



# Regenerating native oaks in California

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Some of California's 150-year-old native oak stands are in danger of disappearing because of poor regeneration. Researcher Douglas McCreary and others have shown that, with proper treatment and planting of acorns and seedlings, California blue and valley oaks can be artificially propagated. This oak seedling was 16 months old.

***Livestock are frequently blamed for poor regeneration of native oaks in California, but research indicates that other factors are also involved. Conditions favoring natural regeneration may occur only once or twice a century. Artificial regeneration is a practical but currently costly alternative.***

Since the turn of the century, there have been persistent reports that several native oak species were not regenerating sufficiently to maintain existing stand densities and species distributions. Such reports have been confirmed, at least for some areas, by a task force commissioned in 1983 by California's Board of Forestry to study the state's hardwood resources, identify problems, and recommend solutions. One of its findings was that blue oak (*Quercus douglasii*), valley oak (*Q. lobata*), and Englemann oak (*Q. engelmannii*) were regenerating poorly in some areas of the state.

Poor regeneration raises concerns about the long-term sustainability of these oaks. If there aren't enough seedlings and saplings to replace mature trees that die, these species can't be managed as renewable natural resources. Stand densities will decline, and existing hardwood rangelands could eventually be converted to other types of vegetation. Surveys indicate, however, that the degree of regeneration is very localized. In some areas, abundant seedlings and saplings can be found.

In other areas, stands consist almost entirely of mature trees.

## Reasons for poor regeneration

The finger of blame for poor regeneration has been pointed at a wide range of factors. Livestock are frequently blamed, because cattle and sheep vigorously eat both acorns and seedlings. However, in research plots at the University of California's Sierra Foothill Range Field Station in Yuba County and Hopland Field Station in Mendocino County where livestock have been excluded for over 20 years, few seedlings have established themselves. Such evidence does not absolve livestock from all responsibility for limiting natural regeneration of oak trees, but it does indicate that other important factors are involved.

Feeding on acorns by insects, deer, wild pigs, various rodents, and birds takes a heavy toll, greatly limiting the number of seeds that remain on the ground long enough to germinate. Probably more important is the damage to young seedlings by deer, rabbits, rodents such as pocket gophers, and defoliating insects such as grasshoppers and caterpillars. Browsing, defoliation, and root damage are believed to be major factors preventing seedlings from growing into saplings.

Feeding by animals and insects, however, does not clearly explain why there are apparently fewer seedlings and saplings today than 50 to 150 years ago when most present stands originated. Some believe the scarcity of young plants may simply reflect the fact that widespread seedling establishment is rare and occurs only when

certain events or conditions happen at the same time. According to this "pulse" theory, large numbers of seedlings may get started only when a heavy acorn crop, a wet spring, and low populations of acorn and/or seedling-eating animals occur in the same year. Such conditions may happen simultaneously only once or twice a century, and have not occurred recently.

Others feel that changes in land management during the last 200 years may be to blame. Extensive grazing, fire suppression, and land clearing may have created an environment that is no longer hospitable for seedlings. These practices may also have led to more acorn- and seedling-eating animals.

A more recent theory, being studied by range scientists Rice, Menke and Welker at UC Davis, suggests that inadequate soil moisture may be the principal barrier to successful oak regeneration. According to this theory, there has been a widespread shift in the last two centuries in the composition of range vegetation. Native perennial bunchgrasses have been replaced by introduced annuals, and grass litter has been maintained at low levels because of grazing. Annual plants grow more densely, rapidly depleting soil moisture in the spring and depriving oak seedlings of enough moisture to survive and grow.

## Artificial regeneration

Whatever the reasons for poor natural regeneration, if increased seedling establishment is desired, it will probably require artificial regeneration. At present, there is little information about how to do this successfully. Few native oaks are produced in California, and most of those are grown as large container plants for landscape settings. High costs make the use of such seedlings for widespread wildland plantings unlikely.

Several studies were recently initiated at the Sierra Foothill Range Field Station to increase knowledge about regeneration and to develop strategies for establishing and growing native oaks. The station is located in typical oak woodland in the foothills northeast of Sacramento. This ar-

ticle describes preliminary results from these research projects.

