

Seasonal Growth Patterns of Blue and Valley Oak Seedlings Established on Foothill Rangelands¹

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Abstract: Blue (*Quercus douglasii* Hook. & Am.) and valley (*Quercus lobata* Née) oak seedlings were planted on a foothill rangeland site in 1987 and 1988. Both species were watered their first year but received no irrigation thereafter. They were evaluated during each subsequent spring and summer for survival, weekly height growth and total year-end height. Seedling survival was extremely high for both species and height growth was rapid and vigorous. Blue oak seedlings four growing seasons after planting averaged over 2.3 m and valley oaks after three seasons averaged 2.0 m in height. Yearly height growth occurred in a series of flushes beginning around the end of March. Typical seedlings had either two or three flushes, although the average number per year has been declining. During flush periods, growth was rapid, often exceeding 15 cm per week. The greatest height increment occurred during the second flush. These results suggest that both blue and valley oaks have the capacity to grow rapidly as young seedlings if suitable environmental conditions are maintained.

Two native oak species reported to be regenerating poorly in portions of California are blue oak and valley oak (Bolsinger 1988, Muick and Bartolome 1987). While concern about the natural regeneration of these species has been voiced since the turn of the century (Sudworth 1908), only during the last five years has a large amount of research focused on understanding and solving this problem. Results from these studies have greatly increased our knowledge of the causes of poor regeneration and have demonstrated a variety of techniques for successfully growing and planting seedlings. To date, however, most of the studies have evaluated field performance in terms of survival or year-end size, and little has been reported about phenological development or seasonal growth patterns. Such information can be vital to understanding basic physiological mechanisms operating within seedlings, and can help clarify some of the factors limiting field performance of both natural and planted seedlings. This paper describes the results of an intensive two-year evaluation of blue and valley oak seedlings planted on a foothill rangeland site. It is hoped that this information will provide some insights into the factors influencing juvenile seedling growth and help promote greater establishment success in regeneration plantings.

METHODS

Blue Oak Trial

The first field plot was established in April 1987 with the planting of 120 blue oak seedlings at the Sierra Foothill Range Field Station near Browns Valley, California (elev. 200 m). These seedlings came from acorns collected near Rescue, California (elev. 425 m) and had been grown for one year in plastic boxes approximately 6 cm square by 13 cm deep. They were transplanted into a bare field plot into holes that had been augered to a depth of 90 cm and backfilled. The soil at the site was an Auburn-Las Posas-Argonaut rocky loam and was between 60 and 100 cm deep. Prior to planting, a 21 g fertilizer tablet (20-10-5) was placed approximately 30 cm deep in each hole. Immediately after planting, seedlings were covered with 40 cm tall pieces of aluminum screen to prevent browsing and insect damage. As the seedlings grew taller, these cages were opened at the top and were eventually replaced by 90 cm tall screen cylinders. Several seedlings which died during the first 2 weeks were replaced.

At the time of planting, seedlings were thoroughly watered and were irrigated regularly with drip irrigation throughout their first summer. However, no irrigation was provided during the three subsequent years.

Valley Oak Trial

These seedlings were planted a year later, adjacent to the blue oak plot. The same number of seedlings was planted with the same spacing, augering and fertilization treatments. Seedlings were from acorns collected in Briones Park in Contra Costa County (elev. 100 m) the previous fall and had been grown for approximately four months in 4 by 4 by 15 cm containers. After planting, seedlings were watered during the subsequent summer with varying levels of irrigation as part of another experiment (McCreary 1989). However, no irrigation was provided in 1989 or 1990.

Measurements

At the end of the 1987 growing season (blue oaks only) and the 1988, 1989, and 1990 growing seasons (blue and valley oaks) the survival and year-end height of each seedling were

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recorded. In addition, in both 1989 and 1990 leaf-out date of each seedling was determined, as well as the weekly height increment of the terminal branch of each seedling during 24week periods beginning in early April. Since both species tended to have droopy leaders, terminal height was determined by straightening out the main branch and recording either total seedling height or height increment of the actively growing shoot. If there was no single obvious terminal shoot, the height of the tallest branch was recorded.

In addition to height measurements, the number of flushes in each growing season was also recorded. This was determined by evaluating height increment patterns, as well as examining the terminals for buds, bud swelling, and if flushing occurred, for evidence of bud scars on the stem. From the collected data several variables were also calculated including average weekly height increment, the number of seedlings actively growing during any week (those that grew 2 cm or more), and height increment per flush.

