Tree Planter's Notes, Vol. 44, No. 2 (1993)

Top Pruning Improves Field Performance of Blue Oak Seedlings

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Large 1-year-old container-grown seedlings of blue oak (Quercus douglasii *Hook. & Arn.) were top pruned at the time of field planting and compared to both large and small unpruned controls. After two growing seasons, top-pruned seedlings were significantly larger and had significantly greater height and caliper incre-menu than either other seedling type. Seedlings planted early (December 15) also had higher survival rates and tended to grow slightly more than those planted 6 or 12 weeks later. These results suggest that blue oak seedlings should be planted early in the sea-son, and that those with large tops should be top pruned before outplanting.* Tree Planters' Notes 44(2):73-77; 1993.

Blue oak *(Quercus douglasii* Hook. and Arn.) is one of several species of native California oaks that is reported to be regenerating poorly in portions of the state (Muick and Bartolome 1987, Bolsinger 1988). This deciduous white oak is endemic to California and grows primarily in the foothills surrounding the Central Valley. Although it has little commercial value other than for firewood, the blue oak is a tremendously important component of California's natural landscape and is vital to numerous wildlife species. In recent years there has been considerable concern about habitat loss in blue oak woodlands and public support for conservation efforts.

The reasons for the poor natural regeneration of blue oak are varied and complex and include browsing by deer and livestock, insect defoliation, acorn predation, and competition from introduced Mediterranean annuals. The effects of competition are exacerbated by the fact that there is often little or no rainfall in the blue oak region during the summers.

In the last few years, efforts have been initiated to develop techniques to successfully regenerate this species artificially. These have included studies on acorn collection, storage, and planting (McCreary 1990, McCreary and Koukoura 1990); methods for growing seedlings (Krelle and McCreary 1992); and techniques for planting, protecting, and maintaining seedlings in the field (Adams et al. 1991).

At present, many of the native oak seedlings produced in California are grown in small containers or "liners" and transplanted to the field when they are 1 year old. While in containers, their root growth is severely restricted, and as a result, these plants have a much different size and configuration than naturally grown seedlings. With unrestricted root growth, native California oaks typically develop a large, deep root system--often before their shoots emerge from the ground. For example, in a study at the University of California's Sierra Foothill Research and Extension Center, blue oak seedlings grown in deep boxes designed to monitor root growth had many roots over 30 cm long before the shoots were visible (Tecklin and McCreary 1991). After 5 months, average root length was nearly 90 cm, while the shoots were less than 15 cm.

When root growth is restricted, the ratio of roots to shoots decreases and the seedlings may become out of balance; that is, the roots may be too small in relation to the tops to provide adequate moisture and nutrient uptake when they are outplanted. Such seedlings may grow slowly or even die.

For many tree species, top pruning in the nursery (or just before outplanting) has been used to reduce the size of the shoot and restore a more favorable root-shoot ratio (Duryea 1984). This practice has been found to be especially beneficial for hardwoods. Cutting off part of the shoot not only reduces photosynthetic capacity, it also lowers moisture requirements by reducing the transpirational surface. This may confer an advantage to seedlings planted in an environment where soil moisture is limiting.

Although top pruning has been used successfully for several species of eastern and southern oaks (Russell 1973, Larson 1975, Adams 1984), it has not been previously tested for any California oak species. The purpose of this study was to evaluate how top pruning and planting date would affect the survival and growth of blue oak seedlings outplanted on a foothill rangeland site.

Materials and Methods

Several hundred seedlings, grown from acorns collected in fall of 1988 from 6 adjacent blue oaks near Red Bluff, California, were grown for 1 year in round, open-ended paper containers approximately 4 cm in diameter and 20 cm tall. These seedlings were kept in a greenhouse for 5 months and then moved outdoors. Before outplanting, seedlings were divided into two groups: **small seedlings,** which were between 10 and 20 cm tall, and **large seedlings,** which were between 25 and 35 cm tall. This latter group appeared to be too tall for the small containers and most likely would benefit from top pruning. The large seedlings were further randomly divided into a group that was pruned to a 15-cm top immediately after planting and a group that was left unpruned. Thus, three seedling stocktypes were compared: small seedlings, large seedlings, and pruned large seedlings. At the time, the pruning treatment seemed drastic, because it reduced seedling height by more than 60%, leaving behind a short bare stem with no branches and few visible buds.

