Giant Sequoia Mortality in Burned and Unburned Stands

Does prescribed burning significantly affect mortality rates?

By Sherman Lambert and Thomas J. Stohlgren[1]

The importance of fire to the ecology of giant sequoia ***(Sequoiadendron giganteum)*** is well documented. Muir (1894) first noted the conspicuous fire scars found on many large trees in the late 1800s. Kilgore and Biswell (1971) and Harvey et al. (1980) present strong evidence that fire is necessary for giant sequoia reproduction.

In the past 20 years, personnel of Sequoia and Kings Canyon National Parks have conducted prescribed fires to reduce some of the heavy fuels that have accumulated because of earlier fire suppression policies (Bancroft et al. 1985). The overall goal of this fire management program is to ”restore or maintain the natural range of fire behavior and effects (i.e., the fire regime) to the maximum extent possible so that the natural ecosystems can operate essentially unimpaired by human interference” (Sequoia and Kings Canyon National Parks 1984). A key part of this fire management program is monitoring the effects of prescribed fires on vegetation, including one of the primary resources of the park: giant sequoias.

This article examines the extent to which recent prescribed fires may have caused giant sequoia mortality as well as how pre-existing fire sears have influenced mortality rates.

Methods and Materials

The Sequoia Tree Inventory Project was conducted between 1963 and 1969, before prescribed fire was extensively used (Hammon, Jensen, and Wallen Mapping and Forestry Service, Inc. 1964). All giant sequoias within Sequoia and Kings Canyon National Farks were mapped, measured, and described according to condition (e.g., bole condition, extent of fire scarring). Tree diameters were recorded to the nearest inch for trees less than 1 foot in diameter and to the nearest foot for tree diameters 1 foot or larger. Trees were assigned to one of five groups according to the area of fire scarring in the stem: none (N), less than 25 square feet (S1), 25 to 100 square feet (S2), more than 100 square feet (S3), and center burned (C).

In 1985 and 1986, we reinventoried all giant sequoias from inventory maps in preselected areas of the Giant Forest grove. Sample sites were chosen from areas that were known to be either unburned or recently (between 1979 and 1984) preseribed burned, based on fire history maps. In areas burned in 1984, extremely heavy ground fuels were manually removed before burning from the bases of a few giant sequoias that already had large fire scars (S3) or center burns (C). About 280 acres each of burned and unburned forest were sampled. The d.b.h. of each reinventoried tree was remeasured. Tree mortality was noted within each of four diameter groups: less than 1 foot, 1-6 feet, 7-12 feet, and 13 feet or greater.

Two-way contingency tables were constructed to compare morality within various combination of fire

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Table 1. Giant sequoia survival from 1964 to 1986 at the Giant Forest grove, Sequoia and Kings Canyon National Parks, Three Rivers, CA.

Diameter at d.b.h.	Fire scar group N[1] Live	N[1] Dead	S1[2] Live	S1[2] Dead	S2[3] Live	S2[3] Dead	S3[4] Live	S3[4] Dead	C[5] Live	C[5] Dead	Total Live	Total Dead
ft	no.											
Unburned Area												
<1	161	75	0	0	0	0	0	0	0	0	161	75
1–6	148	3	7	1	1	0	0	0	1	0	157	4
7–12	71	0	16	0	5	0	5	0	14	1	111	1
>12	13	0	8	0	7	0	10	0	10	2	48	2
TOTAL	393	78	31	1	13	0	15	0	25	3	477	82
Burned Area												
<1	92	101	0	0	0	0	0	0	0	0	92	101
1–6	191	12	10	0	0	0	2	0	2	0	205	12
7–12	63	0	12	0	9	2	11	0	5	0	100	2
>12	7	0	4	0	12	0	28	2	10	1	61	3
TOTAL	353	113	26	0	21	2	41	2	17	1	458	118
GRAND TOTAL	746	191	57	1	34	2	56	2	42	4	935	200

[1] *0 square feet of tree stem is fire-scarred.*
[2] *Less than 25 square feet of tree stem is fire-scarred.*
[3] *25–100 square feet of tree stem is fire-scarred.*
[4] *More than 100 square feet of tree stem is fire-scarred*
[5] *Tree stem center is fire-scarred.*

scar, diameter, and burn groups (Sokal and Rohlf 1981). Chi-square tests were performed to test for significant differences. When possible fire scar and diameter group data were pooled to simplify the analysis. Fire-scarred (all fire scar groups but N) and unscarred (fire scar group N) trees were also analyzed separately to look at relationships between burning and subsequent mortality.

