

Effects of Fire and Browsing on Regeneration of Blue Oak¹

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Abstract

Blue oaks (*Quercus douglasii*) are not regenerating well over much of California. The roles of fire and browsing in regeneration are probably significant, but poorly understood. We burned two foothill blue oak woodland sites which contained significant numbers of small trees between 40 and 70 cm tall, then compared height growth over 14 years among 48 trees that were: a) unburned and unbrowsed, b) unburned but browsed, c) burned and browsed, and d) burned and unbrowsed. Fire completely killed and/or removed the tops, but all plants subsequently resprouted, creating an even-aged stem class. We found no evidence that fire stimulated regeneration. Protection from moderate browsing pressure by deer and cattle (approximately 75-80 percent of twigs to a height of 150 cm were browsed) favored regrowth and subsequent escape above the browse line, although some browsed plants also reached or exceeded browse height. Height growth differed significantly by site. On one site 11 of 12 unbrowsed plants had escaped to above the browse line, with several over 3 meters tall. On the other site growth was slower, but 9 of 11 surviving unbrowsed plants were above the browse line. Fourteen years after fire enough blue oaks were successfully recruited on both sites from the shrub into the sapling class to maintain or increase overall stand density.

Introduction

Blue oaks recruit successfully in some locations of the state but not others (Bartolome and others 1988). Several factors have been proposed to explain recruitment and regeneration patterns, including grazing or browsing pressure and fire. These two factors are linked. White (1966) suggested that reduced deer and livestock numbers about 1890 favored oak regeneration. Vankat and Major (1978)

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claimed that heavy livestock use in the late 1800s reduced herbaceous competition and fire frequency sufficiently to stimulate recruitment.

Although fire is generally considered a destructive disturbance in blue oak woodland (Griffin 1977) because it may kill mature trees, McClaran and Bartolome (1989) and Mensing (1992) found a strong positive association of the timing of apparent blue oak recruitment and fires. Because fire top-kills trees and concentrates stem ages from re-sprouts, a positive association of apparent recruitment and fire is not surprising but also does not eliminate the possibility of fire-induced stimulation of regeneration (McClaran and Bartolome 1989). Small blue oaks are rarely killed by fire and vigorously re-sprout (Tietje and others 2001). Once a small oak re-sprouts it is potentially subject to browsing pressure which can eventually kill the plant or retard escape as a recruit into the sapling or tree class (Muick and Bartolome 1988).

This study assessed the impact of browsing and burning on small blue oaks in moderately dense stands with more than 800 mm of annual precipitation. This type of site was selected because small plants with potential for recruitment are frequently present. Results are not applicable to drier and more open oak savannahs. Fire and browsing were chosen for treatment because management for regeneration must control those two factors. We hypothesized that the combination of protection from browsing and increased growth following fire would lead to recruitment of new trees into the overstory from the suppressed pool of small shrub-like oaks.

Study Areas

The Crowe Ranch (study area 1) is located in Lassen County east of Redding at an elevation of 800 meters. Precipitation averages 800 mm per year. Cattle normally graze lightly in the study area, which is primarily an upland included with irrigated pasture, but were excluded during the spring of the burn to allow fuel accumulation. Deer are locally common. The area is blue oak dominated at approximately 25 percent tree canopy cover. The study area had been burned under prescription in July 1981 to remove some oaks and brush for range improvement, therefore the site supports less tree cover than historically. Following the 1981 fire many blue oaks resprouted and were between 40 and 70 cm tall in 1986.

In July 1986 the Crowe Ranch study area was burned by the Lassen County Range Improvement Association as part of a 100 hectare prescribed burn. Conditions were good for a range improvement burn, with temperature at the start of the burn (1700 hrs) 33 degrees C and a relative humidity of 19 percent. Wind was less than 8 kph. The flame front at the study site measured 1.5 to 2 meters in dry grass fuel that weighed 2500 kg/ha. Conditions resulted in complete combustion of grass and tops of the small oaks. All small oaks were top killed. Post fire sampling was initiated in spring 1987.

The Ellis ranch (study area 2) is in Madera County near North Fork. The vegetation is similar to the Crowe ranch, with a blue oak canopy of about 25 percent. The study site had numerous small blue oaks between 50 and 70 cm tall which had regenerated following clearing of small trees in the mid-1970s and a range improvement burn in 1979. The site is at approximately 800 meters elevation and receives 800 mm of annual precipitation. The pasture is irregularly grazed moderately by cattle but was unused in the year preceding the fire. Deer are scarce in the area.

The Ellis ranch was burned in July 1987 as part of a 600-hectare range improvement burn conducted under the state Vegetation Management Program. Conditions for a range improvement burn were good, with the temperature at the start of the burn (1,000 hrs) 27 degrees C, at a relative humidity at 20 percent. Wind was less than 8 kph and grass fuels totaled 2,000 kg/ha. The flame front varied from 0.6 to 1.2 meters and most of the dry material was consumed, but some unburned grass and oak litter remained at the soil surface. All study plants were top killed. Postfire sampling began in spring 1988.

