

SHORT COMMUNICATION

## FIRE HISTORY IN CALIFORNIA'S SOUTHERN SIERRA NEVADA BLUE OAK WOODLANDS

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### ABSTRACT

Fire history for blue oak (*Quercus douglasii* Hook. & Arn.) woodlands in California's southern Sierra Nevada range was characterized with samples of 49 trees. Mean fire interval was 12.8 years from 1850 to 1965, with apparent fire exclusion since that time. Changes in fire frequency could affect oak woodland ecosystem processes such as recruitment, tree growth and mortality, and vegetation composition.

*Keywords:* blue oak, fire history

*Citation:* Standiford, R.B., R.L. Phillips, and N.K. McDougald. 2012. Fire history in California's southern Sierra Nevada blue oak woodlands. *Fire Ecology* 8(2): 163-167. doi: 10.4996/fireecology.0802163

### INTRODUCTION

Blue oak (*Quercus douglasii* Hook. & Arn.) woodlands are widespread in California, USA, occurring on 1.2 million ha, which represents the largest vegetation type of the state's 3.6 million ha of oak woodlands (Waddell and Barrett 2005). Over 90% of California's blue oak woodlands are privately owned (Waddell and Barrett 2005), and contain the highest level of biological diversity of any broad habitat in the state (Allen-Diaz *et al.* 2007).

Fire has been documented as a regular part of the California's oak woodland ecosystem for the past several thousand years (Byrne *et*

*al.* 1991). Fire has been used as a management tool by Native Americans to improve game habitat and enhance desirable vegetation types (Anderson 2007). Following settlement by Europeans, private ranch owners continued to utilize fire as a management tool to enhance livestock forage production and maintain a more open stand structure, although fire suppression has become a more common management policy in recent years (Allen-Diaz *et al.* 2007).

McClaren and Bartolome (1989) documented a mean fire interval (MFI) of 25.2 years between 1681 and 1848, 7.1 years from 1849 to 1948, and no fires from 1949 to the

present for blue oak stands in the central Sierra Nevada foothills. They showed the importance of fire in blue oak recruitment, likely resulting from resprouting of top-killed stems, with 64% to 78% of all trees becoming established within one year of a fire event. Stephens (1997) found that the MFI of a mixed oak-pine stand in the Sierra Nevada foothills approximately 70 km east of Sacramento, California, was 7.8 years during the period from 1850 to 1952.

## METHODS

As part of a larger replicated study to evaluate thinning levels in blue oak stands, this project documented fire history for blue oak stands to the south of the areas studied by McClaran and Bartolome (1989) and Stephens (1997). The study area was located on a private blue oak woodland ranch in the southern Sierra Nevada foothills near the town of California Hot Springs in Tulare County, California, USA (latitude 35° 53' 17", longitude 118° 41' 37"). The elevation averaged 838 m. The slopes ranged from 8% to 18%, with a northwest aspect. The area was seasonally grazed as part of a cow-calf livestock operation.

The study area covered 0.7 ha, which included nine sample plots 0.04 ha in size and buffer areas between the plots. The study area was established in 1994. The general stand structure data for the study area (Figure 1) is shown in Table 1. Three plots were thinned to one-third of their original basal area, three plots were thinned to two-thirds of their original basal area, and the remaining three plots were untreated controls. As part of the thinning design, 49 trees were felled in the six plots with thinning treatments. The trees were randomly selected to meet the post-thinning basal area goals. Only trees over 1 cm diameter at breast height (dbh) were included in the study design.

Each tree was harvested at a stump height of 0.15 m in 1995. We cut a tree round at the



**Figure 1.** Overview of blue oak woodland study site in Tulare County, California, USA.

**Table 1.** Pre-thinned blue oak stand structure of sample area in southern Sierra Nevada, Tulare County, California, USA.

Stand characteristic	Average ( $\pm$ 95% confidence interval)
Trees ha <sup>-1</sup>	702.5 ( $\pm$ 113.6)
Basal area (m <sup>2</sup> ha <sup>-1</sup> )	20.8 ( $\pm$ 3.2)
Average dbh (cm)	19.3
Volume (m <sup>3</sup> ha <sup>-1</sup> )	97.9 ( $\pm$ 26.5)
Crown cover (%)	45 ( $\pm$ 9)

