Reprinted from Madrono
Vol. 28, No. 3, July 1981

THE HISTORICAL ROLE OF FIRE IN THE FOOTHILL COMMUNITIES OF SEQUOIA NATIONAL PARK

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ABSTRACT

The historical role of fire in the foothill-chaparral and oak-woodland communities of Sequoia National Park must be understood before a management program can be developed that will assure the perpetuation of those community types. Historically, lightning-ignited fires were supplemented by intentional ignitions by Indians and, later, by European settlers. The park fire records since 1920 portray the frequency of both man-caused and lightning fires by year, month, and elevation. Fires have been most common at higher elevations and during summer. This corresponds with the period of maximum drought stress and minimum foliage moisture content. The largest share of the area burned has been within the chaparral community. However, nearly *75* percent of the zone has not burned during this time.

The role fire should be allowed to play in the low-elevation foothill communities of Sequoia National Park poses a management dilemma. Although the objective of fire management programs in national parks is generally to allow fire to play as natural a role as possible in determining vegetation mosaics (Parsons, 1977), the buildup of highly flammable fuels following decades of fire suppression often makes this impossible. Despite evidence that periodic fire has played a vital role in the evolution and maintenance of the foothill-chaparral and oak-woodland communities of the southern Sierra Nevada (Vankat, 1977), current fuel conditions are such that naturally ignited fires cannot safely be allowed to burn. Previous years of fire suppression have resulted in extensive, highly flammable, over-mature fields of brush (Parsons, 1976). In addition to the problems encountered in controlling summer wildfires, such conditions make it difficult to implement a safe, effective program of prescribed burning.

This paper reviews available information on the fire history of the foothill-chaparral and oak-woodland communities of Sequoia National Park. This information provides part of the baseline data necessary for the development of an integrated fire management program for the area. The data were derived primarily from the park's fire atlas, which lists and maps all of the fires that have occurred since 1920. Other accounts of the early fire history of the area in and around Sequoia National Park are reviewed in Vankat (1977) and Kilgore and Taylor (1979).

It is not possible to use standard fire history techniques in brush and grassland communities. Chaparral fires typically burn all or most of the above ground biomass. Thus, while it is possible to date the last fire, there is no accurate way of dating previous ones. Similarly, fires in grass or woodland areas are commonly of low enough intensity not to leave scars on the scattered trees. While it is known that fire plays an important ecological role in chaparral and woodland communities (Biswell, 1974; Griffin, 1977), it is difficult to document fully the fire history of such areas. Historical accounts and personal recollections must be relied on heavily in such situations.

THE FOOTHILL ZONE

The area encompassed by this study includes more than 28,000 hectares in the southern Sierra Nevada along the western boundary of Sequoia National Park. Located within the North, Middle, Marble, East, and South Fork drainages of the Kaweah River, the foothill zone spans an elevation range between about 460 m and 1830 m. The topography is generally steep with narrow canyons and cliffs. The climate of this zone is Mediterranean-type with hot dry summers and cool moist winters. Annual precipitation averages 65 cm at the lower elevations and more than 90 cm at the upper elevations. Summer temperatures frequently exceed 38°C. Soils are primarily sandy loams of granitic origin. They are often shallow on the steeper hillsides but attain several meters in depth in more favorable locations.