Methods

At each ranch 24 small blue oaks between 40 and 70 cm tall were selected for study. The 24 plants were divided into four groups of six plants each. Four treatments were: 1) unburned and unbrowsed, 2) unburned and browsed, 3) burned and unbrowsed, and 4) burned and browsed. The burn treatment was manipulated by construction of a fire-line which split the 24 plants into burned and unburned groups; the unbrowsed treatment by the random allocation of wire mesh cages to half of the plants in each burn treatment. Each plant was permanently marked with rebar and a metal tag. In midsummer prior to any treatment (July 1986 at the Crowe Ranch, July 1987 at the Ellis ranch), we measured each plant for height and maximum and minimum crown diameter.

Because we were interested in potential changes in growth form we also counted number of stem meristems on each plant by 10 cm height increments. Measurements were repeated for three years following the burns and again in 2000, 14 years after fire at the Crowe Ranch and 13 years after fire at the Ellis Ranch. Meristem counts were not repeated in 2000. Means were evaluated and compared for significant ($p < 0.05$) differences with t-tests.

Results

The average height and meristem distribution pretreatment did not differ significantly for the two study areas. Burning removed the tops of small blue oaks, resulting in a decrease in average height (*figs. 1 and 2*). Burned plants quickly resprouted and only one of the total of 48 plants died during the first 3 years. That was a burned and unbrowsed plant at the Crowe Ranch, which was likely killed by rodents in the second year of the study. By 2000 two more plants had died at the Crowe Ranch and two died at the Ellis Ranch in the intervening 13 years but no cause could be assigned. The total mortality during the study was 5/48 (10 percent) and not related to any particular treatment.

The resprouting pattern of burned plants, as reflected by meristem distribution, was one of rapid elevation of a few meristems in the first post burn year followed in the next 2 years by production of more lower meristems so that by the third post-burn year meristem distribution resembled that of unburned plants. At the Crowe Ranch, burned and grazed plants still showed significantly fewer meristems above 50 cm, while at Ellis the differences had disappeared by year three. Generally, however average plant height was the better response variable to evaluate treatment so we did not remeasure meristem distribution in 2000.

Height recovery from burning differed on the two sites. Changes in plant crown volume and diameter precisely followed the pattern of simple height measurements and will not be described separately. By the second year following burning at the Ellis Ranch, average heights of all treatments including burning significantly exceeded pretreatment (*fig. 1*). Recovery took longer at the Crowe Ranch but was observed in all treatments to pretreatment heights by the third year (*fig. 2*). Browsing protection significantly increased the rate of recovery for the first three years at the Ellis Ranch but not at the Crowe Ranch.

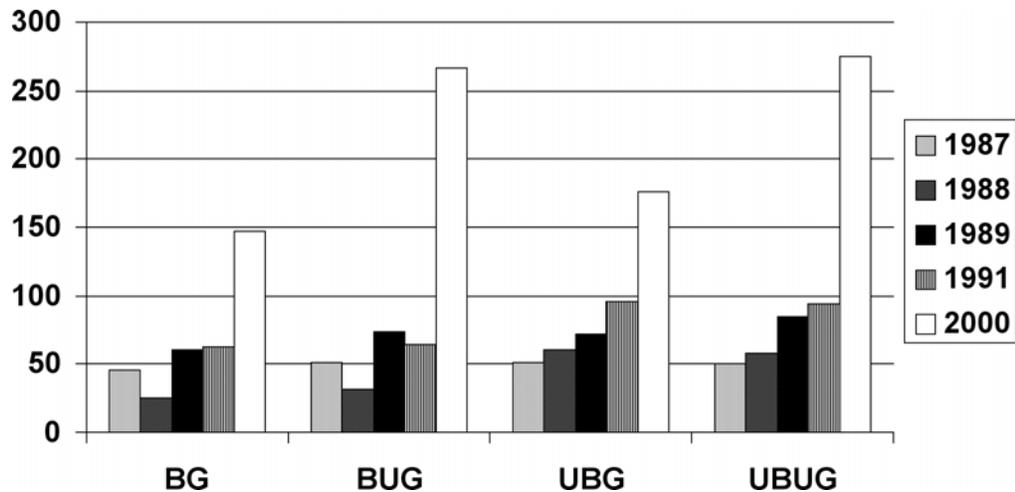


Figure 1—Average heights (cm) of small shrubby blue oaks at the Ellis Ranch measured prior to any treatment (1987), for three years after burning in summer of 1987 (1988-1991) and 13 years after fire (2000). Treatments are 1) Burned and browsed (BG), 2) Burned and unbrowsed (BUG), 3) Unburned and browsed (UBG), and 4) Unburned and unbrowsed (UBUG). Height differences between burned and unburned treatments were not significant ($p < 0.05$, t-test) after 1988. Differences between browsed and unbrowsed treatments became significant in 1991 and were still significant in 2000.

