Indian groups within the areas examined."[8] These areas ranged from as far north as the Oregon border to as far south as present-day Los Angeles and from the Pacific Coast to the eastern Sierra Mountains.

Burning also increased the food supply by providing new, protein-rich forage for game, as Daubenmire suggested. Chaparral in California is very thick, with a wide variety of shrub species. Many of the species in this growth have adapted to fire by releasing seeds after such a disturbance. After a fire "sprouting varieties of brush rapidly return with new, highly nutritious growth attractive to browsing animals. . . . The secondary succession initiated by fire results in an overall increase in the production of shrubs and herbaceous plants, with both direct and indirect benefits for hunting and gathering."[9]

Lewis was the first person to "employ a systems approach to present the first geographically broad and ecologically oriented demonstration of a primary means of environmental manipulation used by ... California Indian groups to increase plant and animal resources." The theory presented by Lewis allowed for a more thorough examination of subsistence patterns of Native Californians. Bean and Lawton, shortly following the publication of Lewis' article, were able to "provide a more adequate explanation than previously presented for the failure of agriculture to spread across the state prior to European contact."[10]

Bean and Lawton questioned the need for agriculture and referred to another article by Lewis, which supported this position, stating, "we must ignore the evolutionary assumptions that the development of agriculture was somehow natural and desirable. Instead of viewing agriculture as an imminent goal of human evolution, we should rather ask the question: Why should hunters and gatherers become agriculturalists?"[11]

Timbrook, Johnson, and Earle state that "true agriculture was not adopted by most aboriginal peoples in the state because it would have been not only unnecessary but a step back in efficiency."[12] According to Bean and Lawton agriculture was not needed because aboriginal burning provided a variety of foods such as acorns and berries, as well as increased browse for deer and other game, which also served as a food source. Because of the increased amount and quality of browse the numbers of herbaceous animals were greater. Ethnohistorical accounts by Spanish missionaries often note the high numbers of animals present in the countryside.[13]

Bean and Lawton state that Lewis forced a reevaluation of subsistence patterns in aboriginal California. The burning of the environment, in addition to proto-agricultural techniques such as building reservoirs and irrigation ditches, are not typical activities of hunter-gatherer societies. The "technological processes and complex social organizations of California's hunters and gatherers were integrated with value systems which encouraged increased productivity and the acquisition of surpluses."[14] The acquisition of food surpluses is a direct cause for an increase in population, and with larger populations, increased social complexity. Surpluses gained through indigenous burning were a significant factor in the development of larger Indian societies with greater cultural development than found in hunter-gatherer groups.

Lewis, and Bean and Lawton built the foundations for advanced studies on the use of fire by Native Californians. The 1978 edition of *The Handbook of North American Indians* features a brief section on the effects of fire-use on the environment. The section acknowledges that Indians used fire as a tool of environmental management and that this insight had been provided primarily by Lewis. Baumhoff states that fire use controlled the "growth of seed-producing grasses and also facilitate[d] hunting."[15]

Baumhoff cites Biswell, who conducted a study comparing burned chaparral belts with overgrown belts. Biswell found that "counts of deer in the burned area showed a summer population density of about 98 per square mile after the initial burning treatment. This rose to 131 in the second year and dropped to 84 in the fifth and sixth years. In the dense, untreated brush the

summer density was only 30 per square mile." Biswell explains that this density results "after spring [when] new sprouts [on bushes] appear in three or four weeks and supply highly protein-rich browse for deer during dry summer months."[16]

Timbrook, Johnson, and Earle examined the works by Lewis, and Bean and Lawton that 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." The authors of this article examine Chumash burning activities "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." It has been estimated that the Chumash population had reached 15,000 people at the time of Spanish contact.[17] Their article brings attention to the ethnohistorical evidence that indicates the Chumash were deliberately setting fires, and that these fires had significant long-term environmental effects.

There are many examples of ethnohistorical accounts that describe indigenous burning. In 1528 we find an account by the Spaniard, Cabeza de Vaca, who wrote, "the Indians go around with a firebrand, setting fire to the plains and timber ... to deprive the animals of pasture, compelling them to go where the Indians want." In 1769 Fray Juan Crespi traveled from San Diego to San Francisco and "described grassy hills and valleys and reported evidences of burning by Indians in many areas today now covered with chaparral."[18] Father Crespi wrote in one entry that the area was "well covered with very fine grasses that nearly everywhere had been burnt off by the heathens."[19] Crespi reported seven other instances of scorched landscape.

