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General Patterns of Lightning Ignitions in Sequoia National Park, California[1]

John L. Vankat

ABSTRACT: Patterns of lightning ignitions are described and determined to be nonrandom for geographic location, elevation, slope aspect-position, vegetation, manth, and year (1921-82). Information about patterns is important in developing fire management plans, especially if lightning ignitions are to be used to reestablish fire as a major environmental factor in wilderness areas.

INTRODUCTION

Lightning is an important ignition agent in most wilderness areas of the United States. If lightning ignition patterns show nonrandom spatial and temporal variations, information about patterns may be important in developing fire management plans for these areas. The objectives of this paper are to characterize the general distribution patterns of lightning fire ignitions in Sequoia National Park, Calif., and to determine whether the distribution patterns are random.

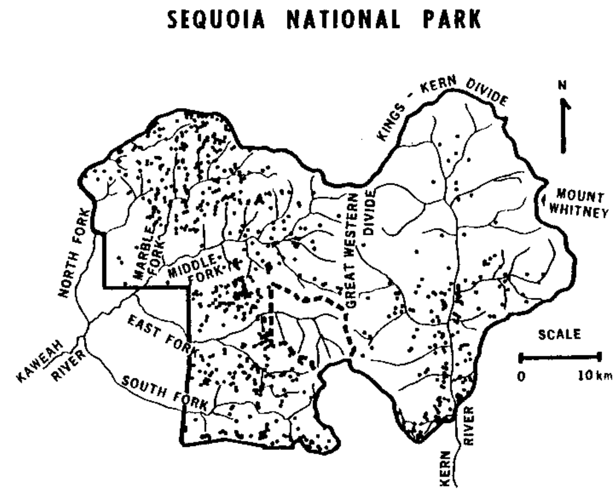

Figure 1.--Map of lightning fire ignitions in Sequoia National Park, Calif. Ignitions are not illustrated for the Mineral King area, a recent addition to the Park.

STUDY AREA

Sequoia National Park is a region of highly varied topography in the southern Sierra Nevada of Calif. Park elevations range from about 1,280 ft (390 m) on the western boundary near the Park headquarters to 14,495 ft (4 419 m) at the summit of Mount Whitney, part of the Sierra Nevada crest that forms the eastern boundary (fig. 1). The eastern half of the Park is drained by the Kern River and is dominated by numerous mountain peaks, plateau-like old erosion surfaces, and several canyons. The Kings-Kern Divide bounds this portion of the Park to the north, and the Great Western Divide separates it from the Kaweah River drainage to the vest. This latter drainage is a westward-sloping old erosion surface with scattered mountains and ridges separating the steep-walled canyons of the North, Marble, Middle, East, and South Forks of the Kaweah River.

The vegetation types of the park are highly diverse. Foothill elevations have chamise

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chaparral, mixed chaparral, and four woodlands: blue oak, black oak, lowland live oak, and upland live oak. Mid-elevations are mostly forested with ponderosa pine and white fir types; the latter includes the giant sequoia groves. At somewhat higher elevations are red fir forest, Jeffrey pine forest, and a few stands of juniper woodland still higher are lodgepole pine forest and subalpine forest. Scattered through the forested areas are stands of meadow and montane chaparral vegetation, and above treeline is alpine tundra. The composition, structure, and environmental relations of these vegetation types have been described by Vankat and Major (1978) and Vankat (1982).

METHODS

Records of fires have been maintained at the Park since 1921. When the original reports on individual fires were available, I consulted them to determine the specific locations of ignitions. I marked these locations on topographic maps from which I obtained data on elevation and slope aspect-position. I also obtained these data for 550 locations placed randomly on the topographic maps.

Ignition locations were also plotted on a vegetation map, and the area of each vegetation type was determined with a digitizer. I used a relatively old map (Anonymous 1939) because personal field reconnaissance indicated that it usefully portrayed the vegetation. More recent maps are available, but the entire park can be covered only by combining maps that have different vegetarian classification units.

Chi-square analyses were used to determine if the ignition patters were random (a = 0.05).

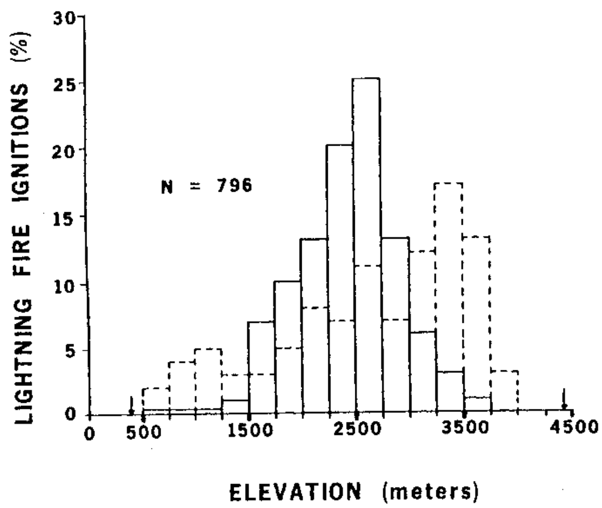

Figure 3.--Bar graph of the distribution of lightning ignitions (solid bars) and a random sample of 550 points (dashed bars) in relation to elevation.