Following Baker et al. (1981), four major plant communities can be identified as occurring within the foothill zone: foothill woodland, chamise chaparral, mixed-evergreen woodland, and black-oak forest. The foothill woodland community is characterized by a grassland under-story with scattered stands of *Quercus douglassii* and *Aesculus californica.* The dominant grasses are primarily introduced annuals that became established following intensive grazing during the late 1800's (Vankat and Major, 1978). They are thought to have replaced native annuals as well as perennial bunchgrasses (Heady, 1977). Chamise chaparral is widely distributed on the xeric slopes of the foothill zone. *Adenostoma fasciculatum* is the dominant and sometimes only species found in this community. The mixed-evergreen woodland is a highly variable mixture of shrubs (e.g., *Cercocarpus betuloides)* and trees (e.g., *Aesculus californica, Quercus chrysolepis)* found primarily on mesic north slopes and at higher elevations. The black-oak *(Quercus kelloggii)* forest, with stands of *Chamaebatia foliolosa, Arctostaphylos viscida,* and *A. patula,* forms a transition between the foothill communities and the mixed-conifer forests. In earlier classification schemes, the foothill zone was generally divided into oak savanna (corresponding with foothill woodland), chaparral (including chamise chaparral and much of the mixed-evergreen woodland), hardwoods (included in the mixed-evergreen woodland), and black-oak forest. Because these community types were often the basis for past fire records, it has been necessary to use them during much of this report.

FIRE HISTORY

Presettlement. Fires ignited by lightning are an important element in the dry summer environment of the Sierra Nevada (Komarek, 1967). Unfortunately, the lack of adequate fire dating techniques for the foothill communities has often made it impossible to quantify the frequency or size of lightning fires in presettlement times.

Additional pre-European ignitions came from the local aboriginal populations. For example, it is known that prior to the first coming of Europeans to the area in the late 1850's, the Western Mono Indians used fire to assist in hunting, to promote growth of wild food crops, and to facilitate the collection of seeds in much of the study area (Lewis, 1973; Vankat, 1977). Both Reynolds (1959) and Lewis (1973) present evidence that most Indian burning was carried out in the fall. The influence of aboriginal man on the Kaweah River region was essentially terminated by 1865, when the last Western Mono left the area (Strong, 1964).

Information available for a nearby mixed-conifer forest (Kilgore and Taylor, 1979) documents a decrease in fire frequency after 1870. This corresponds with the end of Indian occupation but is before fire suppression became effective. It establishes the importance of Indian ignitions in the presettlement forest. While it is impossible to document the extent to which the same is true for the lower elevation foothill communities, it is likely that a similar pattern holds. It is thus logical to assume that the pre-aboriginal fire frequency (lightning ignitions only) was less than in the 1800's, but greater than exists today. While it may not be possible to distinguish fully between the relative frequency or ecological significance of Indian versus lightning fires, it is clear that both played an important role in determining the vegetation patterns found in the foothill zone. It is the policy of the National Park Service to include both lightning and Indian ignitions as part of the natural scene.

Post-settlement. During the 1860's, European settlers first moved into the foothills of the southern Sierra in the area that is now Sequoia National Park. In succeeding years, sheepherders increasingly used the area in moving their flocks to and from the high country. They commonly set fires in the fall while coming out of the mountains in order to clear brush and provide for new, more palatable growth the following spring (Strong, 1964; Vankat, 1977). Vankat (1977) concluded that much of this sheepherder burning can be viewed merely as an extension of aboriginal fires. The two cultures apparently burned "for much the same reasons – to favor certain plant species and to open the forests". Lightning-ignited fires continued to burn during this period.

Following the establishment of Sequoia National Park in 1890, a policy of suppressing all fires was implemented (Vankat, 1977). Due to limited funding and manpower and poor access to many areas, suppression did not become effective until the 1920's. A policy of fire suppression has remained in effect for the foothill region to the present time. The consequences of this suppression policy are now the cause of considerable concern. The reduction of fire frequency has resulted in an increased fuel density and an abundance of old growth, especially in the chaparral communities (Parsons, 1976; Rundel and Parsons, 1979). Increased fuel accumulations make it increasingly difficult to extinguish fires that do get started. There has also been a loss of typical age-class and community-type mosaics and, in some cases, a change in species composition. For example, Vankat and Major (1978) have documented an increase in cover and density and a decrease in diversity in the chaparral communities as well as an increased cover and density of oak species in the woodland types.