Results

The burned sample representing limited preburn clearing was combined with the other burned data because a treatment vs. mortality (within diameter and fire scar groups) comparison was not significant ($X^2 = 2.64$, $P_5 = 0.755$) (X^2 = Pearson chi-square; $P_{subscript}$ denotes *p* value at the specified degree of freedom). A total of 1,135 giant sequoias were resampled in both burned and unburned areas ***(table 1)***. Fire-scarred trees were found in all but the smallest diameter group.

When scarring (Sl, S2, S3, and C fire scar groups) vs. mortality within diameter and burning groups) was tested the resulting chi-square score was not significant ($X^2 = 13.16$, $P_{14} = 0.514$). We combined the four levels of fire scarring (Sl, S2, S3, and C fire scar groups) and compared the mortality of scarred with that of unscarred trees (N fire sear group); the resulting chi-square score was still not significant ($X^2 = 9.54$, $P_6 = 0.145$).

We tested the three largest diameter groups for a diameter vs. mortality (within burning group, all the scar groups combined) comparison; the chi-square score was not significant ($X^2 = 3.83$, $P_4 = 0.430$). When the smallest trees (less than 1 foot in diameter) were combined with the pooled larger trees, the diameter vs. mortality (all fire scar groups combined) chi-square score was significant for both burned and unburned trees (X^2=180.71 and 95.53 respectively, $P_1 < 0.0001$).

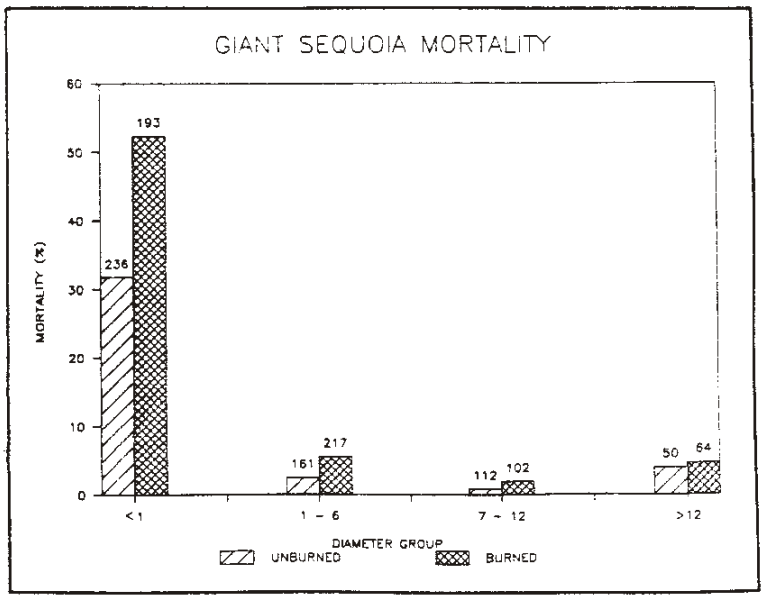

Figure 1. Giant sequoia mortality (1964–86) in burned and unburned areas by diameter group (all fire scar groups combined). Total group sample size appears above each bar.

The burning vs. mortality (within diameter group, all fire scar groups combined) comparison produced a significant chi-square score ($X^2 = 18.55$, $P_1 < 0.0001$) for the smallest trees; however, the chi-square score for the larger trees (all those more than 1 foot in diameter) was not significant $X^2 = 2.75$, $P_1 = 0.097$).

When only unscarred tree data (fire scar group N) were analyzed, there was a significant difference in mortality because of burning within the smallest diameter group (X^2=18.54, P_1 0.0001), but the difference was not significant in the 1- to 6-foot diameter group comparison ($X^2 = 3.29$, P_1= 0.070). The larger unscarred trees had no mortalities to compare.