Seedlings were planted in a bare field at the Sierra Foothill Research and Extension Center, 30 km northeast of Marysville, within a deer and cattle exclosure, on three planting dates (December 15, 1989; February 2, 1990; and March 23, 1990). The study followed a randomized complete block design with nine treatments and three blocks. The nine treatments consisted of all combinations of three stocktypes and three planting dates. These were randomly assigned within each block to 9 adjacent 8-seedling rows. Rows and seedlings within rows were 60 cm apart. Means of each 8-seedling row were used for ANOVA.

Before planting, the area was treated with a 1½% solution of glyphosate to remove competing vegetation. Subsequently, the plot was kept moderately weed-free with a combination of herbicides, hoeing, and hand pulling. Before planting, each planting spot was augered to a depth of 90 cm using a tractor-mounted 15-cm-diameter auger, and a 21-g slow-release fertilizer tablet (20-10-5, N-P-K) was placed about 10 cm beneath the bottom of the roots. Seedlings were planted with their paper sleeves on, but the paper was carefully folded down at the top and the seedlings were planted deep enough so that there was no chance moisture would "wick out" through exposed potting soil. The initial height and caliper of each seedling were measured soon after planting.

During the next 2 years (1990 and 1991), survival, leaf-out date, year-end height, and year-end caliper were recorded. Leaf-out date was also recorded in the spring of 1992. Determining year-end survival in the fall is difficult because of the highly variable leaf drop; therefore, survival in 1990 and 1991 was based on the number of seedlings that leafed out the following spring. Leaf-out date was recorded as the Julian date when the most advanced bud opened and began elongating. Caliper was measured 2 cm above the ground line, and height was the distance from the ground to the tip of the longest shoot when it was held straight. Averages of each of these variables were calculated for each row and analyzed using analysis of variance for a randomized block design. Before analysis, survival was transformed using an arc sin transformation to improve the equality of variances. Whenever significant differences were found for a variable, a Fisher's protected LSD test (Snedecor and Cochran 1967) was conducted to determine which means were significantly different from one another. Differences reported as significant were at the P -- 0.05 level.

Results

Table 1 lists each of the variables analyzed and the level of significance for the main effects (stock

Table 1-Level of significance among treatments for seedling responses evaluated

Seedling responses	Stocktype	Planting date	Stocktype by planting date
First year (1990)			
Survival	NS	**	NS
Height	**	NS	NS
Caliper	**	NS	NS
Height increment	*	NS	NS
Caliper increment	NS	NS	NS
Leaf-out date	**	**	**
Second year (1991)			
Survival	NS	NS	NS
Height	NS	NS	NS
Caliper	**	NS	NS
Height increment	**	NS	NS
Caliper increment	*	NS	NS
Leaf-out date	**	*	NS

*Significantly different at P <=O5 level by a two-way analysis of variance.
**Signrficantly different at P <=.01 by a two-way analysis of variance.
NS = Not significantly different.

type and planting date) and their interactions. As indicated, there were few significant differences among planting dates, but large differences among stocktypes. These are discussed individually below.

Stocktype. There were no significant differences in survival among the three stocktypes (table 2), which ranged from 78 to 83% in 1990 and 76 to 81% in 1991. Height and caliper, on the other hand, were strongly affected by top pruning. Although top-pruned seedlings were initially quite short, by the end of the second field growing season, they were the tallest of any of the stocktypes (figure 1). These differences were only significant at the .10 level of probability because the initial heights of the large pruned seedlings were so dramatically reduced. During both the first and second years, the top-pruned seedlings also had significantly greater height increments than unpruned seedlings of the same initial size class.

Caliper exhibited a similar, though less pronounced, pattern (figure 2). After the first year, the small seedlings had significantly smaller calipers than the other two stocktypes. There were no significant differences in caliper increment. By the end of the second field growing season, however, the calipers of top-pruned seedlings were significantly greater than those of either other stocktype and their caliper increments were also significantly more.