Recent. Although fire records for the study area before the late 1920's are incomplete, they are sufficient to document the fact that fires caused by both man and lightning were frequent occurrences. For example, early park records show at least 37 lightning fires, 6 man-caused fires, and 22 fires of unknown origin occurring within the foothills of the Kaweah River drainage (an area of 28,366 ha) between 1891 and 1919. The great majority of these fires occurred during the dry summer months when the vegetation is highly flammable. Several (both lightning and man-caused) consumed more than a thousand hectares.

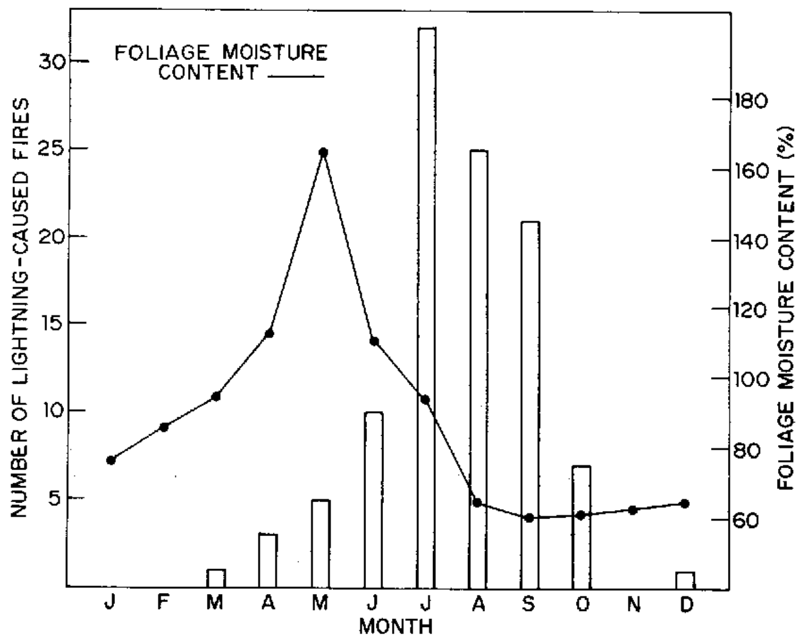
Since the 1920's, nearly complete records have been maintained of all fires occurring within the park. These records provide the only available data base for recent fire history in the foothill zone. Fire frequency and size, of course, have been greatly influenced by suppression activities. Records available for 1920 – 1929 show at least ten fires of 12 ha or larger, but of undetermined origin, burning a total of 4189 ha within the study area (the records of smaller fires have been lost). In the 49 years from 1930 to 1978 a total of 105 lightning and 107 man-caused fires were recorded for the Kaweah drainage foothill zone. Lightning fires averaged 2.14 ± 2.63 (S.D.; range: 0 – 10) per year while 2.18 ± 2.00 (range: 0 – 8) man-caused fires were recorded per year. There were 16 years with no lightning fires, 12 with no man-caused fires, and 4 with no fires at all. Lightning fires burned a total of 592 ha while man-caused fires burned 2811 ha. Most of the fires (91 percent) burned less than 3 ha. It should be noted that the lightning fires reported here represent only those ignitions that resulted in detectable fires. No doubt many lightning strikes are never detected. Furthermore, the increased efficiency of fire suppression capabilities in recent decades has limited the total area burned to well under the area that would have burned without suppression activities.

TABLE 1. TOTAL AREA AND NUMBER OF LIGHTNING FIRES BY 305 m (1000 ft) ELEVATION CONTOURS IN THE ENTIRE KAWEAH RIVER DRAINAGE, SEQUOIA NATIONAL PARK, 1930 – 1978.

