PNW
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Research Station

Science
FINDINGS

INSIDE

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"Science affects the way we think together."

Lewis Thomas

GREAT OAKS FROM LITTLE ACORNS GROW: PLANTING NATIVE OAK IN THE PACIFIC NORTHWEST

Warren Devine

Station scientists have written a new guide for landowners and managers interested in reestablishing native oak in the Pacific Northwest. It is based on findings from a decade of field studies, such as the one shown above in Thurston County, Washington.

"The surrounding country, for several miles in most points of view, presented a delightful prospect consisting chiefly of spacious meadows elegantly adorned with clumps of trees, among which the oak bore a very considerable proportion, in size from four to six feet in circumference."

—George Vancouver, observing Penn Cove on Whidbey Island in 1792

On a grassy plain next to Washington's Black River stands a bristle of plastic cylinders, looking like fat pink and blue candles on a birthday cake. Inside the cylinders are seedlings of Oregon white oak (*Quercus garryana*). The hard plastic protects the seedlings from hungry deer and tree-girdling voles. A sheet of soft plastic mulch covers the soil around each trunk, conserving water in this gravelly soil long enough to get the little trees through the hot, dry summers until they reach the sapling stage. To judge from the vigor of the stems shooting into the air—some are 5½ or even 6 feet tall—most of these seedlings are well on their way.

Warren Devine walks among the cylinders, peering at the stems inside, straightening those that are askew. "They're looking pretty good," he judges. "We'll be able to take these shelters off in a year or so."

Devine is a research forester with the Pacific Northwest Research Station and a member

IN SUMMARY

The decline of oak woodlands is an urgent conservation challenge in the Pacific Northwest. Prior to settlement by Euro-Americans, prairies, oak-dominated savannas, and oak woodlands were abundant in the low-lying areas of the region. Now it's estimated that 1 to 5 percent of that native oak savanna remains. The rest has been supplanted by pastures, fields, Douglas-fir forests, and development. Experts agree that immediate intervention is needed if Oregon white oak ecosystems are to survive.

In the first comprehensive study of Oregon white oak planting techniques, Warren Devine and Connie Harrington of the PNW Research Station identified key factors in survival and growth of planted oak seedlings: planting large seedlings with well-branched roots, conserving soil water by reducing competing vegetation, and protecting seedlings from animal damage. The scientists have produced a landowner guide for planting oak on Pacific Northwest prairies and savannas. This research adds to the group's previous work on the most effective ways to release existing oak stands from encroaching Douglas-fir. Together, the two phases of this research program have produced reliable, science-based protocols for planting and managing Oregon white oak in the Pacific Northwest, helping landowners and managers stem the loss of an ecosystem that has been in decline for more than 150 years.

of the Oak Studies Group based in Olympia, Washington. This study site, on the Black River-Mima Prairie Glacial Heritage Preserve, is a remnant of the once widespread Puget Prairie ecosystem that greeted Euro-American homesteaders in the 19th century.

Devine's study is the first major investigation of how to plant and grow Oregon white oak on lands where it historically occurred. Devine and his colleagues wanted to know what factors influenced the successful establishment of planted oak seedlings on these lands. After more than a decade of work, they have found the answers they were looking for.

KEY FINDINGS

- To increase chances of success, oak seedlings should be large (2 or 3 years old, with a stem diameter of one-quarter inch) at the time of planting, with well-branched root systems. Containerized or bareroot nursery practices that promote branched root development help increase the seedling's growth potential once it is transplanted in the field.
- Adequate soil water is the deciding factor in successful establishment of Oregon white oak seedlings.
- Solid-walled shelters significantly increase seedling height growth during the first few years, but seedlings in mesh shelters tend to catch up after about 5 years. Unsheltered seedlings are highly susceptible to animal damage and also may disappear amid other vegetation.
- Seedlings invest more in developing roots than in top growth during their first year or two in the field, so aboveground growth is slow. But if seedlings are protected from competition and animal damage, growth rates increase significantly during subsequent years.
- Greenhouse-grown seedlings inoculated with mycorrhizae from oak woodlands grew significantly faster than those grown in noninoculated soil.

