

Fire-Return Intervals in Mixed-Conifer Forests of the Kings River Sustainable Forest Ecosystems Project Area¹

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Abstract

Fire-return intervals were studied on six 1.4-ha plots in a 2,070-ha study area in the Dinkey Creek watershed. Stumps in mixed-conifer forest were examined for fire scars created from 1771 to 1994, with 1873 chosen as the end of the pre-Euro-American settlement period because the rate of fire events decreased on most plots after about that year. Mean intervals from 1771 to 1873 ranged from 3.19 to 5.44 years, maximum intervals ranged from 6 to 12 years, and minimum intervals ranged from 1 to 2 years. Differences between plot means were not significant during that period, and the data showed no influence of aspect, elevation, or slope position on return intervals. Plot means were shorter than those reported in other mixed-conifer areas of the central Sierra Nevada. Archived fire records for the study area, on file at the Sierra National Forest, revealed a high rate of lightning-caused fires—an average of one fire requiring suppression every 1.36 years between 1911 and 1965. This contrasts with an average of only one lightning-caused fire requiring suppression every 9 years during a similar period in mixed-conifer forests at Redwood Mountain and Bearskin Creek, 40-50 km south of Dinkey Creek, suggesting that local factors strongly influence fire events.

The Sierra National Forest, in collaboration with the Pacific Southwest Research Station, established the Kings River Administrative Project Area for study of sustainable forestry under two contrasting, landscape-scale ecological approaches (USDA 1994). The Dinkey Creek watershed was selected for application of a three-tiered landscape, assuming that pre-Euro-American fire-return intervals in the Dinkey Creek watershed were similar to those recorded by other researchers in central Sierra Nevada mixed-conifer forests (Caprio and Swetnam 1995, Kilgore and Taylor 1979, Swetnam 1993). It also assumed that the density of trees varies across a watershed in relation to landscape position and that vegetation is most dense in drainage bottoms, grading into a relatively open condition on ridges. Fire is thought to be one causal agent for this gradient because it is believed to be more common and has shorter return intervals on ridges than in valleys.

Fire intervals had not been studied previously in the Dinkey Creek watershed. The goals of this study were to determine the mean fire-return interval and to explore relations between fire interval and landscape position in the mixed-conifer forest. The study was intended to provide land managers with site-specific information about the role of fire-return intervals in determining vegetation density. Results reported here came from a two-part effort that included the ponderosa pine forest type in the Big Creek watershed, which adjoins the Dinkey Creek watershed immediately to the west. Because results from Big Creek were inconclusive, they are not included here.

¹ An abbreviated version of this paper was presented at the Symposium on the Kings River Sustainable Forest Ecosystems Project: Progress and Current Status, January 26, 1998, Clovis, California.

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Study Area

The study area covered 2,070 ha of the Dinkey Creek watershed (37°1'N, 119°7'W) in the Sierra National Forest. Dinkey Creek, a tributary of the North Fork of the Kings River, occupies a southerly trending canyon in the southern Sierra Nevada. Elevation in the study area ranges from 1,450 to 1,950 m. Climate is Mediterranean, with warm dry summers and cool wet winters. Precipitation in the form of rain and snow falls mainly from November to April. Lightning is common in the study area.

Mixed-conifer forests of the study area are characterized by white fir (*Abies concolor* [Gordon & Glend.] Lindley) in codominance with at least two of the following species: sugar pine (*Pinus lambertiana* Douglas), incense cedar (*Calocedrus decurrens* [Torrey] Florin), ponderosa pine (*P. ponderosa* Laws.), or Jeffrey pine (*P. jeffreyi* Grev. & Balf.). Understory species typical for the sites are bearclover (*Chamaebatia foliosa* Benth.), Mariposa manzanita (*Arctostaphylos viscida* ssp. *mariposa* [Dudley] P.Wells), Sierra gooseberry (*Ribes roezlii* Regel), deer brush (*Ceanothus integerrimus* Hook. & Arn.), and little leaf ceanothus (*C. parvifolius* [S. Watson] Trel.). Scientific names of plants follow Hickman (1993).