Our comparisons using only scarred trees (Sl, S2, SS, and C fire scar groups combined) included no small trees less than 1 foot in diameter). The diameter vs. mortality (within burning group) chi-square score was not significant ($X^2 = 1.93$, $P_4 = 0.749$). The burning vs. mortality comparison (within all larger diameters combined) showed no detectable difference between the groups ($X^2 = 0.00$, $P_1 = 1.000$).

Discussion

Giant sequoia mortality in both burned and unburned areas is very low compared to other Sierra mixed-conifer species (Lambert 1985). The larger giant sequoias (more than 1 foot in diameter) showed similar low rates of mortality in both burned and unburned areas (***fig. 1***) over the 23-year period since first inventoried. Because larger tree mortality in the burned areas represents combined fire- and nonfire-induced mortality, no mortality could be attributed to prescribed burning alone.

There is no evidence that previous fire scarring has any relationship to tree mortality. Although the difference is not statistically significant, trees fire scarred in the center had higher mortality rates in unburned areas than in burned areas (***fig. 2***). Unscarred trees had higher mortality in burned stands, but the difference was statistically significant only in trees with diameter less than 1 foot. In unburned areas,

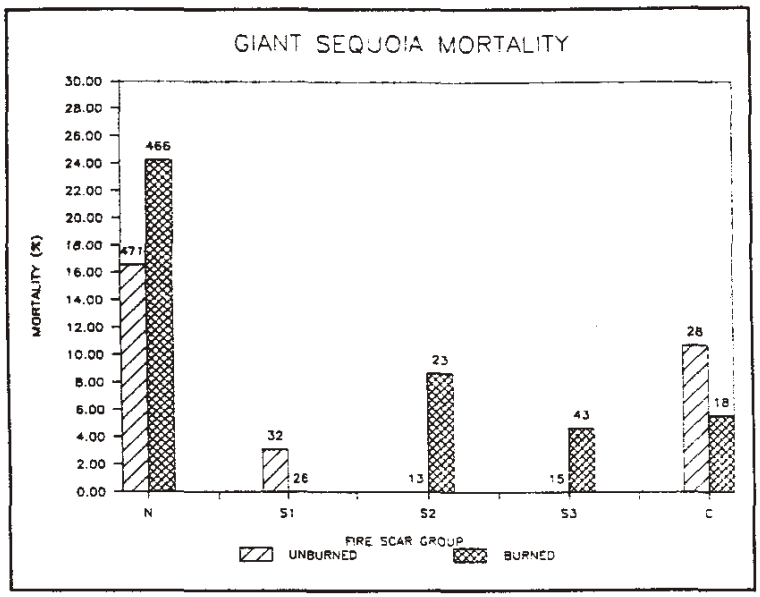

Figure 2. Giant sequoia mortality (1964–86) in burned and unburned areas by fire scar group (all diameter groups combined). Total group sample size appears above each bar.

the highest small-stem mortality was observed in pure, dense patches of giant sequoia saplings, suggesting that strong intraspecific competition probably exists.

Questions have recently surfaced concerning the desirability of removing heavy fuel loads from around the bases of S3 and center-burned trees prior to prescribed burning. This would be an interesting topic for future research in other areas with a longer history of prescribed burning. The Giant Forest record represent too small a sample to address questions concerned with preburn treatments

Our data suggest that the current management practice of applying low intensity prescribed burns is sufficient to maintain low mortality rates of giant sequoias.

Conclusions

Recently burned and long unburned giant sequoia stands have detectably different tree mortality rates, but the effect was almost entirely restricted to trees smaller than 1 foot in diameter. The larger trees had nearly equal mortality rates in burned and unburned stands. Previous fire scars had no detectable relationship to tree survival in either burned or unburned areas.

The type of information presented here is just one part of the ecological database needed to evaluate prescribed and management practices (Parsons et al. 1985). Continued research and monitoring of the effects of fire are essential to the success of the program. The prescribed fire techniques currently being used result in *very* low levels of giant sequoia mortality and appear to be a conservative approach to reintroducing the natural role of fire into giant sequoia forests.

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