## Collection of blue oak acorns

Two studies investigated the effects of different collection dates and prestorage treatments on the timing and extent of germination of blue oak acorns. In the first study, 300 acorns were collected from two sites every other week from late August until late October 1987. Acorns were picked from the lower branches of the trees, and those less than an inch long or with holes, cracks, or spots were discarded. The remainder were (1) refrigerated immediately (35° to 39°F), (2) soaked in water for 24 hours and then refrigerated, or (3) air-dried for a week and then refrigerated. In the second study, 400 acorns were collected from a single tree in late September and divided into six treatment groups. These groups were allowed to dry to varying degrees, ranging from 0% (refrigerated immediately) to 30% (30% moisture loss resulting from two months of air-drying). In early December, all acorns from both studies were placed in a growth chamber for a standard germination test and evaluated twice weekly to determine the germination date for each acorn.

These tests showed that the speed of germination was closely related to collection date, with acorns collected earliest germinating most rapidly. However, there was a wide interval over which acorns could be collected and still have high germination. By the end of the 10-week germination period, acorns from all collection dates had over 90% germination if they were not allowed to dry out.

Acorns from the soaked and refrigerated treatments responded similarly. However, those that were dried for a week had significantly slower and lower germination (table 1). Longer drying intervals were even more damaging. Acorns left on an open tray for a month suffered a 25% moisture loss and failed to germinate. Figure 1 depicts final germination percentages for acorns from the six drying treatments in the second study.

## Effect of sowing date

In late October 1987, several hundred acorns were collected from individual blue and valley oak trees in Nevada County at an elevation of 1400 feet, and refrigerated (35° to 39°F) in zip-lock plastic bags. Beginning in early November, groups of 30 acorns from each species were sown every month for 5 months in an area of 30 rows, each containing 10 planting spots. The rows were 10 feet long and 1.3 feet apart. On each sowing date, acorns from each species were hand-sown 0.5 to 1 inch deep in three randomly selected rows.

## The Integrated Hardwood Range Management Program

The state legislature established the Integrated Hardwood Range Management Program in 1986 in response to concerns about oak management in California. It is a cooperative effort between the University of California's Division of Agriculture and Natural Resources, the California Department of Forestry and Fire Protection, the California Department of Fish and Game, and the Board of Forestry's Range Management Advisory Committee to help enhance, manage, and protect California hardwood resources. As part of the program, six UC Cooperative Extension Natural Resources Specialists are stationed throughout the state to conduct research on problems related to hardwoods and to develop educational programs promoting wise and informed management of hardwood resources. One specific objective of the program is to develop techniques for oak regeneration.

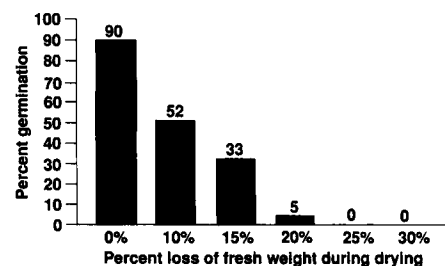


Fig. 1. Total acorn germination after 10 weeks was 90% if acorns didn't dry out. Drying caused significantly lower germination.

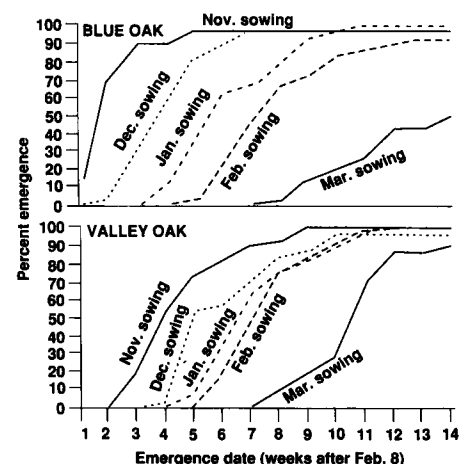


Fig. 2. Cumulative emergence of blue and valley oak seedlings from acorns sown at different times. Blue oaks emerged over a longer period than valley oaks.

TABLE 1. Average germination date and total germination percentage for blue oak acorns from different prestorage treatments

Prestorage treatment	Avg. days to germination*	Total germination*
		%
Immediate		
refrigeration	14 b	96 a
24-hour soaking	11 a	97 a
One week		
air-drying	39 c	81 b

\* Values not followed by same letter are significantly different ( $p < 0.05$ ) by a least significant difference test.



The plot was kept free of weeds by spraying glyphosate in early February, and hand-weeding thereafter. No water or fertilizer was provided.

Emergence of both blue and valley oak species averaged over 95% for this trial. Only the March-sown blue oak acorns had less than 90% emergence by the middle of May. However, sowing date greatly influenced the timing of seedling emergence. The earlier the acorns were sown, the earlier they came up and started to grow (fig. 2 and 3).