Drawing from ethnohistory, the authors argue that the Chumash were well aware of the ecological effects of fire and that the main reason for setting fires was to stimulate the growth "of seed plants, bulbs, and green shoots for human consumption." The authors stress the importance of bulbs as a food source, as they can be stored for long periods of time. The article concludes, "increased plant food yield and improved hunting were probably both seen by the Chumash as good reasons for burning vegetation." The authors challenge Bean and Lawton's assertion that burning was an energy extraction process. They contend, that burning is its own system of food production which proved to be far "more efficient than agriculture was in this ecological setting."[20]

CONTRIBUTIONS BY ARCHAEOLOGY

In 1979, an archaeo-ecological study was released by Kilgore and Taylor that examined the frequencies of fires as recorded by fire-scars in trees' trunks. The "living trees of many coniferous species operate as 'recorders' of fires. When such trees are injured but not killed by fire, the healing process leaves accurate records as fire scars ... once initial scarring takes place, the tree acts as a more sensitive recorder of later fires." Kilgore and Taylor examined rings and fire scars on 220 tree stumps whose dates of cutting are known. They then counted backwards and could determine dates and intensities of fires. The

pair "consider[ed] all variables and sources of possible error, [and] recorded only fires for which [there was] good evidence." Therefore, the presented "records represent a conservative estimate of the number of fires."[21]

Kilgore and Taylor found that only at around fifty years of age did conifer forest species begin to show fire scars. The years of the stumps ranged from C.E. 1478 to 1875, after which records drop off and are nearly nonexistent by 1900. We must bear in mind that "the fewer numbers of scars before 1700 are mostly a reflection of the natural life span of the tree species involved ... only forty-three [of the trees] were living in 1500 and 104 were living in the 1600s."[22]

The results of this study show "positive evidence that fires have burned through the same area of mixed-conifer forest four and five years after an earlier burn." Additional examination of stumps outside of the study group show "two scars in the fifth century with a five year interval, seven scattered dates between the years 1510 and 1620, and a series of eight scars between 1620 and 1739, having a mean interval of 17 years." Additional studies in this area "could develop a fire chronology of 1000 years or more."[23]

The authors attribute some of the burn activity to aboriginal practices. Artifacts have been found at several sites within the study area, specifically bedrock mortars and obsidian chips. They note "the mortars indicate the people probably worked on acorns collected in the area; the long-term or repeated occupation of this site makes clear that acorns and oaks were regularly present during the time of aboriginal occupation. Because conifers are presently overtopping the black oak, fires set by the Waksachi and by lightning probably kept the vegetation more open and favored black oak in the past. . . . The sharp decline of fire-scar occurrence after the early 1870s in [this] study suggest that Indians may have been a significant ignition source."[24]

A study conducted by R. Scott Anderson and Scott Carpenter in 1991 examines paleo-environmental change in the Yosemite Valley. Anderson and Carpenter drilled a core from Woski Pond, a water source in Yosemite National Park "within the immediate vicinity of several pre- and proto-historic sites, occupied at various periods during the past 2000 to 3000 years." The core was 260 centimeters long and showed the record of "paleo-environmental change for the lower Yosemite Valley, spanning the last 1550 years."[25]

The core sample showed that the vegetation in the Yosemite Valley had changed significantly during that time: "A closed conifer forest probably existed around Woski Pond during [ca. 440 A.D. to 1350] based on higher pollen percentages of pine, fir, Douglas-fir, and mistletoe. ... After ca. 650 years ago, however, more open canopy vegetation types such as oaks, sage, and shrubs ... were favored." What is important to note is that the occurrence of a large amount of charcoal in the core sample coincides with the occurrence of certain pollens: "The major change in pollen assemblages begins ca. 700 years BP, with a decline in confers and an increase in oak. Peaks in both charcoal, pollen, and sediment influx occur contemporaneously, indicating a period of erosion. These factors taken together suggest a major vegetation disturbance at the time."[26]