After more than a decade, plants protected from browsing were significantly taller at both sites and early differences between burned and unburned plants had disappeared (*figs. 1 and 2*). We saw no evidence that burning stimulated growth. Browsing at both sites extended to 150 cm and was estimated at 80 percent of the meristems below that level at the Ellis Ranch and 75 percent at the Crowe Ranch. In 2000 at Ellis, 11 of 12 unbrowsed plants had meristems above 150 cm and 4 of 10 browsed plants were above 150 cm. At the Crowe Ranch in 2000 only 1 of 12 grazed plants reached above 150 cm but 9 of 11 ungrazed had escaped to above the browse line.

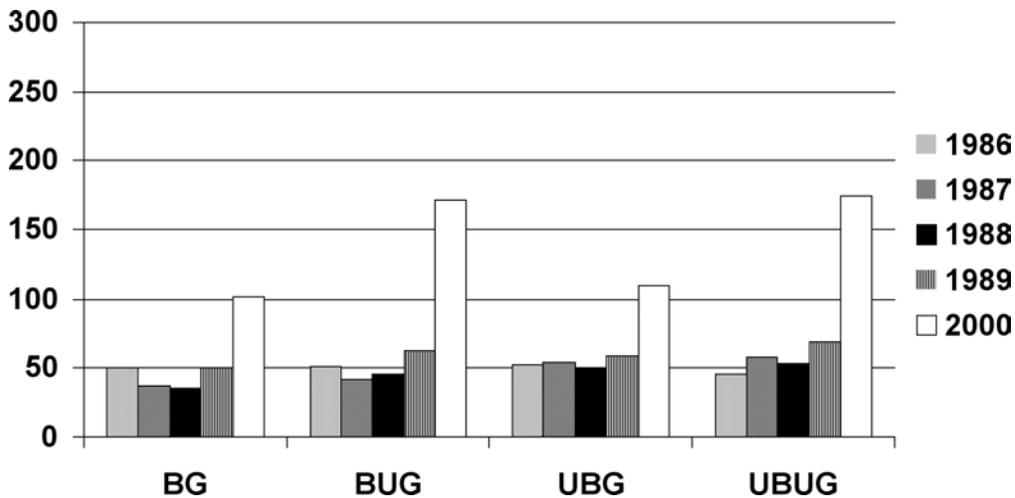


Figure 2—Average heights (cm) of small shrubby blue oaks at the Crowe Ranch measured prior to any treatment (1986), for three consecutive years after burning in summer of 1986 (1987-1989) and 14 years after fire (2000). Treatments are 1) Burned and browsed (BG), 2) Burned and unbrowsed (BUG), 3) Unburned and browsed (UBG), and 4) Unburned and unbrowsed (UBUG). Height differences between burned and unburned treatments were not significant ($P < 0.05$, t-test) after 1988. Differences between browsed and unbrowsed treatments became significant in 1989 and were still significant in 2000.

Conclusions

The two sites differed considerably in plant response to treatment, with regrowth more rapid at the Ellis Ranch than at Crowe. The majority of plants at Ellis were above the browse line after 13 years, even unprotected plants. The cause of the differences between the sites is unknown, but shows that future research and recommendations for management need to account for probable considerable variability in response in different locations.

Fire appeared to lack any stimulatory effect on regrowth. We had hypothesized that burning combined with protection from browsing would speed elevation of meristems above the browse line. The results do not support this contention, plants grew best at both sites when protected from browsing and unburned.

Appropriate management for recruitment from sprouts will depend on growth rates for the specific site. At the Ellis ranch, under existing browsing pressure and projected early growth rates, even some unprotected sprouts would have exceeded the browse line after six or seven years. The major concern for enhancement of tree recruitment should be keeping the area free of a fire during that period to ensure successful regeneration into the sapling stage. At the Crowe ranch, for successful regeneration into the sapling stage, small plants must be protected from burning and browsing for ten or more years.

Fires, whether natural or prescribed, set back the growth of small shrubby blue oaks and do not result in a stimulation of regrowth and are not a stimulant to regeneration. Fires are also not necessarily incompatible with regeneration if the fire frequency is low and/or regrowth rates are high enough. The association of fires with

episodes of regeneration in blue oaks as observed by McClaran and Bartolome (1989) is more a result of the effect of fire on apparent age class of the stems of resprouting plants than a stimulatory effect. Browsing pressure probably plays an important role in the sites studied by suppressing height growth whether or not the plants are burned. Suppression by browsing appeared sufficient to prevent regeneration of unprotected plants at Crowe but not at Ellis. Because no mature trees died during the study on either site, recruitment from small shrubby blue oaks increased overall density of sapling and larger trees on the sites.

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