Methods

The study area was stratified into three tiers—upper (ridge top), middle, and lower (riparian)—using geomorphologic designations of landscape processes. Upper areas were experiencing some fluvial erosion, primarily classified as eroding hillslopes. Middle slopes were dominated by fluvial and mass-wasting processes and experiencing some colluvation and debris sliding. The lower tier was generally an area of deposition. Two 1.4-ha study plots were located in each tier in mixed-conifer forest with known harvest dates within the last 11 years. Selected sites were examined for evidence of fire by using methods described in Arno and Sneek (1977). Sample plots had at least six relatively fresh stumps from trees more than 200 years old. All sampled stumps were located with a global positioning system (GPS) and labeled with metal tags. No attempt was made to control for plot elevation or aspect.

I selected an average of 7.7 stumps from each plot for a total of 46 stumps and, with a chain saw, removed a slab from the top of each stump exhibiting a continuous fire record in the form of open cat faces or fire scars (Drumm 1999). Slabs were sanded with 500-grit sand paper and examined under 10x and 20x magnification. Dates of fires were determined by counting annual growth rings backwards in time from the known year of harvest. Correlation of ring sequences into a single chronology was done for each plot by using methods described in Arno and Sneek (1977). Missing rings, often associated with fire events, may have resulted in some error in the data, so dates associated with a single fire event were interpreted accordingly.

Results and Discussion

Fire dates ranged from the mid-1500's to 1943. The clearest fire records came from sugar pines and generally dated from about 1770. Numbers of fire events per year declined in 1871, after what appeared to be a fairly active and widespread fire period. Thirty-two of the 46 stumps sampled recorded fire events in 1871, but only six recorded fire events in 1873. Caprio and Swetnam (1995) sampled in the Kaweah River drainage, 55 km south of my study sites; Wagener (1961) sampled further north, at various locations in the central Sierra Nevada; and Kilgore and Taylor (1979) sampled 40-50 km to the south. All documented a similar period of high fire activity in the early 1870s, followed by a decline, suggesting a regional influence on fire activity in the early 1870s. Kilgore

and Taylor (1979) cited two sources that document a period of drought between 1869 and 1871 and drew a relationship between the drought and a “larger, higher-intensity fire” that occurred in 1871. Swetnam (1993) found a similar correlation between low-rainfall years and widespread fire events along 160-km transects in the southern Sierra Nevada. However, the lack of correlation between the 1862-1864 event listed in Kilgore and Taylor (1979) and large numbers of fire scars in the Dinkey Creek watershed imply that local conditions vary and may play an overriding role in local fire behavior.

Mean fire-return intervals from 1770 to 1871 ranged from 3.19 to 5.44 years (*table 1*), a range generally shorter than reported in other studies. Comparable sites sampled by Caprio and Swetnam (1995) had mean return intervals of 6.58 and 7.82 years, and return intervals at similar elevations were 14 to 17 years, mainly from giant sequoia groves (Kilgore and Taylor 1979).

The apparent shorter return intervals in the Dinkey Creek area may be a result of high lightning activity. Known lightning “hot spots” exist in three locations near the study area—Bear Mountain, Cabin Meadow, and Dinkey Station (*fig. 1*). According to Sierra National Forest fire atlases, 39 lightning fires occurred within the study area between 1911 and 1964, a rate of one every 1.36 years. None of these fires was allowed to burn more than 2.5 ha, but we can probably assume that lightning activity in this area has not changed appreciably since the mid-1700’s. This level of lightning activity is significantly higher than that reported by Kilgore and Taylor (1979) in their giant sequoia study sites to the east of Dinkey Creek. They reported two fires in the area of Redwood Mountain and three in the Bearskin Creek area from 1921 to 1972, or an average of only one every 9 years.

Caprio and Swetnam (1995) reported an inverse relation between elevation and the number of lightning-ignited fires, speculating that sites at lower elevations are more flammable because they support more understory vegetation and, hence, generate more fuels. Although the high number of lightning ignitions in the Dinkey Creek study area is consistent with the findings of Caprio and Swetnam, I did not find a significant relation between elevation and return intervals in the Dinkey area, possibly because of a relatively small sample size.