Elevation (m)	Total area (ha)	No. lightning fires	No. fires per 1000 ha
<610	627	2	3.2
610– 914	3,134	1	0.3
915–1219	5,877	4	0.7
1220–1524	8,267	18	2.2
1525–1829	10,461	81	7.7
1830–2134	12,146	99	8.2
2135–2439	12,577	139	11.0
2440–2744	12,538	118	9.4
2745–3049	9,795	70	7.1
>3050	7,758	10	1.3

Data on the frequency of lightning fires as a function of elevation within the entire Kaweah drainage (Table 1), with the exception of the lowest elevation where the sample area is small, show a steady increase in the number of fires as well as the number of fires per unit area, up to an elevation of 2440 m. This corresponds with the findings of Komarek (1967) and Keeley (197'/) for the forest and chaparral regions of California and relates in large part to an increasing frequency of lightning strikes with elevation. The decrease in fires at the highest elevations relates primarily to decreasing fuel supplies. Whereas lightning fires most frequently ignite in the middle elevations, under hot, dry, summer conditions they sometimes burn downslope through the highly flammable brush and grasslands. It should be emphasized that while lightning strikes are relatively rare at the lower elevations, they do occur (Griffin, 1977). It is likely that occasional lightning fires that ignite below the park would burn into the study area were they not suppressed. When ignited under the proper conditions, few ignitions are needed to burn large areas of highly flammable chaparral and oak woodland.

The distribution of lightning fires by month for the study area is presented in Fig. 1. Most of the 32 recorded July fires occurred in the latter part of the month. The late-summer peak in lightning fires corresponds with the onset of maximum flammability as represented by decreasing foliage



moisture content (Fig. 1). This timing corresponds with the period of maximum temperatures and minimal precipitation, conditions also favoring maximum burning potential. Thus, the high incidence of lightning fires during the late summer and early fall may be as much a function of weather conditions and vegetation flammability as of lightning-strike frequency.

FIG. 1. Mean number of lightning-caused fires by month for Kaweah River drainage below 1830 m, 1930 – 1978, and mean monthly foliage moisture content for *Adenostoma fasciculatum* within the study area. Foliage moisture determination followed Countryman and Dean (1979).

The monthly distribution of man-caused fires within the study area corresponds closely with that of lightning fires (Fig. 2). Again, the peak occurs during the period of hot, dry weather and low foliage moisture content when the vegetation is most likely to burn. The one significant difference from the distribution-of lightning fires is the relatively large number of man-caused fires in June. This difference may relate to the fact that electrical storms are rare in June but the period of high visitor use has already begun (Fig. 2). The strong correlation between the timing of peak visitor use and the incidence of man-caused fires emphasizes the potential danger from unwanted wild6res during the summer months.

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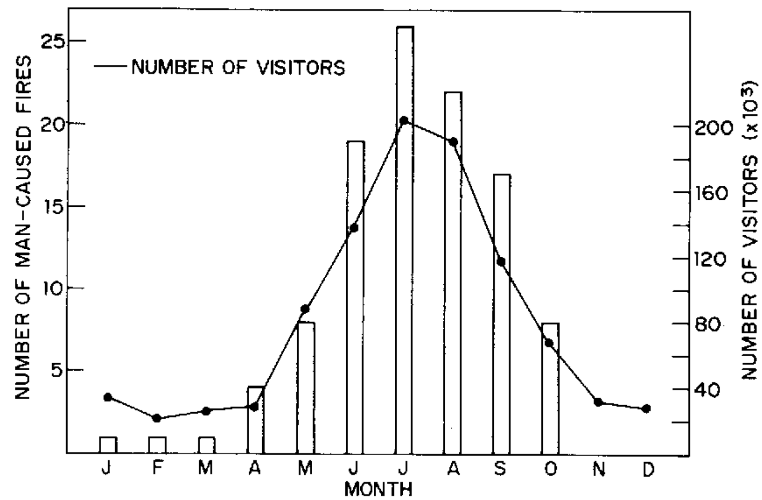

Fig. 2. Mean number of man-caused fires by month for the Kaweah River drainage below 1830 m, 1930 – 19/8, and monthly 1978 visitation rate for Sequoia National Park.