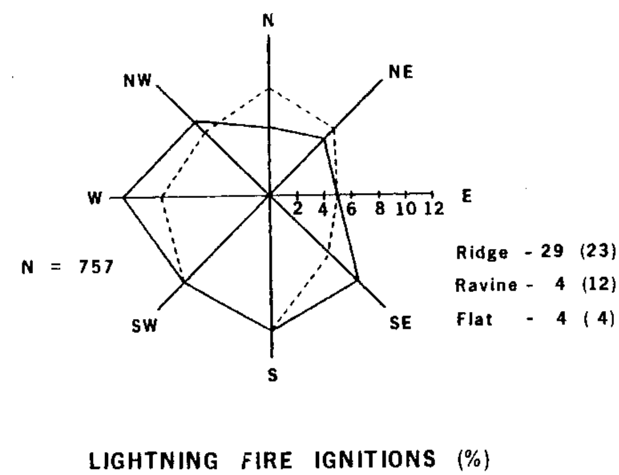

Figure 2.--Bar graph of the distribution of lightning ignitions (solid bars) and a random sample of 550 points (dashed bars) in relation to elevation.

RESULTS AND DISCUSSION

From 1921 through 1982, a total of 848 lightning ignitions were recorded for the Park (excluding the Mineral King area, a recent addition). Records from different years sometimes contained different types of data; therefore, not every ignition record could be included in each pattern analysis. Also, the number and characteristics of unreported ignitions must have varied over the period of records, given changes in such factors as the methods used to detect ignitions; however, I estimate that this has had only minor effect on the general patterns described below.

Patterns of Geographical Location

Figure 1 shows that lightning ignitions have been concentrated geographically in the western half of the Park, especially in areas separating forks of the Kaweah River. The heaviest concentration is associated with Paradise Ridge, which is between the Middle and East Forks. Ignitions in the eastern half of the Park are concentrated in the lower Kern Canyon area.

Patterns of Elevation

Lightning ignitions have ranged in elevation from approximately 1,900 to 11,500 ft (579 to 3,506 m). The range is restricted by the small land area of the Park at lower elevations and by the lack of ignition fuels at higher elevations. Ignitions have been most common in the Park's mid-elevations and appear to be almost normally distributed around the 8,200 to 9,020 ft (2 500 to 2 750 m) category (fig. 2.) There is a statistically significant difference between this observed distribution and the distribution of the random sample of points. Ignitions were over represented in the 4,920 to 9,840 ft (1 500 to 3 000 m) portion of the Park's elevational range and were under represented at lower and higher elevations (fig. 2).

Patterns of Slope Aspect-position

Eleven categories of slope aspect-position were defined: N, NE, E, SE, S, SW, W, NW, flat, ravine, and ridge. Figure 3 shows that the ridge position accounted for 29 percent of the lightning ignitions, the five most xeric slope aspects each accounted for nearly 10 percent, and the three most mesic aspects and the flat and ravine positions each accounted for nearly 5 percent. Again, there is a significant difference between this distribution and that of the random points. Ignitions were over represented in the SE, W, NW, and ridge categories and were under represented in the N, NE, and ravine categories. The results for the ridge and ravine positions reflects their sharp contrast in elevational prominence. The results for the slope aspects may be related to differences in moisture levels of ignition fuels, because SE, W, and NW aspects usually are more xeric than N and NE aspects.

Patterns of Vegetation

Figure 4 shows the distribution of lightning ignitions in relation to major vegetation types. Several of these types have been disproportionately subjected to ignitions, in that their percentage of total ignitions was much greater than their percentage of vegetated land area within the Park: Jeffrey pine forest (12 percent of the ignitions and 6 percent of the land), red fir forest (21 and 13 percent), and white fire forest (22 and 14 percent). Ignition percentages only slightly exceeded land area percentages for montane chaparral (5 and 4 percent), ponderosa pine forest (7 and 6 percent), and lodgepole pine forest (21 and 20 percent). The subalpine forest had a much smaller percentage of ignitions than vegetated land area (6 and 16 percent). Other vegetation types with an under representation of ignitions are meadow (<1 and 5 percent), chamise chaparral (<1 and 4 percent), upland live oak woodland (3 and 8 percent), and, to lesser degrees, all other foothill vegetation types (mixed chaparral and various woodlands). This distribution of ignitions vas determined to be nonrandom.

In part, this pattern of ignitions reflects the previously described relationship between ignitions and elevation, given that the distribution of major vegetation types of the Park is highly correlated with elevation (Vankat 1982). In some cases there also appears to be a relationship with the pattern for slope aspect-position; for examples, the Jeffrey pine forest, with an over representation of ignitions, is more common on xeric than mesic sites (Vankat 1982). In addition, the pattern of vegetation also relates to differences in the nature of ignition fuels; for example, meadow vegetation ignitions are under represented

Monthly and Yearly

The monthly and yearly distributions of ignitions are also nonrandom. Figure 5 illustrates that ignitions have been recorded for all months except February but are most concentrated in July (35 percent of the total), August (29 percent), and September (21 percent). These months are part of the summer drought of California's Mediterranean climate. The vegetation is especially susceptible to ignition during this period. Presumably, ignitions are not common in fall and winter because of high precipitation and in spring and early summer because of the persistence of heavy snowpacks at mid- and high elevations.