RESULTS

Blue Oak — Survival, Height Growth and Leaf-out Date

Seven seedlings died during the first summer, but no mortality has occurred since. Average height increment during the first year was approximately 25 cm. Since then, however, seedlings have grown rapidly and now average over 2.3 m in height (fig. 1). There was a very consistent pattern of growth during 1989 and 1990. In both years seedlings began leafing out (leaves emerging through the bud scales of the most advanced bud) during a two-week interval, beginning in the last week in March. Average leaf-out date was March 30 in 1989 and March 25 in 1990. There was also a consistent pattern for growth

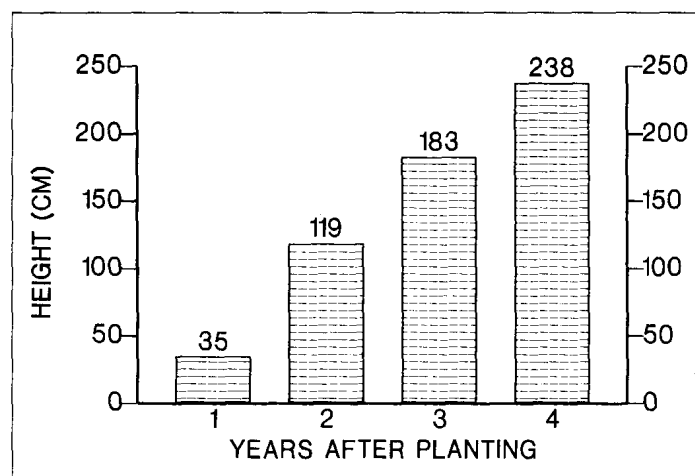


Figure 1—Average total height of blue oak seedlings 1, 2, 3 and 4 years after planting.

initiation among seedlings within the plot. For both years the difference between the date the first and last seedling leafed out was only 11 days.

Flush Pattern

For both years the first flush of growth lasted about two weeks, with relatively little height increment (fig. 2). By the middle of April, most seedlings had stopped elongating and set a resting bud. The period between the first and second flush varied considerably among seedlings but the average time, about five weeks, was fairly consistent between years. However, while all seedlings had at least two flushes in 1989, there were four seedlings that only had one flush in 1990. By the end of May in both years most seedlings had resumed active growth and were elongating rapidly. The greatest height increment occurred during this second flush. For instance in 1989, second flush increment accounted for 68 percent of the total height growth, while in 1990 it accounted for 83 percent (fig. 3). Not only was

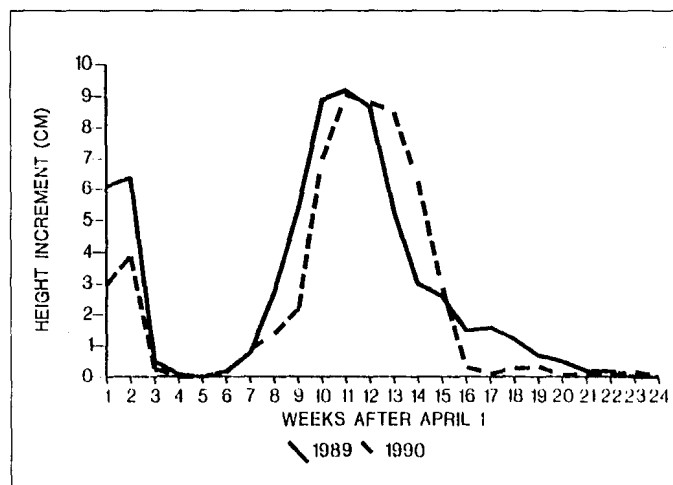


Figure 2—Average weekly height increment of blue oak seedlings in 1989 and 1990.

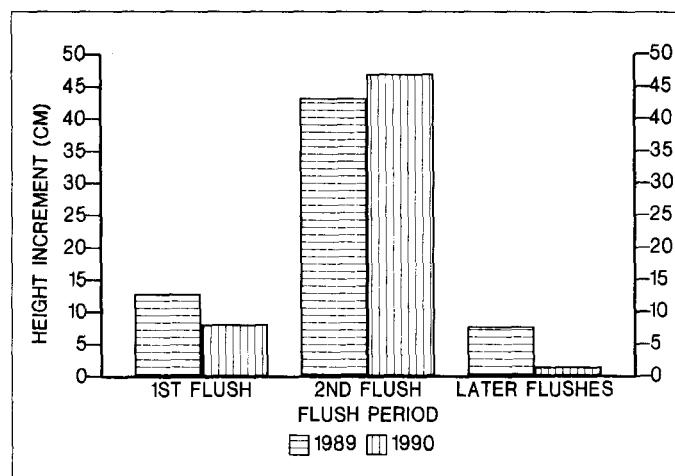


Figure 3—Average height increment per flush (averaged over all seedlings) of blue oaks in 1989 and 1990.

there a large total amount of growth during this period, but the growth rate was exceedingly rapid. During the peak growth period, average height growth of all seedlings in the plot was nearly 10 cm a week, while many individuals grew more than 15 cm. The elongation interval was also far longer than for the first flush, averaging about six weeks. Almost half of the seedlings also had a third flush in 1989. However, the initiation of this flush varied tremendously, from mid-summer until early fall. In general, this flush period was relatively brief and contributed little to total height increment. In 1990, only a handful of seedlings had a third flush, however. The average number of flushes in 1989 was 2.41, compared to an average of 2.08 in 1990.