THE BRINK OF EXTINCTION

The decline of oak woodlands has become an urgent conservation challenge in the Pacific Northwest. In presettlement times, prairies, oak-dominated savannas, and oak woodlands were abundant in the low-lying areas of western British Columbia, Washington, Oregon, and northern California. Since then, an ecological transformation wrought by settlement, fire exclusion, agricultural development, invasive species, and urbanization has pushed this ecosystem to the brink of extinction. It is estimated that only 1 to 5 percent of native oak savanna remains. The rest has been supplanted by pastures, fields, Douglas-fir forests, and other artifacts of Euro-American settlement.

Experts agree that immediate intervention is needed if Oregon white oak ecosystems are to survive. But until now, there has been little science-based information on how to sustain existing oak woodlands and grow new ones. Landowners have had to tackle oak restoration by using instinct and extrapolating data from other woodland ecosystems.

Scientists with the Pacific Northwest Research Station have been working hard to change that. A set of experiments begun by the Oak Studies Group in the late 1990s has yielded reliable methods both for releasing oaks from Douglas-fir—a vigorous competitor that invades oak stands and overtops and shades out the oaks—and for establishing new oak trees by planting seedlings. In 2006, research forester Connie Harrington, the group's research leader, collaborated with Devine to write a landowner handbook, *A Practical Guide to Oak Release*. A companion handbook, *Planting Native Oak in the Pacific Northwest*, was released in February 2010.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

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USDA United States Department of Agriculture

Forest Service

Joseph Kraft

An estimated 1 to 5 percent of native oak savanna present before Euro-American settlement remains in the Pacific Northwest. The rest has been lost to agriculture, Douglas-fir forests, and development.

APPEALING OPENNESS

When Euro-American settlers arrived in the Oregon Country, they found wide expanses of oak-dotted savanna in the foothills of the Cascades and Coast Range. The Native Americans inhabiting these lands had been managing them for thousands of years with low-level fire. Acorns were an important Native food source; the frequent light burns maintained the dominance of the oaks by killing would-be competitors such as Douglas-fir. Mature oaks can withstand low-level fire, and young oaks damaged by fire readily sprout and produce new stems. The burning also lent an appealing openness to the country, refreshed the native bunchgrasses for the benefit of game, and encouraged growth of other essential food plants such as camas and berry-producing shrubs.

As the immigrants settled the land, the prairies and oak savannas were supplanted by farms, pastures, and towns. The settlers halted the Indians' burning, and less-frequent fire allowed Douglas-fir to encroach on lands formerly dominated by oaks. Over time, conifers overtopped and shaded the oaks, which eventually kills them.

Today the Oregon white oak ecosystem has been reduced to a few remnants. This is a significant loss for several reasons. In a region dominated by conifers, oak communities represent unique habitat for many wildlife species. The trees provide homes for birds, mammals, reptiles, amphibians, invertebrates, and many plant species, some of them endangered or threatened. Acorns provide food for mammals and birds. The oaks also benefit from their wildlife inhabitants; for example, the caching of acorns by Steller's jays is one way oak trees are naturally established on new ground.

For humans, oak savannas are a cultural and aesthetic treasure. They are pleasing to the eye, and they provide a portrait of the landscape as it was before Euro-American settlement.

CREATING NEW OAK WOODLAND

The planting phase of the oak research started in 2001, when Harrington installed the planting trial at the Glacial Heritage Preserve, along with several more at the nearby Joint Base Lewis-McChord. The military base has the largest extent of oak stands and oak-dominated savannas in western Washington, and Harrington was already conducting oak-release studies there. She met Lathrop Leonard, a forester on staff at the base and a master's student at The Evergreen State College in Olympia.

Leonard wanted to study oak planting for his master's project, so he started his own trial plantings at the base, using seedlings provided by the Oak Studies Group. "My desire to expand the planting work dovetailed nicely with Lathrop's interest in an oak-planting project," Harrington says. Leonard wrote up his first-year results and completed his thesis, and shortly thereafter departed. The Oak Studies team, which by now included Warren Devine, took over Leonard's plots.