Table 2-*Survival and leaf-out date for seedlings from different stocktypes*

	Small unpruned	Large unpruned	Large pruned
Survival			
1990	78% a	83% a	83% a
1991	76% a	81 % a	81 % a
Leaf-out date			
1990	March 19 a	March 27 b	March 26 b
1991	March 14 b	March 20 b	March 6 a
1992	March 15 a	March 17 a	March 18 a

In each row, values followed by different letters differ significantly (P <= .05) according to Fisher's protected LSD test.

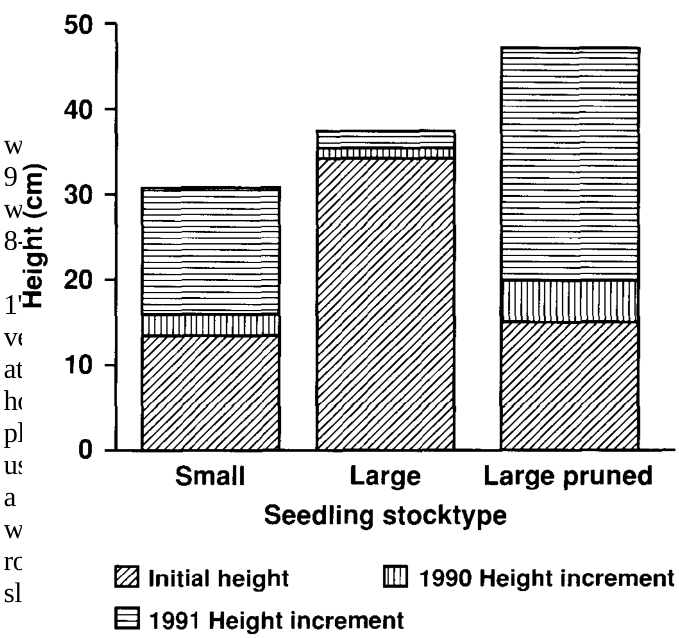

Figure 1—*Yearly height for different stocktypes.*

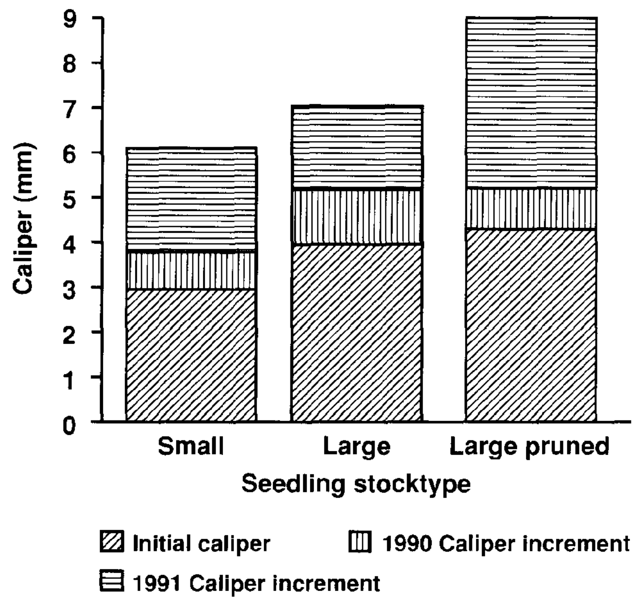

Figure 2—*Yearly caliper for different stocktypes.*

Leaf-out date was not consistent between years. In the first growing season, the small unpruned seedlings leafed out approximately 1 week earlier than the other two groups (table 2). During the second year, however, top-pruned seedlings leafed out over a week earlier than the other stocktypes. By the spring of 1992, all stocktypes leafed out at approximately the same time.