Valley Oak — Survival, Height Growth and Leaf-out Date

After three seasons, all of the valley oak seedlings that were planted are alive. Average yearly height growth was slightly greater than that of the blue oaks (fig. 4) and seedlings are now just under 2 m tall. Average leaf-out date for the valley oaks was March 30 in 1989, and March 21 in 1990.

Flush Pattern

The same general growth pattern observed for blue oaks was also followed by the valley oaks, with a relatively weak first flush followed by a rapid, vigorous second flush (fig. 5). However, there was greater variability among valley oak seedlings in the growth patterns than for blue oaks. For instance, there was a three-week period beginning around mid-April in both years when not a single blue oak seedling was actively elongating. For valley oaks, on the other hand, at no time between April and mid-June of either year were all seedlings inactive.

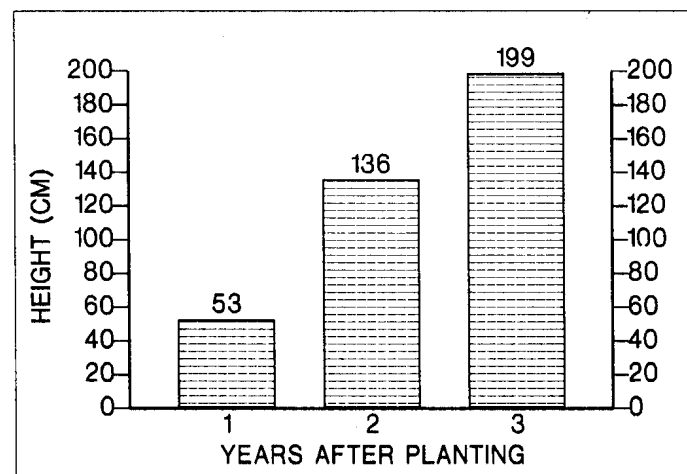


Figure 4—Average total height of blue oak seedlings 1, 2, 3 and 4 years after planting.

The pattern between years was also much more inconsistent for valley oaks. In 1989, the pattern was quite similar to that for the blue oaks, with most seedlings flushing early, setting a bud and then initiating a second flush in early June. In 1990, however, 14 percent of the seedlings did not set a bud in April and continued elongating into the summer. These longer first flushes also resulted in a higher percent of the overall growth accounted for by the first flush than it was in 1989 (fig. 6). As with the blue oaks, the average number of flushes per seedlings was greater in 1989 (2.57) than in 1990 (1.88).

DISCUSSION

One of the most surprising results of this study was the high survival and rapid growth rate of both species, even though no

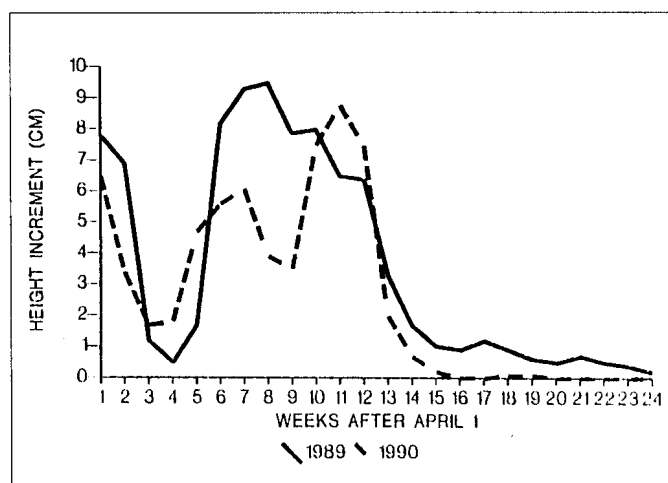


Figure 5—Average weekly height increment of valley oak seedlings in 1989 and 1990.

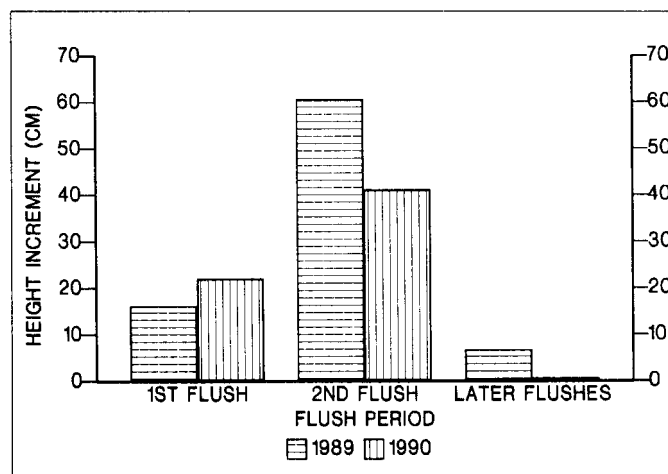


Figure 6—Average height increment per flush (averaged over all seedlings) of blue oaks in 1989 and 1990.