Figure 6 indicates a general increase in the number of recorded ignitions (except for the 1940's, when various restraints brought about by World War II may have interfered with maintaining a complete record of ignitions). The increased ignitions may have resulted from improvements in detection and record keeping

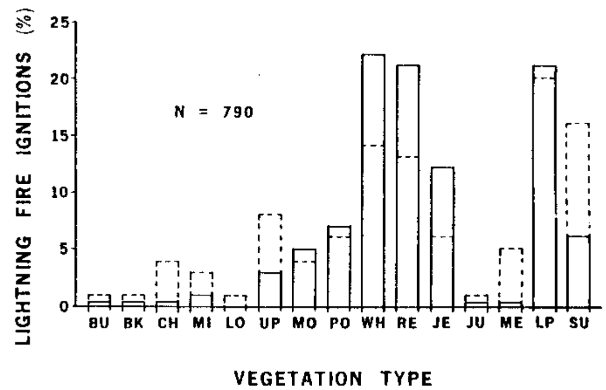

Figure 5.--Bar graph of the distribution of lightning ignitions (solid bars) in relation to vegetation types. The percentage of vegetated land area of each vegetation type is also illustrated (dash bars). Abbreviations of the vegetation types are as follows: BU = blue oak woodland BK = black oak woodland CH = chamise chaparral; MI = mixed chaparral; LO = lowland live oak woodland; UP = upland live oak woodland; MO = montane chaparral; PO = ponderosa pine forest; WH = white fir forest; RE = red fir forest; JE = Jeffrey pine forest; JU = juniper woodland; ME = meadow; LP = lodgepole pine forest SU = subalpine forest.

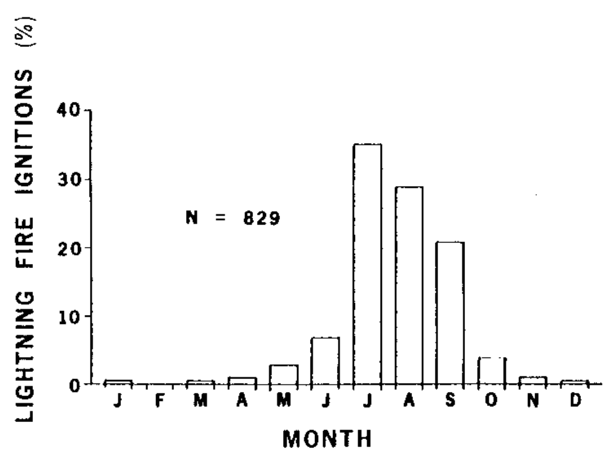

Figure 4.--Bar graph of the distribution of lightning ignitions by month

and changes in climate and vegetation. Perhaps the most important of these was the improved detection, which occurred as extensive aerial observations began in the late 1960's and 1970's. The possibility that changes in vegetation (for example, the dramatic increases in forest densities during this century [Vankat and Major 1978]) may have contributed to the increase in ignitions is intriguing; however, unequivocal evidence of this and of the level of importance of the other possible causes of the increase is lacking.

CONCLUSIONS

Initial research on the general patterns of lightning ignitions in Sequoia National Park has shown that ignitions are not randomly distributed with regard to geographic location, elevation, slope aspect-position, vegetation, month, or year. Therefore, I suggest that information on lightning ignition patterns is important in developing fire management plans, especially if lightning ignitions are to be used to reestablish fire as a major environmental factor in wilderness areas where fire suppression programs have been successful. With regard to Sequoia National Park, additional research is needed to characterize ignition patterns within smaller areas, such as individual fire management zones and watersheds, to determine ignition frequencies in these areas, and to determine relationships between lightning ignitions and fire size.

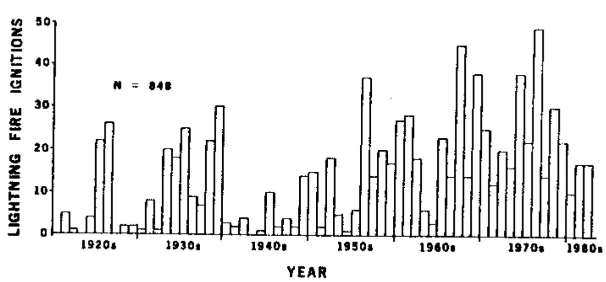

Figure 6. – Bar graph of the distributions of lightning ignitions by year. Data for 1921 are unavailable.

ACKNOWLEDGMENTS

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REFERENCES

Anonymous. Vegetation type map. Sequoia National Park, CA: U.S. Department of the Interior, National Park Service, Branch of Forestry; 1939.

Vankat, J. L. A gradient perspective on the vegetation of Sequoia National Park, California. Madrono. 29: 200-214; 1982.

Vankat, J. L.; Major, J. Vegetation changes in Sequoia National Park, California. J. Biogeogr. 5: 377-402; 1978.