

Stump Sprouting of Blue Oaks Ten Years after Harvest¹

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Abstract

A study was conducted at five sites throughout California to determine how the sprouting of harvested blue oak (*Quercus douglasii*) is affected by the date the trees are cut down, the height of the residual stumps, and whether stumps are protected by fencing or not. After 10 years, 34 percent of the stumps had viable sprouts. The greatest effects were from fencing. Four times as many protected stumps survived than those exposed to browsing animals. Most of the mortality in unfenced areas occurred since the last evaluation eight years ago. Twice as many 90-cm-tall stumps had surviving sprouts than basal-cut stumps, and these sprouts were both taller and had larger diameters. Differences among harvest dates were relatively small, but there were significant differences among sites for most variables evaluated. However, there were no clear site attributes to explain these differences. These results indicate that the cutting of trees in densely stocked blue oak stands can be used to alter the age structure of stands and foster the establishment of young sprout-origin trees. The replacement of even-aged stands with stands of varying ages may help mitigate the negative impacts of inadequate regeneration.

Introduction

Purpose of Original Study

In 1987 a study was initiated at five sites throughout the range of blue oak in California to examine the sprouting of this species following harvest (*table 1*). One of the objectives of this project was to identify variables that influenced sprouting so that sprouting could be encouraged in densely stocked stands that were thinned. Such thinning might be undertaken to obtain firewood, to increase forage production, or to enhance the growth of residual trees. Since it has been shown that natural regeneration of blue oak is inadequate to sustain populations in portions of the blue oak range (Bolsinger 1988, Muick and Bartolome 1987, Swiecki and others 1997), knowing which variables influence sprouting could be used to develop a harvest strategy that alters the age structure of stands through harvesting, potentially promoting stand longevity.

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Table 1—*Characteristics of blue oak study sites.*¹

Site characteristics	County				
	Mendocino	Glenn	Butte	Amador	San Luis Obispo
Elevation (m)	490	240	170	82	550
Density (stems/ha)	483	518	464	470	485
Basal area (m ² /ha)	17	9	15	12	11
Annual precipitation (cm)	93	55	52	46	55
Soil:					
Depth (cm)	60	70	45	100	42
Texture	silt loam	clay loam	clay loam	grav. loam	grav. loam
Series	Laughlin	Sehorn	Auburn	Red Bluff	Millsholm
Subgroup	Ultic	Entic	Lithic	Ultic	Lithic
	Haploxeroll	Chromoxerert	Xerochrept	Palexeralf	Xerochrept

¹ Precipitation data are from the nearest NOAA weather station. Soils information is from U.S. Soil Conservation Service reports for Glenn, Butte, Amador, San Luis Obispo and Mendocino Counties.

Methods of Original Study

The original study was designed to evaluate the sprouting of blue oak in response to season of harvest, stump height, protection from browsing animals, and stand location. The harvest sites ranged from Glenn County in the north to San Luis Obispo County in the south: three were located in the foothills of the coast range, and two in the foothills of the Sierra Nevada.

Four plots were established at each site. Each plot contained at least 96 trees with a diameter breast height (DBH) of 7 cm or larger. Plots ranged in size from 0.15 to 0.30 ha. At each site two plots were randomly chosen to be “protected”, and two were left “unprotected”. Protection consisted of erecting a 1.8-m tall fence around the plot perimeter, effectively preventing access by deer, cattle, and sheep. While unprotected plots at each site were grazed by domestic livestock, season of use and stocking rate were not recorded.

Within each plot trees were tagged with sequential numbers from 1 to 96. Half of the tagged trees within each plot were randomly selected for harvest. Of these 48 harvest trees per plot, 12 were harvested in each of the four seasons (summer, fall, winter and spring). Of these 12 harvest trees per plot and harvest season, half were randomly chosen to be cut at 90 cm, and half at ground line.