Simultaneously occurring in the area was a significant shift in the dominant culture; "throughout the late Holocene, distinct changes have occurred

delimiting successive cultural systems" in the Yosemite Valley. Important innovations included "changes in stone tool production and use, resource procurement, trade and other cultural traits [that] depict[ed] a shift in lifestyle from seasonal hunting and gathering within the Crane Flat and Tamarack complexes, to more sedentary occupation characteristic of the Mariposa complex, with increased reliance on oak acorns for consumption and trade."[27] All occurring at the same time, this core sample shows that the major vegetative change in the valley was due to a large fire, which accounts for such a large peak in charcoal at approximately 650 years B.P. Following this time period, there are small but frequent deposits of charcoal. A major fire cleared most of the conifers out of the valley and regular burning, possibly introduced by the Mariposa complex, would allow for the flourishing of oaks and shrubs, explaining the presence of such pollens after the year 1350.[28]

THE CAHUILLA AND THE USE OF FIRE

In 1987 J. W. Cornett conducted an ecological study in the Sonora desert of Southern California to better understand how palm trees flourish in this environment. There are many groves of palms, some numbering in excess of one thousand trees, "a truly remarkable environment within the hottest and driest portion of the North American desert." Cornett asserts, "evidence suggests that the size, vigor, and distribution of desert fan palm oases in the Sonora desert have been affected by human activity."[29]

We find that "evidence of Indian presence was discovered at approximately seventy percent of the oases." Such evidence consisted of potsherds, lithic material such as mortars, and signs (pictographs) in and around the groves. It is obvious that Indians were staying at the oases and knew about the existence of most oases in the area. Living at palm groves was ideal, since "palms provided construction material for dwellings, bows, baskets, and clothes, as well as wood for tools, ceremonial objects, and fire starting material."[30]

The Cahuilla "set fire to the palms to facilitate the harvest of fruit by removing the dead skirts [which] permitted gatherers to climb the trunk and secure the hanging fruit clusters." The Cahuilla also burned to clear the land and provide easy access to seeds. The author "found that walking through a palm oasis which had not experienced fire was no easy task [because] a great deal of material piled up on the oasis floor, including old fruit stalks, fallen trunks, palm fronds and shrubs. . . . Collecting fallen seeds from this jumble would also have been an arduous task."[31]

> Burning for the purpose of clearing brush is further explained: A photograph of Palm Canyon in 1926 shows approximately eighty-two trees in the area. . . . In 1984 a photograph taken from the identical angle shows 132 palms. This sixty-two percent increase is partially attributable to the elimination of cottonwoods from a large portion of the oasis—the result of the Palm Canyon Fire of 1946. Fire temporarily removes all other plant species, leaving only the fire resistant palms. With competition removed, palm seedlings are far more likely

> to be established. The benefit to the Indians was that a valuable plant species replaced those of less value.[32]

A third explanation for Cahuilla palm burning was to "increase the yield of fruit." It has been reported that palm fruit is actually sweeter from trees managed with fire. And while there have been no scientific studies to confirm this, "a survey involving 350 palms [did show] those which had burned within the past four years produced sixty-three percent more fruit than did unburned palms."[33]

CHANGE IN RESEARCH METHODOLOGY

As theory and ecological evidence regarding Native Californians and the use of fire in land management developed, changes in the methodology of research become more prominent. Research after 1990 places greater emphasis on ecology, specifically how vegetation's reaction to fire directly benefited Native peoples in the areas of food, medicine, and plant material resource production. This new research asserts that indigenous land management practices were refined to such an extent that Indians were actually horticulturalists rather than hunter-gatherers. The aim of much of this research is to provide a more in-depth explanation of how the use of fire supported California's large Native population.

In 1990, Anderson began to publish observations of ecological responses to fire. She found that fire was beneficial to Native Californians not only in increasing forage for game and encouraging acorn production, but also vital to basketry and other material culture requiring plants, and geophyte cultivation. Burning "maintain[ed] grasslands and meadows, improve[d] browse for deer, enhance[d] production of basketry and cordage materials, modif[ied] understory species composition in forests, and reduce[d] fuel accumulation that might otherwise sustain intense fires."[34]

The maintenance of grasslands and meadows was very important for the growth of other plants, as "most of the plants useful to Sierran tribes are highly shade intolerant."[35] By burning meadows and grasslands young trees were killed which, otherwise left alone, would have matured into shade-producing agents and ultimately been detrimental to resource production. This condition can happen with geophytes, a form of edible root, which "have high light requirements, needing full sunlight to flower ... they may dwindle in size and numbers in shaded environments with increased plant competition."[36] Burning meadows, in addition to reducing shade-producing agents, also served to eliminate competition to the more desirable forms of plant life.

