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Comparison of Fire History Estimates between Open-scarred and Intact Quercus douglasii

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ABSTRACT.—Reservation has been expressed regarding relying on samples from trees with open scars to estimate fire history. A greater probability of scarring for open-scarred trees is one reason commonly given for restricting samples. Fire scars in 181 scarred *Quercus douglasii* cross sections were dated from two different stands. In the stand with no fires for the last 35 yr, open-scarred trees revealed a shorter fire history, 90% fewer fire dates, and a mean fire interval (MFI) that was shorter than determined from intact trees. In the stand with no fires for the last 15 yr, MFI and length of record were comparable but open-scarred trees accounted for 27% fewer fires than intact trees. Open-scarred trees were twice as likely to scar as intact trees, but the average number of scars tree^{-1} were similar. Time since last fire is critical, as scars may heal before sampling. This suggests that fire history estimates will be most affected by sample restriction in areas with long periods of fire suppression.

INTRODUCTION

Dating of fire scars is the most common method to estimate fire history (McBride, 1983). Trees with visible, open, fire scars (cat-faces) are typically used as the sole source of samples for fire scars (McBride and Laven, 1976; Arno and Sneck, 1977). Open-scarred trees are thought to be more susceptible to scarring by subsquent fires than intact trees and therefore to harbor more scars from past fires (Romme, 1980). Also, it is more practical to sample open-scarred trees because scars are guaranteed and tree felling is not required. McBride (1983) questioned relying on open-scarred trees without knowledge of the error associated with this sampling bias. Effects of sampling intensity on fire history estimates have been described (Kilgore and Taylor, 1979; Arno and Peterson, 1983), but the effect of restricting samples to open-scarred trees has not been measured.

My objectives were to assess the effect of restricting samples to open-scarred trees on fire history estimates and to evaluate the assumption that trees are more susceptible to scarring when an open scar is present. My approach used fire scars in *Quercus douglasii* H. & A. to compare fire history estimates and scarring potential between intact and open-scarred trees.

METHODS

Study sites were on the University of California Sierra Field Station, 30 km E of Marysville, California, in the Sierra Nevada foothills. Station vegetation is primarily foothill oak woodland (Griffin, 1977) with two layers: an open tree canopy $\leq$12 m tall with 300–500 trees ha^{-1} and a continuous annual grassland understory $\leq$1 m tall. Winter deciduous *Quercus douglasii* accounted for >90% of the trees on the study sites (McClaran, 1986). Temperature and rainfall patterns are representative of a Mediterranean climate with hot dry summers and cool wet winters and an average annual rainfall of 73 cm. Fire season begins in June, when drying herbaceous vegetation (1000–3000 kg ha^{-1} net annual aboveground production) becomes flammable, and persists until rains start in October or November. Two 5-ha study areas were approximately 5 km apart on $\leq$10° slopes, with the Koch pasture at 500 m elevation and Campbell pasture at 300 m.

In 1982–1983 all *Quercus douglasii* were cut in nine 0.05-ha plots on the Campbell site (300 trees) and in six 0.1-ha plots on the Koch site (372 trees). I collected cross sections

Table 1.—Comparison of average scars tree^{-1}, fire scar dates and mean fire interval (MFI) between intact and open-scarred *Quercus douglasii*

Site	Tree condition	# of trees	Average scars tree^{-1}	Fire dates	MFI
Campbell	Intact	77	1.5[a]	1890, 1905, 1914, 1919, 1929 1934, 1936, 1939, 1954, 1958, 1968	7.8
	Open scar	18	1.6	1905, 1919, 1934, 1936, 1939, 1954, 1958, 1968	9.0
Koch	Intact	76	1.6	1681, 1708, 1733, 1741, 1773, 1803, 1852, 1856, 1865, 1868, 1871, 1879, 1890, 1900, 1905, 1914, 1919, 1936, 1941, 1948	14.1
	Open scar	10	1.1	1936, 1941	5.0

[a] There were no significant differences (Wilcoxon Rank Sum test; $P < 0.05$) between intact and open-scarred trees for scars tree^{-1} at either site and MFI values on the Campbell site. Statistical inference for MFI differences was not possible for the Koch site because only one interval was available for the open-scar tree population

from all trees at 5 cm aboveground and prepared them for dating by sanding with 200-grit paper. To determine each tree age and fire scar date I counted annual rings along two radii (Stokes, 1980). I lumped the few outlying scar dates with the closest well-documented fire date (Arno and Sneck, 1977), but this adjustment did not exceed a ±1 yr correction.

I compared length of fire history, fire dates and mean fire interval (MFI) between intact (unscarred or healed) and open-scarred trees to estimate the effect of sample restriction on fire history estimates.

To evaluate the assumption that *Quercus douglasii* is more susceptible to scarring when an open scar is present, I compared average proportion of trees scarred between intact and open-scarred trees. To estimate average proportion of scarred trees I calculated the proportion of scarred trees that were standing and intact or open-scarred at the time of each fire, summed the scarring proportions from each fire, and divided by the number of fires. Presence of open scars at the time of each fire was determined by dating when each fire scar healed. In addition, I determined average number of scars tree^{-1} for sections with scars to compare scarring potential between intact and open-scarred trees.

Results and Discussion

Difference in fire scar history estimates from intact and open-scarred trees varied between study areas (Table 1). Trees with open scars on the Koch site revealed a much shorter fire history, 90% fewer fire dates, and a trend toward a shorter MFI than intact trees. Paucity of fire dates for open-scarred trees made statistical inference of MFI estimates impossible. Trees with open scars on the Campbell site revealed similar length of fire record and MFI as intact trees, but 27% fewer fire dates.

Time since last fire (Table 1) and maximum tree age also varied between study areas. The Koch area had no recorded fire for the last 35 yr and maximum tree age was >400 yr. The Campbell area had no recorded fire for the last 15 yr and maximum tree age was <150 yr. Absence of trees >150 yr on the Campbell site limited potential length of fire

history record relative to the Koch site. However, this difference in stand age does not affect within-site comparisons between intact and open-scarred trees.

A significantly greater proportion of trees with open scars at the time of subsequent fires was scarred than intact trees (0.22 ± 0.03 SE and 0.09 ± 0.01 SE; $P < 0.05$, using a binomial test). Average number of fire scars in intact and open-scarred trees was not different (Table 1). Only Kilgore and Taylor (1979) reported scarring data using comparable procedures; however, their results are limited to one fire in 1797. They found 68% (15 of 22) of open-scarred trees and <2% (2 of 15) of intact trees were scarred by that fire.

This study of *Quercus douglasii* indicates that restriction of fire scar samples to open-scarred trees would limit accuracy of fire history estimates relative to use of both open-scarred and intact trees. Although degree of difference between fire history estimates from intact and open-scarred trees varied between study areas, these results support McBride's (1983) concern that sample restriction affects fire history estimates. Davis (1980) and Stewart (1986) also recognized the need to survey intact trees to produce a more complete fire history, but they did not quantify the degree of error associated with sample restriction.

Sample restriction affected fire history estimates even though trees with open scars were twice as likely to be scarred than intact trees. Time since last fire is critical, as scars may be allowed to heal before sampling. This suggests that fire history estimates will be most affected by sample restriction in areas with long periods of fire suppression.

If fire scars continue as a basis for fire history estimates, then error associated with their sampling methods should become part of these estimates. Sample restriction to visible open-scarred trees is, and will remain, a popular method because it minimizes destructive sampling. I found substantial effect of sample restriction on fire history estimates in *Quercus douglasii*. Efforts should be initiated to describe sample restriction effects for other taxa and the role of fire suppression on these effects.

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