Plot location did not significantly influence fire-return intervals, though some influence of aspect is suggested by the data. More fire scars were found per tree on sites with northerly aspects, even though such sites showed trends toward slightly lower fire frequencies. The apparent greater continuity of scar

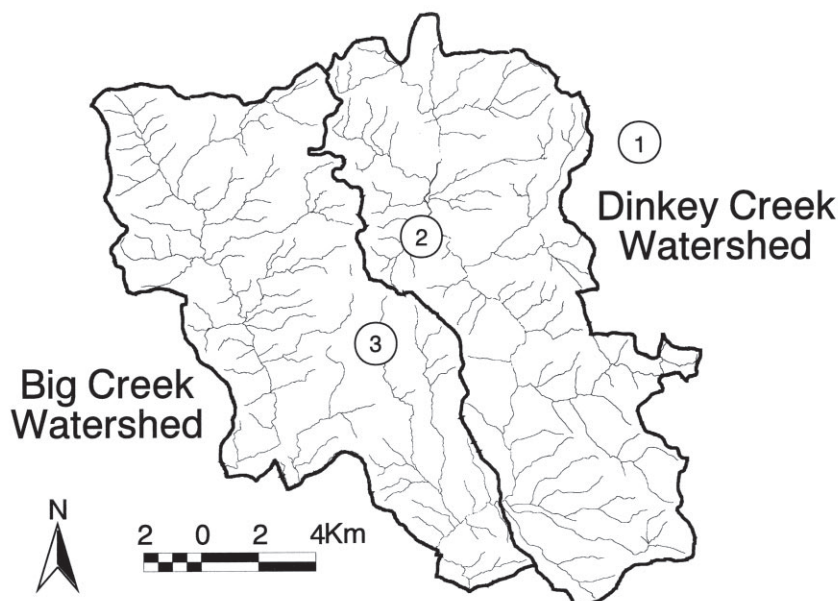


Figure 1—Areas in or near the Dinkey Creek watershed that experienced high lightning activity from 1911 to 1964: 1—Bear mountain; 2—Cabin Meadow; 3—Dinkey Station.

Table 1—Fire-return intervals (years) in the Dinkey Creek watershed, Sierra National Forest, 1770-1871

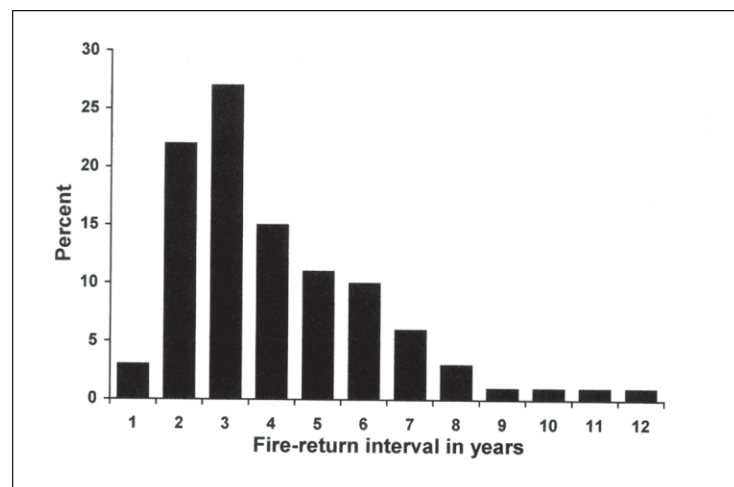
Plot number and tier ¹	Aspect	Elevation (meters)	Mean fire-return interval \pm SD	Min.– max. fire-return interval	Number of years ²	Tree stumps sampled	Number of fire events
P1, lower	S	1,707	4.45 \pm 2.2	2-11	99	8	21
P2, lower	N	1,463	3.96 \pm 2.3	1-10	96	6	24
P3, middle	NNE	1,634	5.44 \pm 2.2	2-9	99	7	18
P4, middle	SW	1,798	3.19 \pm 1.4	1-6	100	8	33
P5, upper	SSW	1,902	3.64 \pm 1.8	1-10	103	10	28
P6, upper	N	1,780	4.33 \pm 2.4	2-12	102	7	20

¹ Lower tier = the riparian management zone; upper tier = about 30 percent of the watershed, from the ridge top down; middle tier = remaining side slope between the lower and middle tiers, comprising about 50 percent of the watershed.

² Duration of the interval sampled.

data suggests that cooler (more mesic) conditions on northerly aspects reduce the number of missing rings a tree may exhibit after fires, or that the cooler conditions may limit fire-scar formation to events that burn hotter and presumably cover a larger area. It is clear, however, that additional work is needed to fully understand the effects of landscape position on fire-return intervals.