Prescribed burning, in addition to increasing sunlight and stopping unwanted plant competition from taking over, also served to clear accumulated underbrush. Anderson and Moratto cite Jewell, who claims that "burning at higher elevations was for the expressed purpose of removing shrub and duff layers, promoting a more tightly assembled snowpack. This dense snowpack melted off more slowly, reducing flooding and causing ephemeral creeks and streams to run longer in the summer."[37] Burning underbrush often was

used "simply to clear off old grass, bushes, and trees to facilitate travel."[38] The mere burning of undergrowth helped maintain grasslands, regulated the water supply, and increased the efficiency of travel.

FIRE AS A PROVIDER OF FOOD

Fire facilitated the gathering of food in several ways. Acorns, which were a staple of Native Californians, were gathered with the aid of fire because "fallen leaves and brush reduced the visibility of acorns and thus, increased the search time for these seeds. . . . Therefore, burning under the oaks in certain areas enhanced the gathering of acorns."[39] In addition to aiding acorn gathering, fire encouraged fruit growth. Denevan cites Cronon as saying, "fire created conditions favorable to strawberries, blackberries, raspberries, and other gatherable foods."[40] This statement is corroborated by Anderson and Moratto who note that "burning of chokecherries, manzanita berries, strawberries, and elderberries has been recorded among the Maidu, Foothill Yokuts, Western Mono, and Miwok tribes to increase fruit production, thin dense shrub canopies, [and] reduce insect activity by eliminating old wood."[41]

Anderson and Moratto also note that many Native Californian tribes burned "herbage for better wild crops," "mushroom patches to improve quality and abundance," "bulb, corm, and tuber areas to reduce plant competition, recycle plant nutrients, and increase the size and quantity of underground stems"; "seed collection sites were also burned to eliminate insects and diseases, and keep open areas within forests and [reduce] plant detritus."[42]

Geophytes can also be used for "foods, basketry, and medicines." This particular resource "flourish[es] after fires," making burning a feasible way of increasing the plant's abundance.[43] This is due to infant bulbs attached to the root that, in the event of a fire, break off and begin growing new plants.[44] In addition, "burning off the land increased the ease of harvest of certain plants."[45]

Animal populations were also encouraged through the growth of geophytes. "In California an array of small and large mammals, including blackbears, elk, deer, wild pigs (exotic), and pocket gophers, uproot the bulbs, corms, and tubers of herbaceous plants" for food.[46] Burning of the landscape "kept underbrush down and facilitated the search for game" by increasing visibility and limiting hiding places. In some instances tribes "set fire to chaparral as a means of forcing out rabbits and other small animals in order to capture them. As well, annual burning ensured ample forage for deer, antelope, and tule elk." [47]

FIRE USE IN WARFARE AND MARKING TERRITORY

The uses of fire in aboriginal times have not been solely practiced for the purposes of horticulture. Evidence shows that fire has been used for warfare among California Indians. Part of the maintenance of grasslands and meadows also served to "lessen the chance of surprise attacks by enemy tribes."[48] Burnt landscape may also have been a signal to other tribes that they were

crossing into land that was being used. Anderson and Moratto comment that the management of gathering sites was a way of marking one's relationship with the area and was a signal for gaining land use rights."[49]

Stewart also offers evidence of fire used in warfare. He cites an ethnohistoric account by John Bradbury who comments about an 1809 prairie fire that, "at this late season the fires are not made by the hunters to facilitate their hunting, but by war parties; and more particularly when returning unsuccessful or after a defeat, to prevent enemies from tracing their steps … from California also, fire is reported as a weapon and was probably used wherever practicable."[50]

FIRE AND BASKETRY PRODUCTION

Fire was most important in its capacity to provide basket-weaving materials. Anderson states, "one of the most significant reasons for the indigenous management of wildlands in California was for the production of weaving material for baskets."[51] There was a need for environmental management of basketry material because "the use of baskets was so central to daily living that it represented fifty percent of the plant material culture of the sixty or so tribes in the state."[52] In addition, Anderson cites Dawson, who took photographs showing that "every [Native] family in California had a large contingent of baskets, each serving different purposes within the household" and show habitation sites [with] the abundant baskets in and around the shelters."[53]

Deergrass is a common plant stalk used historically by at least twenty tribes for basketry material. One coiled basket required numerous stems from this plant. For a Western Mono gambling tray "it would take over 3,000 flower stalks." A cooking basket "would use a quarter more, or 3,750 culms." [54] If each family had numerous baskets, and each basket required thousands of stems, and there could be up to several hundred people in a village, villages would need hundreds of thousands of these stems each year to meet their requirements. Because of such tremendous need, "collecting basketry material was a sizable collective enterprise."[55]