irrigation was provided after initial establishment. This growth occurred in spite of the fact that some seedlings were repeatedly browsed by deer, covered by powdery mildew, and/or chewed on by a variety of insects. Thus, even though both species have been found to have problems naturally regenerating, results from these trials indicate that once established, seedlings are very resistant to mortality factors. Of 240 total seedlings planted, only seven died the first year, and none have died since.

Growth rate for blue oak has also been dramatically greater than expected. While valley oak is reported to grow fairly rapidly under favorable conditions, blue oak is generally characterized as an extremely slow growing species. In this field trial, however, yearly height growth of blue oaks averaged well over 50 cm a year, and there has been no evidence of a significant slowdown. While it is impossible to predict field performance at other sites based upon this one trial, these results suggest that slow growth of blue oaks in the field is probably a result of environmental limitations, rather than an inherent propensity to grow slowly. This is encouraging since one of the greatest barriers to successfully regenerating native oaks is browsing of young plants by deer and livestock before they become tall enough to withstand these pressures. If seedlings can be planted, protected, and maintained in such a way that the growth rate can be significantly increased, the interval during which plants are vulnerable could be greatly reduced. While such intensive management (weed control, augering, screen protection, etc.) is currently costly, it may be ultimately less expensive than repeated plantings, slow growth, and in some cases, land being unavailable for other uses (i.e., livestock production).

Another dramatic finding of this study was the marked periodicity of terminal growth and the great disparity between first- and second- flush increment. This pattern contrasts with that of many conifers grown in similar environments, where the first (and sometimes only) flush results in the majority of height growth and subsequent flushes contribute little. This result was surprising since the buds preceding the first flush for both species were so much larger, robust, and appeared to be more developed than those preceding the second flush.

There are several possible explanations for these growth patterns. In contrast to most conifers, both oak species evaluated are deciduous and were just starting to leaf out when terminal elongation began. It is possible that the initial height growth was therefore limited by lack of photosynthesis. By the time the second flush began, on the other hand, the leaves were fully expanded and able to generate more photosynthate to support terminal growth.

Environmental conditions when these flushes took place were also quite different and may have further contributed to the observed growth differences. At the time of the first flush, soils were very wet, but soil and air temperatures were still relatively cool. By the time the second flush began, however, there was still abundant soil moisture (since the competing vegetation was controlled) but temperatures had increased substantially. For instance in 1989 average air temperatures were 18°C during the first two weeks in April and 22°C during the first two weeks in June, while soil temperatures 15 cm beneath the surface were 17°C and 23°C respectively. Such increases could have sub-

stantially influenced growth rates since these temperatures are closer to the optimum range for photosynthesis and other processes favoring growth (Salisbury and Ross 1969).

The final factor which may also have contributed to height growth differences between flushes was competition from root growth. During periods of active root growth, roots act as a sink and can reduce the energy available for the above ground part of the plant. While it is known that there is a periodicity to root growth patterns for most woody species (Kramer and Kozlowski 1979) and there is often a marked peak of root activity in the early spring, not enough research has been done on the two species evaluated here to determine if this was occurring.

A final observation from these trials was that both species seemed very resilient and able to withstand a wide range of environmental conditions. When both species were browsed by deer before mid summer, they quickly resumed growth from previously dormant lateral buds. They also tolerated a tremendous range of temperatures from a low of -9°C to a high of 43°C and even survived a rare foothill snow storm which seriously damaged an adjacent planting of eucalyptus. As young seedlings they were also able to remain actively growing under what appeared to be very harsh conditions. In 1988, for instance, 40 percent of the blue oaks were flushing in August, even though there had been very little rainfall since April and almost all other vegetation on the hillsides had turned brown.

CONCLUSIONS

These trials indicate that planted blue and valley oak seedlings can have high survival and are capable of extremely rapid juvenile growth under favorable environmental conditions. Seedlings planted in augered holes containing a slow release fertilizer tablet, and maintained in a weed-free plot, grew an average of over half a meter, a year, even though no irrigation was provided after initial establishment. Only seven of the 240 seedlings died during the first year, and none died thereafter.

Both species also exhibited a determinate growth pattern with stem elongation occurring as a series of flushes separated by periods of inactivity. By far the greatest growth took place during the second flush which commenced near the end of May and lasted for approximately six weeks. Height growth during this period often exceeded 15 cm a week for certain seedlings. The average number of yearly flushes per seedling was generally between two and three, but tended to decrease as the plants became older.

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