The maximum period between fire events in the study area ranged from 6 to 12 years (*table 1*), but the distribution of return intervals on all plots was weighted toward shorter intervals of 2 and 3 years (*fig. 2*). Short fire-return intervals have implications for land managers in supporting the fine-grained model proposed by Swetnam (1994) and Chang (1996). According to these sources, a system under short fire-return intervals would have a fine-grained appearance of patches in the landscape. In fact, the landscape would be in a steady state of disequilibrium, one constantly changing at a small scale, but one that remains in a fairly stable condition, overall. Biodiversity may be high because many different light and structural conditions are represented over a relatively small area.

Figure 2—Frequency distribution of fire-return intervals in the Dinkey Creek study area, 1770 to 1871.

Conditions today have changed enormously, and stand conditions have become more homogeneous at a small scale but less homogeneous at a large scale. Minnich (1983) and Swetnam (1994) discussed this phenomenon. Historic logging practices, which removed the large-tree component in much of the Sierra Nevada and targeted specific desirable species like sugar pine, have also contributed (McKelvey and Johnston 1992).

Acknowledgments

Mary Drumm's assistance with the field work was indispensable. Neil Sugihara, Forest Service Regional Fire Ecologist, was responsible for initiating the project, and Mark Smith, silviculturist on the Sierra National Forest, obtained funding from the Sierra National Forest. Don Potter and Jared Verner provided helpful review comments. To all I express my deep appreciation.

References

- Arno, S.F.; Sneek, K.M. 1977. **A method for determining fire history in coniferous forest of the mountain west**. Gen. Tech. Rep. INT-GTR-42. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 28 p.
- Caprio, Anthony C.; Swetnam, Thomas W. 1995. **Historic fire regimes along an elevational gradient on the west slope of the Sierra Nevada, California**. In: Brown, J. K.; Mutch, R. W.; Spoon, C. W.; Wakimoto, R. H., technical coordinators. Proceedings of the symposium on fire in wilderness and park management; 1995 March 30–April 1; Missoula, MT. Gen. Tech. Rep. INT GTR-320. Ogden, UT: Intermountain Research Station, Forest Service, U.S. Department of Agriculture; 173-179.
- Chang, Chi-Ru. 1996. **Ecosystem responses to fire and variations in fire regimes**. In: Sierra Nevada ecosystem project, final report to Congress, vol. II. Assessments and scientific basis for management options. Davis, CA: University of California, Centers for Water and Wildland Resources, Wildland Resources Center Report No. 37; 1,071-1,099.
- Drumm, Mary K. 1999. **Fire history of the mixed conifer series in Kings River adaptive management area, Sierra National Forest, California**. Arcata, CA: Humboldt State University; 32 p. M.S. thesis.
- Hickman, James C., ed. 1993. **The Jepson manual: higher plants of California**. Berkeley and Los Angeles, CA: University of California Press; 1,400 p.
- Kilgore Bruce M.; Taylor, Dan. 1979. **Fire history of a sequoia–mixed conifer forest**. Ecology 60: 129-142.
- McKelvey, Kevin S.; Johnston, James D. 1992. **Historical perspectives on forests of the Sierra Nevada and the Transverse Ranges of southern California: forest conditions at the turn of the century**. In: Verner, Jared; McKelvey, Kevin S.; Noon, Barry R.; Gutiérrez, R.J.; Gould, Gordon I., Jr.; Beck, Thomas W.; technical coordinators. The California spotted owl: a technical assessment of its current status. Gen. Tech. Rep. PSW-GTR-133. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 225-246.
- Minnich, Richard A. 1983. **Fire mosaics in southern California and northern Baja California**. Science 219: 1287-1294.
- Swetnam, Thomas W. 1993. **Fire history and climate change in giant sequoia groves**. Science 262: 885-889.
- USDA [U.S. Department of Agriculture]. 1994. **Sustainable forest ecosystem preliminary administrative study**. Prather, CA: Kings River Ranger District, Sierra National Forest, Forest Service, U.S. Department of Agriculture; 117 p. [Unpublished internal document.]
- Wagener, Willis W. 1961. **Past fire incidence in Sierra Nevada forests**. Journal of Forestry 59: 739-748.