Planting Date. Field performance was influenced far less by planting date than it was by stocktype (table 3). In fact, there were no significant differences among planting dates for height, caliper, height increment, or caliper increment for either 1990 or 1991, although for most of these variables, seedlings planted on the earliest date had slightly higher average growth. During the year of planting, as expected, leaf-out was later for later

Table *3-Survival, leaf-out date, height, and caliper for seedlings front different planting dates*

	December 15	February 2	March 23
Survival			
1990	90% a	75% b	79% a,b
1991	89% a	71 % a	78% a
Leaf-out date			
1990	March 19 a	March 23 b	March 30 c
1991	March 11 a	March 18 b	March 10 a
1992	March 17 a	March 16 a	March 18 a
Height (cm)			
1990	24.3 a	23.0 a	24.4 a
1991	43.6 a	34.0 a	38.5 a
Caliper (mm)			
1990	4.8 a	4.8 a	4.4 a
1991	7.9 a	6.5 a	7.5 a

In each row, values followed by different letters differ significantly ($P <= .O5$) according to a Fisher's protected LSD test.

plantings. The following year, however, the second planting date had the latest leaf-out, while in 1992, leaf-out dates for the three planting dates were almost identical. In 1990, survival was greatest for the earliest planting, and least for the middle planting date.

The only significant interaction between stocktype and planting date was for leaf-out the first year. In this instance, top pruning greatly delayed leaf-out for the last planting date, although it had little effect on the earlier planting dates.

Discussion

Our initial hypothesis of this study was that reducing the size of a seedling's shoot would create a more favorable shoot-root ratio and improve field performance. This is exactly what we found. Top pruning large 1-year-old container blue oak seedlings dramatically improved field growth compared to unpruned large seedlings or small seed lings. Although this treatment initially created short, bare, branchless seedlings, after 2 years, these seedlings were larger than either unpruned seedlings of the same initial size or small unpruned seedlings. In general, it took 2 years for the benefits of the treatment to be apparent. During the first year after planting, differences in both height and caliper increments were relatively small. By the second year, however, caliper increments of pruned seedlings were more than double those of unpruned seedlings of the same original size, and height increment was more than 10 times greater. Pruned seedlings also had significantly greater height and caliper increments during the second year than small seedlings. This last result suggests that given the choice between planting large and small 1+0 stock, the large stock will likely perform better as long as it is top pruned at or before planting. However, it should be noted that genetic differences between the large and small stock types may have contributed to these differences in growth. While all seedlings were from bulked acorns from a common collection, it is possible that the genotypes that produced the largest seedlings in the nursery were also predisposed to more rapid growth after field planting.

One of the possible reasons that the large pruned seedings grew considerably more during the second growing season was that they leafed out more than a week earlier than small seedlings, and more than 2 weeks earlier than large unpruned seedlings. In the dry Mediterranean climate of California, where soil moisture can become limiting early in the spring, early leaf-out likely confers an advantage because plants can make better use of more favorable growing conditions. However, it is not clear why top pruning the previous year caused this earlier leaf-out. By the third growing season, leaf-out dates of all treatments were similar.

Surprisingly, planting date had relatively little influence on field performance. Although the survival of seedlings planted the earliest was the greatest in 1990, there was little difference between those planted in early February or late March. There were also no significant effects of planting date for any of the four growth variables (height, caliper, height increment, or caliper increment) either year, although the seedlings planted earliest tended to grow more.

Conclusions

This study indicates that top pruning large blue oak seedlings improves field performance. Although they were initially shorter, pruned seedlings grew faster during the next two seasons, were significantly bigger after 2 years than seedlings from the other stocktypes, and generally appeared more vigorous. This treatment is especially recommended for seedlings that have grown tall and "leggy" and appear to have out-of-balance shoot-root ratios. Top pruning could either be done in the nursery or just before or after field planting. Such a treat ment would add little to seedling cost. Based on the results of this study, it is recommended that seedlings be pruned to a 15-cm height.

Although top pruning tended intitially to cause seedlings to develop multiple shoots, most seedlings quickly reestablished dominant leaders arid after 2 ½ years in the field, did not appear bushier than unpruned ones. Planting date did not greatly influence field performance, although those seedlings planted earliest tended to have higher survival and slightly more growth. Other things being equal, it is therefore recommended that seedlings be planted early in the season.

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