Devine and Harrington planted more than 1,000 2- and 3-year-old container-grown and bare-root nursery seedlings at various sites in western Washington. They started with seedlings of various sizes and types of root systems and gave them different levels of water, fertilizer, protection from animals, and exclusion of weeds, in several combinations. They also planted seedlings each month from late fall through late spring to compare the effects of planting date. One early result across many plantings was that larger seedlings, at least ¼ inch in stem diameter, grew better after planting than smaller seedlings.

Overall survival of the planted seedlings was high, averaging 90 percent during the first few years. However, growth rates differed among the treatments. Several years of data and subsequent analysis, says Devine, have made it clear that soil water is the most important factor in getting the seedlings to survive and grow.

Warren Devine

A researcher waters an oak seedling. The shelter around the tree protects it from hungry wildlife. The plastic sheeting on the ground serves as mulch, helping retain soil water.

The researchers installed sheets of commercially produced plastic weed block as mulch around some of the seedlings to keep the competing vegetation down, and left others with no mulch. They irrigated both sets of seedlings weekly. The irrigation did increase first-year growth, but only in the seedlings that were also mulched with plastic weed block. Whether or not mulch was present, the irrigation water was gone from the soil after about 5 days.

"Most of these glacial soils of the Puget Trough are sandy and fast-draining," says Devine. "The best way to keep soil water available is to eliminate the competing vegetation." However, seedlings planted on very dry sites or in droughty years may need to be irrigated as well as mulched to get them through their first summer. East of the Cascades, irrigation may be a necessity.

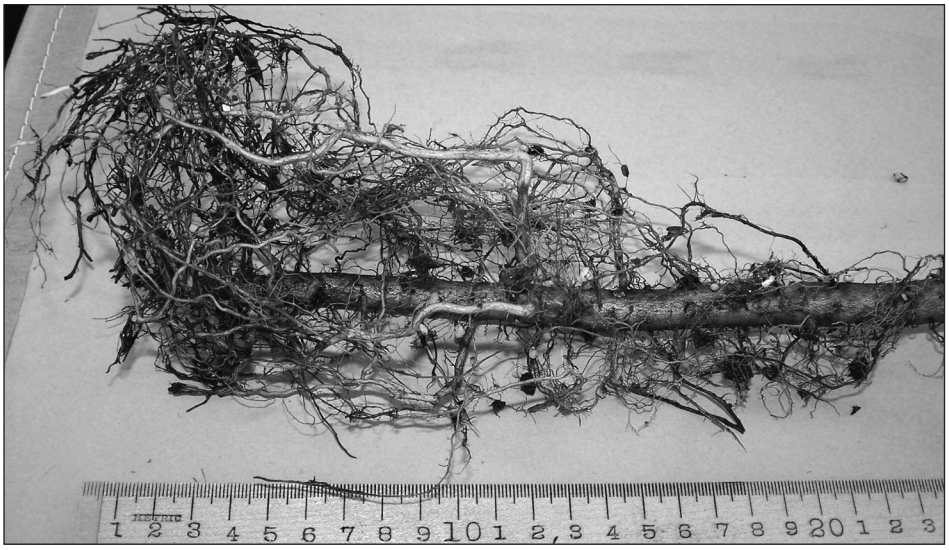
Another important factor proved to be time of planting, which is related to soil moisture. Seedlings planted from late fall through February had more time to develop robust root systems in their first year than did those planted in April, on the cusp of the dry season.

A well-developed root system greatly improves survival and growth of seedlings. In a related study of containerized seedlings, the researchers tested root-pruning techniques for their effects on root development. Seedlings grown in pots can become root-bound: when the long taproot grows to the bottom of the pot, it curls around and forms a spiral, which must be cut off when the seedling is planted. A technique called air-pruning, which uses bottomless pots raised above the greenhouse tables, encourages the taproot to branch instead of spiral. Air-pruned seedlings tend to have more lateral roots than either seedlings in intact pots or those raised in nursery beds for bare-root planting. A disadvantage is that potted seedlings are more expensive to grow than bare-root seedlings, and they are heavier to carry to the field and plant. Root systems of bare-root seedlings also can be enhanced by manipulation of the nursery bed through undercutting (passing a sharp blade through the soil beneath the seedlings) or wrenching (running a vibrating blade through the soil to reduce soil-root contact).