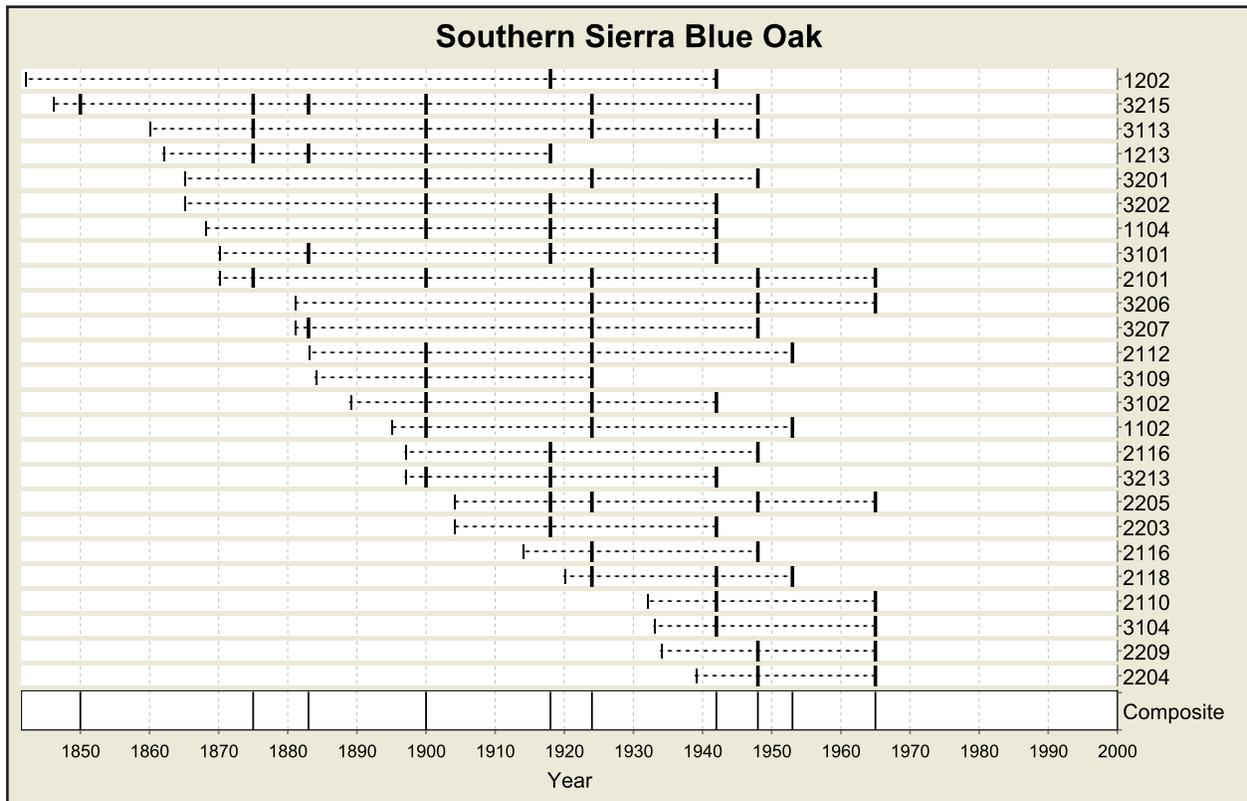
base of each harvested tree. We sanded each round to prepare it for tree ring analysis. Each round was aged by counting the annual rings along two radii under microscopic observation. There was at least one fire scar on approximately 50% of the trees sampled. Following the procedure described by McBride (1983), we identified fire scars by visual observation of disruption and healing patterns on the tree rounds. We determined the year of the scarring by the age of the annual ring where the scarring was observed. We used the Fire History Analysis and Exploration System (FHAES) to graph fire scars and to calculate MFI and associated statistical parameters (Grissino-Mayer 2001).

## RESULTS

The general fire history of the stand based on the trees sampled (Table 2) and the composite fire history diagram for the study area (Figure 2) show that fire was a regular part of the blue oak woodland ecosystem from the mid-nineteenth century through 1965, with fire scars observed every 5 years to 25 years throughout that period. For the next 30 years, however, no fires were recorded as scars in trees from the study area. We are using fire scars as the proxy for fire events in the stand. We recognize that this may underestimate the number of low intensity fires that do not disrupt the growth pattern on the annual rings.

**Table 2.** Blue oak woodland fire history from southern Sierra Nevada foothills, Tulare County, California, USA. SD = standard deviation.

General fire history category	Value
Number of stumps in sample	49
Number of stumps with at least one fire scar	25
Stump age range (yr)	56 to 153
Mean fire interval (yr) (SD)	12.8 (7.0)
Median fire interval (yr)	12
Fire interval range (yr)	5 to 25
Fire record length (yr)	146
Last fire	1965



**Figure 2.** Composite fire history diagram of individual fire scars for blue oaks in Tulare County, California, USA.

## DISCUSSION

The presence of fire scars in the sample trees demonstrates the regular occurrence of fire in blue oak stands in the southern Sierra Nevada foothills over the past century and a half. Fire was a fairly common ecological disturbance event in blue oak woodlands during much of the nineteenth and twentieth centuries. The apparent MFI was very similar to earlier work by McClaren and Bartolome (1989) and Stephens (1997) farther north in the Sierra Nevada range. The study confirms that the pattern changed in the 1960s during an era of fire exclusion policy.

The change in fire return interval is a consideration in the development of sustainable oak woodland ecosystem management strategies. A statewide remeasurement of blue oak woodlands (Holzman and Allen-Diaz 1991) showed a general trend of increasing blue oak stand density in an era of fire exclusion. This fifty-year period of fire exclusion in our project may explain the relatively high density of the blue oak woodlands in this study area, which was the motivation for the corresponding research investigating different thinning levels at this site.

## ACKNOWLEDGMENTS

We wish to thank the Versteeg family in California Hot Springs, California, for donating their land for this study, and J. McBride for loaning his lab's microscopic equipment for fire scar analysis.

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