Blue oaks emerged over a wider interval than valley oaks. The average emergence date of blue oaks from the November sowing was more than two weeks earlier than for valley oaks. For the March sowing, valley oaks came up an average of 11 days later. Only 50% of the blue oaks sown in March germinated, compared with 90% of valley oaks.

### Blue oak planting trial

In April 1987, one-year-old blue oak seedlings, raised in small plastic containers, were planted on a 5-foot spacing in a weed-free field. Planting holes were dug 3 feet deep with a power auger, and 21-gram fertilizer tablets (20-10-5) were placed below the roots. Seedlings were drip-irrigated from planting time until August, at 2 gallons of water once a week for the first 2 months, and 2 gallons every other week thereafter. Screen cages were placed over the seedlings to protect them from grasshoppers, mice, and deer.

At the time of planting, the 120 seedlings were randomly divided into four groups of 30. Each group received one of the following treatments: shade (an 8- x 12-inch screen block placed on the south side of the seedling); mulch (a 3-foot square of roofing felt around the seedling); shade plus mulch; and a control.

At the end of the first growing season, 95% of the seedlings had survived. Growth varied greatly, ranging from dieback of the initial stem to more than 2 feet. Average height growth of all surviving seedlings was over 10 inches. There were no significant differences in either survival or height growth among the four treatments.

Growth of all seedlings in 1988 was even more rapid and vigorous, even though no irrigation was provided. By late August, seedlings averaged 44 inches tall and had grown, on average, 2.5 feet during their second season. In general, seedlings that remained small and stunted during the first season also grew slowly the second year. There were still no significant differences among treatments.

### Conclusions

This research demonstrated that, with proper treatment and planting of acorns and seedlings, California blue and valley oaks can be successfully propagated. If blue oaks are to be seeded directly, acorns should be collected during September or early October while they are still on the trees. After collection, they should be refrigerated immediately (in 1.75-mil zip-lock

storage bags) to prevent drying and kept cold until they are planted. Both blue and valley oak acorns can be planted from early fall (after the first soaking rains) until mid-winter. Early sowing is favored. In dry years, early initial growth may give seedlings a better chance to become established before soil moisture becomes limiting.

These results have important implications for the production of native oaks in bare-root nurseries. Early-season sowing should allow nursery operators to produce larger seedlings in a shorter time.

Blue oak seedlings can be successfully established by directly planting small container plants. Excellent survival and vigorous growth can be achieved if seedlings are planted in deep augured holes and irrigated and fertilized during the first summer after planting, and if the area around them is kept free of competing vegetation. Damage to seedlings from insects, mice, and deer can be prevented by caging with aluminum window screen. Additional measures to protect seedlings from livestock may be necessary in grazed areas.

Research on the artificial regeneration of oaks is continuing. Investigations include seedling container size, fertilization, effects of acorn size, direct-seeding acorns versus planting seedlings, and irrigation practices.

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## Drainage reduction potential of furrow irrigation

Blaine R. Hanson

***The most practical way to dispose of irrigation drainage water in the San Joaquin Valley is to reduce the volume of the water at its source through better irrigation management. Upgrading furrow irrigation systems and cutting run lengths in problem areas reduced drainage 60% to 80%.***

Subsurface drainage results from overirrigation (least-watered areas of the field receive more than the soil moisture depletion) and nonuniform irrigation. Because of nonuniformity, if the least-watered areas receive enough water to replace soil moisture de-

pletion, other areas must receive more, and subsurface drainage occurs. Keys to drainage reduction are thus to improve the uniformity of application and reduce the amount of water applied by improving application efficiency.

A source of nonuniformity in furrow irrigation is the advance time—the time it takes for water to flow from the upper end of the field to the lower. Soil infiltration rate, length of run, furrow inflow rate, surface roughness, slope of the field, and furrow cross-sectional shape all affect advance time, but the infiltration rate has the greatest influence. The advance time plus the time required for water to infiltrate to a desired depth at the end of the furrow is the set time. Advance time is easily measured

and is used to assess the effect of system changes on the uniformity of infiltrated water.

A second source of nonuniformity is variability of the soil intake rate in different areas of the field. This includes differences in soil texture, random variability of the infiltration rate within a soil texture, and variability caused by differences between wheel and nonwheel furrows. The extent of this variability is usually unknown. For one soil texture, however, a UC study showed distribution uniformity (DU) to be about 68% (coefficient of uniformity, CU = 80%).

Nonuniformity can also result from different individual furrow inflow rates during a set, variability in the field inflow rate during