There is one major set back to gathering hundreds of thousand of straight stems for basketry:

> mature shrubs and trees often exhibit dense canopies, and as individual branches grow through this maze of branches toward the light, they bend and twist in crooked patterns. . . .straight branches are highly desirable to weavers because they split more easily and evenly, and made stronger, more uniform baskets.[56]

However, "these types of branches seldom occur naturally on mature plants."[57] For this reason Native Californians would burn the shrubs in the fall. These "plant species respond to burning ... by vigorously sprouting new shoots from dormant or adventitious buds. The result is long, straight, slender switches with inconspicuous leaf scars, and no lateral branching. These are characteristics most valued by basket makers."[58] Burning forces a plant's

growth into a youthful, vegetative state. Such stalks could reach up to two meters in length.[59]

Another advantage that the young growth phase provides is in the area of bark color. Bark color is determined by what

> is called an anthocyanin, which is a kind of pigment, and it may be only present in the epidermis of very young shrub growth. A good example is the color that occurs in the young branches of redbud (*Cercis occidentalis*), a widespread shrub in California that is utilized by numerous tribes for wine-red designs. Young redbud branches exhibit a striking red color, but as they grow and age, the wine-red epidermal tissue is replaced with true bark which is gray. Thus weavers specifically selected young redbud growth for its red pigment.[60]

In another article, Anderson emphasizes that fires were set to "manipulate [both] the branch architecture and bark color of plants which could then be harvested the following year to make a specific cultural product."[61]

When the shoots had grown as much as they could for the season they were harvested. What resulted the spring "after the fires were set, [were] hundreds of thousands of first year shoots of various native shrubs."[62] One of the primary reasons was because "the setting of fires increas[d] the quantity of flower stalks." In fact, deergrass actually "appear[s] to be healthiest where they have been exposed to disturbance." The same plant also "produces abundant viable seed [which] often does not get established in the wild [but] germinates profusely in nursery conditions without special treatment."[63] This finding supports the argument that Indians were acting as environmental managers. The continuity of basket weaving technology was maintained through the use of fire. Without such interaction with the environment plants useful for weaving would be "composed of old, brittle, and crooked branch growth—sometimes harboring insects and diseases," making them useless for basketry material.[64] Anderson asserts that basketry technology "would not have reached the height and diversity in terms of shapes and functions that it did without the use of fire."[65]

CONCLUSION

The study of fire use in Native Californian land management practices can be beneficial to the development of new methods of wildfire prevention, conservation, and ecological restoration efforts. These writings have intended to provide the reader with a starting point for more in-depth research on this topic. The literature regarding Native Californian use of fire has only seen focused development over the past thirty years. The earliest sources consisted of ecological studies, forestry studies, contributions by Stewart, and ethnohistorical accounts which suggested that Native groups used fire. The beginning of modern theory regarding the use of fire was with Lewis and Bean and Lawton in 1973, who proposed that the high population densities and cultural complexity found in Native Californian tribes was a direct result of the use of fire. Timbrook, Johnson, and Earle examined Chumash culture

because of its high population density and sedentary lifestyle and concluded that the use of fire was a crucial factor in producing and maintaining the population.

Studies by Kilgore and Taylor, Cornett, and Anderson and Carpenter show that there is also significant archaeological evidence to suggest that Native Californians were using fire as a tool of environmental management. Kilgore and Taylor's study of fire scars in trees showed forests in California experienced frequent, low-intensity fires for hundreds, possibly thousands, of years. Anderson and Carpenter's study of core samples from the Yosemite Valley show frequent charcoal deposits in the soil, accompanied by significant changes in pollen proportions in the area. Cornett observed the growth of palm oases in Southern California and concluded that human ignition must have encouraged the growth of palm trees in the desert to provide resources for survival.

In the early 1990s research methods began to incorporate more fieldwork and the analysis of environmental reaction to disturbance. The results of this research over the past ten years has revealed that fire encouraged growth of food supplies such as berries and geophytes, and also increased populations of game. Fire also served purposes in warfare and marking territory. Weaving material for baskets and other items was also increased through the use of fire and likely would not have been such a widespread and advanced technology if the use of fire was not a factor.

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