All plots were evaluated at the end of 1988 and 1989. Each harvested stump was evaluated for presence or absence of living sprouts, number of sprouts, length of the longest sprout, and evidence of browsing damage. Results from this trial were presented at the “Symposium on Oak Woodlands and Hardwood Rangeland Management” at Davis in 1990 (McCreary and others 1991). Results indicated that harvest date had relatively little influence on sprouting, while stump height had a large effect, with a greater percentage of taller stumps sprouting. Similarly, there were significant differences in percent sprouting and average sprout growth among sites, with the most favorable site having sprouts more than twice as long as sprouts

from the least favorable site. Fencing had relatively little effect on the incidence of sprouting, but greatly influenced the lengths of longest sprouts, with fenced plots having longer sprouts. Incidence of sprouting was negatively correlated with DBH of the cut trees.

Methods

In late 1997, all plots were revisited and all stumps reevaluated. Each stump was assessed for presence or absence of living sprouts, length of the longest sprout, and diameter of the largest sprout at its base. The length of the longest (tallest) sprout was the distance from the base of the stump to the tallest point in the stump clump. We also evaluated each stump (with or without living sprouts) for deterioration and decay, assigning a score from 1 to 4, with higher values indicating more stump deterioration. Except for sprout diameter and the decay rating, these were the same variables measured in 1988 and 1989.

Data was analyzed as it was following the 1989 assessment using analysis of variance for a doubly nested randomized block design, with sites as the main plots, fences as the sub-plots, and combinations of harvest dates and stump heights as the sub-sub plots. However, due to missing data resulting from higher mortality, by 1997 a simplified model was required to analyze all variables except survival. Because few differences were found for harvest dates when this study was evaluated in 1988 and 1989, and the average height, diameter and number of sprouts were similar among the four harvest dates during the 1997 evaluation, we used a simplified model that combined responses among harvest dates. Because even a survival of zero did not result in any missing values, this variable was analyzed as before using the full model. Finally we compared decay ratings among stumps with and without surviving sprouts, and among fencing and stump heights, using two-sample t tests.

Results

Survival (Percentage of Stumps with Living Sprouts)

Overall survival dropped from 63 percent to 34 percent during the eight years between measurements. However, this reduction in survival was not equally apportioned among treatments. By far the largest reduction in survival was for unfenced stumps. Average survival of unfenced stumps in 1989 was 59 percent, compared to 14 percent in 1997. In contrast, average survival of fenced stumps was 67 percent in 1989 and 54 percent eight years later. There were also significant differences between the survival of basal-cut stumps and those cut at 90 cm, with the taller stumps having twice the average survival of those cut at ground level (46 percent vs. 23 percent) (*table 2*). This was consistent with results eight years earlier.

Table 2—Survival (pct) of different treatments 10 years after harvest.¹

Fencing	Pct survival	Stump ht.	Pct survival	County	Pct survival	Season of harvest	Pct survival
Fenced	54 a	Basal	23 a	Mendocino	29 a	Summer	38 a
Unfenced	14 b	90 cm	46 b	Glenn	28 a	Fall	35 a
				Butte	44 a	Winter	36 a
				Amador	32 a	Spring	27 b
				San Luis	38 a		
				Obispo			

¹ Values within a column are significantly different (P<0.05) if they are followed by a different letter (Fisher’s protected LSD test).

Sprouting differences among sites were considerably less during the more recent assessment than they were in 1989 (*fig. 1*), and there were no significant differences among them. Interestingly, while there were no significant differences in survival among harvest dates in 1988 and 1989, there were significant differences (P=0.049) in 1997, with the spring harvest date having significantly lower survival than the other three seasons of harvest (*table 2*).