To protect the seedlings from browsing deer and nibbling voles, the researchers tested solid-walled and mesh-type tubular shelters and left some of the seedlings unsheltered. Although both solid shelters and mesh shelters protected the seedlings from animals, the solid-walled shelters promoted faster height growth for the first few years. Mesh shelters offered good protection, but seedling branches often became entangled in the mesh and eventually had to be cut free. Unsheltered trees were browsed heavily and fell far behind the sheltered ones. Seven years after planting, the seedlings planted in mesh and solid shelters were similar in size.

The solid shelters blocked a substantial amount of sunlight, however, and the seedlings that grew in them were spindlier than those growing in the mesh tubes. This was found to be only a short-term problem; a few years after the seedlings had grown above the tops of the shelters, their stems had become thicker and their tops more branched.

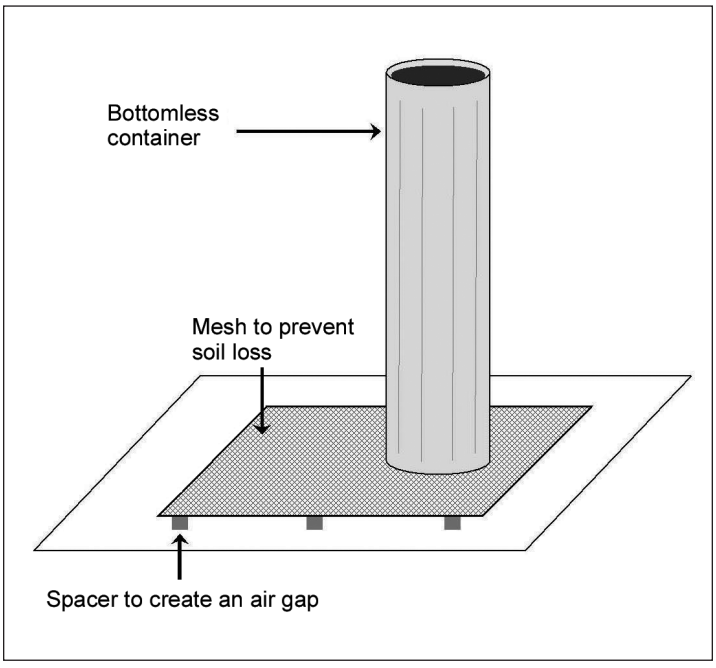
Controlled-release fertilizer made little difference in survival and growth, but mycorrhizae did. Mycorrhizae are naturally occurring root-fungi associations that help plants take up soil nutrients. Woodland oak seedlings have more mycorrhizal root mass, and more kinds of mycorrhizae associated with their roots, than do nursery seedlings. Adding mycorrhizae to the roots of seedlings grown in pots significantly increased their growth.



Bridget Korman

Warren Devine

An ideal root system (above) has many small secondary roots that provide good root-soil contact; a poor-quality root system (below) has few of these small roots.



An example of a setup to facilitate air pruning and produce seedlings with many small roots.

FOLLOW-THROUGH

In the early years after planting seedlings, Devine and Harrington recommend that managers make annual visits to remove weeds, ensure that shelters are upright and trees aren't tangled in them, maintain mulch, and monitor for animal damage. After the seedlings are established, long-term control of invasive competitors, especially Douglas-fir, will be needed if the oak savannas and woodlands are to have a chance of maintaining their dominance.

A 2008 modeling study by Harrington and co-investigator Peter Gould, also a research forester with the Oak Studies Group, showed that, without regular prescribed burning or some other means to prevent Douglas-fir encroachment, two-thirds of today's prairies will be Douglas-fir woodlands in 50 years. Today's pure oak stands will be well on their way toward being overtopped and killed. The modeling showed that even regular thinning of mixed oak–Douglas-fir stands—a strategy a landowner might use to try to balance commercial timber production with oak restoration—will not keep the oaks alive and growing over the long term.