The park fire atlas, which maps all fires that burned more than 4 ha in the study area since 1920 (unpublished data), shows that much of the foothill zone of Sequoia National Park has not burned in at least 60 years. Biswell (1974) has expressed the opinion that this is probably a considerably longer fire-free period than most of these low-elevation communities have experienced for many centuries and perhaps for thousands of years. Together with the evidence for buildup in both live and dead fuels in stands of increasing age, this indicates a serious over-abundance of dense, over-mature, highly flammable brush. It also suggests a lack of distinct age-class boundaries that could be effective fire breaks. Lack of such boundaries can hinder the development of a safe, effective program of prescribed burning (Philpot, 1974).

By superimposing the map of fires larger than 4 ha on a vegetation map of the park we have calculated the area burned since 1920 within each vegetation type (Table 2). The greatest area burned was in chaparral, with the next greatest being in hardwoods. When converted to a percentage of the community type available, the oak savanna and chaparral have had the greatest proportions burned. In all, 8360 ha or slightly less than 30 percent of the foothill zone has been burned at least once by either lightning or man-caused fire since 1920. In addition, 1246 ha, primarily in chaparral, have been burned two or three times during this period (Table 2).

Not included in Table 2 are four prescribed burns which have been ignited as part of the park's fire management program (Parsons, 1977). These fires, which have all occurred since 1969, have burned a total of 1099 ha in the study area. Of this, 48 percent has been in the chaparral. Most of the area of prescribed burns (557 ha) had previously burned since 1920.

TABLE 2. AREA OF EACH FOOTHILL (<1830 m) VEGETATION TYPE BURNED BY MAN-CAUSED AND LIGHTNING FIRES IN THE KAWEAH RIVER DRAINAGE, 1920 – 1978. Percents are based on area of vegetation type within the drainage below 1830 m (study area) only.

Vegetation type	No. hectares burned	Percent of vegetation type burned	No. hectares reburned
Oak savanna	1073	46.8	194
Chaparral	4271	38.1	673
Hardwoods	1635	20.5	251
Black oak	351	19.3	38
Conifers	10330	13.9	90
Total	8360	25.1	1246

MANAGEMENT IMPLICATIONS

Together with data on vegetation patterns, age class boundaries, biomass accumulation, flammability, and an understanding of fire's role in the reproduction and succession of important plant and animal species, fire history data provide a basis for predicting the immediate and long term effects of any fire and so provide an essential basis for developing a fire-management program. Such information establishes criteria for simulating the natural fire regime by re-establishing the seasonal and elevational distribution of historical fires. It also helps to establish which vegetation types and even which specific areas have gone the longest without being burned. Such information is valuable in setting priorities for future management actions.

The foothill zone of Sequoia National Park, like much of the rest of the foothill zone of the southern Sierra Nevada, contains extensive areas of over-mature, highly flammable brush. When unplanned fires ignite, especially at the lower elevations, it is often essential that immediate suppressive action be taken. Otherwise highly destructive, uncontrollable wildfires may result. This threat is of special concern due to the location of giant sequoia groves immediately uphill from the foothill communities and in the path of potential conflagrations.

I conclude that through a carefully planned prescribed burning program it will be possible to reduce the accumulated fuels and at the same time increase the number of distinct age classes and vegetation boundaries. This will not only restore more natural conditions but will facilitate suppressive action on future wildfires (Philpot, 1974). While the first several prescribed burns, for reasons of control, may need to be in late fall or winter, once a more diverse vegetative and age-class mosaic has been created it should be possible to burn safely at the time of year when natural fires are known to have occurred. In all cases, prescribed burns must be carefully planned to minimize risks while at the same time accomplishing desired objectives. This requires a thorough understanding of the relationship of fire behavior to moisture content of foliage, biomass accumulation, and various weather parameters for each vegetation type. If carefully conducted, such a program should assure the continued survival of healthy foothill woodland and chaparral communities in the southern Sierra Nevada.

ACKNOWLEDGMENTS

This research was supported by the National Park Service. Rick Hedlund provided invaluable assistance in summarizing past fire records. Phil Rundel, James Parsons, Jon Keeley, and James Griffin reviewed and helped to improve the final version of the manuscript.

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(Received 2 Jun 1980; accepted 12 Nov 1980; revised version received 18 Dec 1980.)