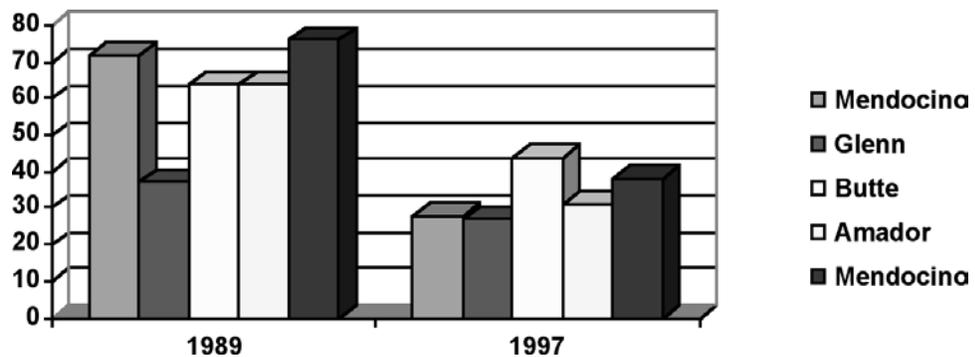


Figure 1—Percentage of stumps with living sprouts two and ten years after harvest (averaged over stump heights, harvest dates and protection treatments) at each harvest site.

Number of Sprouts

There were significantly more sprouts on stumps in unfenced plots than in fenced plots, and taller stumps had significantly more sprouts. There were also significantly more sprouts on stumps at the Mendocino site than at any of the other sites (*table 3*).

Table 3—Average number of sprouts from different treatments 10 years after harvest.¹

Fencing	No. of sprouts	Stump ht.	No. of sprouts	County	No. of sprouts
Fenced	6.1 a	Basal	7.2 a	Mendocino	18.2 a
Unfenced	10.7 b	90 cm	9.6 b	Glenn	6.5 b
				Butte	5.8 b
				Amador	6.2 b
				San Luis Obispo	6.1 b

¹ Values within a column are significantly different (P<0.05) if they are followed by a different letter (Fisher’s protected LSD test).

Sprout Length

The lengths of the longest sprouts were significantly greater in fenced than unfenced plots; lengths were also greater for taller stumps (*table 4*). There were significant differences in sprout length among harvest sites, with those in Mendocino and San Luis Obispo Counties having significantly shorter sprouts than those in Amador and Butte Counties.

Table 4—Length of longest sprout (cm) from different treatments 10 years after harvest.¹

Fencing	Sprout length	Stump ht.	Sprout length	County	Sprout length
Fenced	246 a	Basal	131 a	Mendocino	101 a
Unfenced	113 b	90 cm	228 b	Glenn	177 ab
				Butte	259 b
				Amador	226 b
				San Luis Obispo	134 b

¹ Values within a column are significantly different (P<0.05) if they are followed by a different letter (Fisher’s protected LSD test).

Sprout Diameter

Sprout diameter followed a pattern very similar to that for sprout length. There were significantly larger diameter sprouts for taller stumps and for stumps within fences (*table 5*). Sprouts in plots in Amador and Butte Counties were significantly larger than those in Mendocino and San Luis Obispo Counties.

Table 5—Diameter of largest sprout (cm) 10 years after harvest.¹

Fencing	Sprout diameter	Stump ht.	Sprout diameter	County	Sprout diameter
Fenced	4.2 a	Basal	2.6 a	Mendocino	1.6 a
Unfenced	2.0 b	90 cm	3.6 b	Glenn	3.2 b
				Butte	4.9 c
				Amador	3.9 bc
				San Luis Obispo	1.9 a

¹ Values within a column are significantly different (P<0.05) if they are followed by a different letter (Fisher’s protected LSD test).

Decay

The decay of stumps did not vary by stump height or fencing, but there were some differences between sites, with Mendocino and Glenn having significantly greater average stump decay than the other three sites. Not surprisingly, decay ratings were significantly higher for stumps that did not have surviving sprouts than they were for stumps with living sprouts. Average values were 2.8 for the former, and 2.5 for the later.

Discussion

Sprouting is common for many species of hardwoods and it is likely that many of the oak trees that are alive in California today originated from sprouts that grew from a stump after the top was killed by fire or felling. Most sprout-origin trees are easily recognized because they often have multiple stems. In areas where fire destroyed the stand, or where all of the oaks were cut down at the same time, most of the trees have several stems and tree-ring studies reveal that many originated simultaneously (McClaran and Bartolome 1989, Mensing 1992), presumably from sprouting.