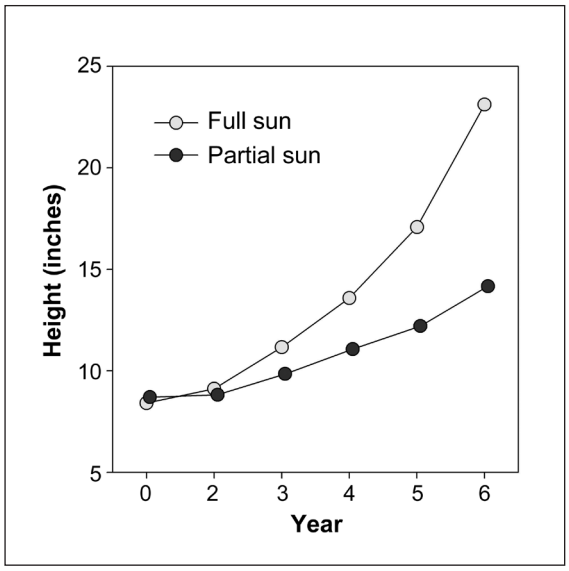
These findings reinforce the urgency of the situation, says Connie Harrington. "The window of opportunity for restoring oak and prairie landscapes in the Puget Sound lowlands and other regions is small, and it is going to take aggressive management to maintain or enhance these landscapes."

Warren Devine

A technician examines growth on oak seedlings 8 years after planting.

LAND MANAGEMENT IMPLICATIONS

- Without postplanting management, growth rates of Oregon white oak seedlings are typically very low. For faster growth and increased survival, competing vegetation should be controlled intensively for at least 2 to 3 years after planting. This prevents planted seedlings from becoming overtopped and increases availability of soil water. Conserving soil water by mulching seedlings is generally more effective than irrigation or weeding by hand, although seedlings planted on very dry sites or in dry years may need to be watered during the first year.
- Both solid-walled and mesh shelters offer adequate protection from browsing animals, but each has drawbacks. Seedlings grown in solid shelters have spindly growth in early years; thus, shelters should be retained for a few years after seedlings emerge from the top, or seedlings should be staked after the shelter is removed. Seedlings grown in mesh shelters may eventually need to be cut free from the mesh.
- Seedlings should be planted no later than the end of February to allow them to develop robust roots.



Oregon white oak seedlings planted in full sunlight outgrow those planted in partial sunlight, illustrating the importance of periodic maintenance to make sure other vegetation is not shading out the seedlings.

Fortunately, she says, there's been a surge of interest in oak habitat restoration among private landowners, conservation organizations, and public agencies. The Nature Conservancy, a key research partner, is already putting the team's findings to work. The Conservancy has been restoring oak savanna on the Glacial Heritage Preserve for several years. They planted some oak test plots a few years before the Oak Studies Group installed theirs.

"Our trees are still smaller than the ones the Forest Service planted later," says Pat Dunn, program director for The Conservancy's South Sound area. "And you might think, well, they'll catch up. But when you're waiting 50 years to get a habitat-size tree, if you can jumpstart the process by multiple years at the beginning, that's important." The Nature Conservancy has modified its planting practices in keeping with Devine and Harrington's guidelines. "Their work has improved our basic knowledge of oaks here in South Sound and throughout the region," says Dunn, "and it's helped improve our techniques."

New knowledge cannot, of course, ensure the follow-through required to bring oak ecosystems back from the brink. But for landowners and others who don't want to see native oak disappear, the new management guidelines are a good place to start.

"Patience is the companion of wisdom."
—Saint Augustine

FOR FURTHER READING

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The Oak Studies Group's Web site: http://www.fs.fed.us/pnw/olympia/silv/oak-studies/.

WRITER'S PROFILE

Gail Wells is a science writer based in Corvallis, Oregon. She is the author of The Tillamook: A Created Forest Comes of Age *(2nd ed. 2004) and coauthor of* Lewis and Clark Meet Oregon's Forests: Lessons from Dynamic Nature *(2001).*

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SCIENTIST PROFILES

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CONNIE HARRINGTON is the research leader for the Oak Studies Group and a research forester interested in silviculture, tree physiology, and plant productivity. She received her Ph.D. from the University of Washington in 1984.

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The many volunteers who planted and measured oak seedlings

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The Nature Conservancy

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