The ability of oaks to sprout from their base following death of the aboveground portion of the tree varies by species (Longhurst 1956), size of the individual tree (Johnson 1977), and environmental conditions at the site (Hannah 1987). Generally, sprouting is greater for evergreen or live oaks than for deciduous oaks; for smaller diameter stumps; and for trees growing in moister environments with more light. While blue oak is commonly thought of as a weak sprouter compared to tanoak and California black oak (McDonald 1990), the original assessment of the 960 trees harvested in this study found that a relatively large proportion (63 percent) had living sprouts two years after harvest (McCreary and others 1991). More smaller stumps sprouted than large ones, but we detected no differences in sprouting among the four seasons of harvest, in contrast to Longhurst (1956) who reported higher sprouting for blue oaks harvested in winter. Standiford and others (1996) also reported relatively high sprouting for blue oak in the northern Sacramento Valley, with 54 percent of the trees having sprouted, even though many stumps had originally been treated with herbicides to prevent re-growth.

As indicated above, one of the initial goals of this study was to try to identify variables that influenced sprouting so that harvesting in densely stocked stands could be used as a management tool to alter age structure. By promoting a more uneven age structure through harvest, it was hoped that stand longevity would be promoted and, even if natural regeneration was insufficient to replace mortality under natural circumstances, lengthening the life of stands might promote seedling recruitment since there would be a greater interval for this to occur. It was further speculated that opening the stands through thinning, and fencing out grazing and browsing animals, might also promote natural regeneration, though these effects were not evaluated in the study.

The data from this study suggests that sprouting can be used to alter age structure in stands, since even after 10 years, a sizeable number of the harvested trees have living, vigorous sprouts. However, it is also clear that sprouting is influenced by a number of variables. The most dramatic effects were from fencing, since in most locations, a decade of exposure to browsing animals resulted in high sprout mortality

and reduced sprout growth. This effect was particularly evident at the plot in Mendocino County where high populations of deer from a resident herd, and additional pressures from a flock of sheep, resulted in a high proportion of the sprouts being killed and greatly reduced sprout growth on stumps that weren't fenced. High levels of browsing damage at this one site also resulted in several significant interactions between fencing and site. While all sites exhibited greater stump survival, sprout length, and sprout diameter in fenced plots compared to unfenced ones, the magnitude of these differences was far greater at the Mendocino plot than anywhere else.

At the Mendocino site heavy browsing in unfenced plots caused the average number of sprouts per stump to be approximately three times more at that location than anywhere else. The repeated browsing resulted in dense, brush-like sprout clumps on the few stumps that had surviving sprouts. Clearly, if one wishes to promote sprouting after harvest in areas with heavy browsing pressures, it is critical to protect stumps from browsing for at least 10 years.

While there were differences in sprout growth among sites, it is not clear what site variables were likely responsible for this. The site with the highest average annual precipitation (Mendocino) had the smallest average sprout length and diameter. Perhaps growth was influenced by environmental conditions associated with different elevations, since the sites with greatest growth (Butte and Amador) were at the two lowest elevations.

An initial concern was that taller stumps might decay more rapidly, causing sprouts to die. After 10 years there is no evidence that this is occurring. There were no significant differences in decay ratings between basal-cut stumps and those cut at 90 cm, and for almost all variables measured, taller stumps continued to perform better.

Conclusions

Results from this study indicate that even after 10 years, over a third of harvested trees have viable sprouts. However, there was considerable attrition in the eight years since the last assessment. The majority of sprout death during this 8-year interval appeared to be caused by browsing damage because the increase in mortality outside fenced exclosures was approximately four times that inside. In areas where browsing pressures are intense, either from livestock or deer, it is critical to protect sprouts. Season of harvest had relatively little impact on sprouting, but there was considerable variation in survival of sprouts, as well as sprout growth, among harvest sites. Sprouts from stumps cut at 90 cm continued to perform better than those cut at ground level, and there was no indication that these stumps deteriorated rapidly or that their sprouts died. Overall this study indicates that thinning of densely stocked blue oak stands can alter stand structure and will probably promote the establishment of a new, younger, cohort of trees. In this manner, it may prolong the life of stands, even when there is poor natural regeneration.

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