United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

General Technical
Report
PNW-GTR-804
February 2010

Planting Native Oak in the Pacific Northwest

Warren D. Devine and Constance A. Harrington

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Authors

Warren D. Devine and **Constance A. Harrington** are research foresters, Forestry Sciences Laboratory, 3625 93rd Avenue SW, Olympia, WA 98512-9193.

Cover photos by Warren Devine, Laura Blume, and Michael Wiedmer.

Abstract

Devine, Warren D.; Harrington, Constance A. 2010. Planting native oak in the Pacific Northwest. Gen. Tech. Rep. PNW-GTR-804. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 25 p.

The extent of oak woodland and savanna habitat in the Pacific Northwest has been dramatically reduced since settlement in the mid-1800s. This report presents a practical guide for landowners and managers who are interested in reestablishing native oak by planting seedlings. Keys to successful establishment are (1) planting quality seedlings, (2) controlling competing vegetation to increase soil water availability, and (3) protecting seedings from animal damage. A variety of effective cultural treatments, including mulch and tree shelters, are described in detail. Although early growth rates of planted oak seedlings are quite variable, even within the same site, this variation decreases over time after the seedlings become established.

Keywords: Oak, planting, regeneration, restoration, *Quercus garryana.*

Contents

Introduction

The goal of this guide is to provide information to help Pacific Northwest landowners and land managers through the process of establishing native oaks (*Quercus* spp.). Although none of the treatments or techniques mentioned here are mandatory for planting oak seedlings, they are all designed to increase the chance of success. This guide is primarily aimed at restoration plantings, from hundreds to thousands of seedlings, but most of these techniques also can be used by a landowner interested in planting oak on a much smaller scale. Additional information sources are listed at the end of the guide.

Oak in the Pacific Northwest

Oak woodlands, savannas, and associated prairies provide a unique habitat in a region dominated by conifer forests. Oak trees are an important structural component in these unique communities that are home to birds, mammals, reptiles, amphibians, invertebrates, and numerous plant species (fig. 1). Acorns produced by the oak trees provide a food source for a variety of animals. Oak trees also benefit from animals, as establishment of Oregon white oak (*Quercus garryana* Dougl. ex Hook.) in new areas occurs primarily through acorn caching by Steller's

Warren Devine

Figure 1—Many of the best-preserved groves of oak trees in the Pacific Northwest are found in parks, around farmsteads, or on military lands.

jays (*Cyanocitta stelleri*) and squirrels. The open landscape that characterizes the prairie and oak savanna ecosystem was maintained by native peoples for thousands of years through their practice of frequent burning. Oaks are among the few tree species that tolerated fire. After settlement, fire-suppression, agriculture, urban development, and invasion of other species, including Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), resulted in the loss of much of the oak woodland and savanna habitat in the coastal Pacific Northwest. Recently, interest in restoring these communities has brought about an interest in planting native species including oaks.

This guide focuses on Oregon white oak, a deciduous tree also known as Garry oak, because it is the most common oak species in the Pacific Northwest and the only oak species native to northern Oregon, Washington, and British Columbia. In southern Oregon, California black oak (*Quercus kelloggii* Newberry) and canyon live oak (*Quercus chrysolepis* Liebm.) also occur.[1] Much of the technical information presented here may also be of use to those working with the latter two species.

Where Does Oregon White Oak Occur Naturally?

The native range of Oregon white oak extends from southern California to British Columbia. In the Pacific Northwest, it is most common in the lowlands west of the Cascade Mountain range, although it also occurs east of the Cascades, particularly in the vicinity of the Columbia River Gorge. Owing to its tolerance of extreme soil conditions, as well as its adaptation to fire, Oregon white oak historically occurred on sites where other tree species could not survive. In addition to prairie and savanna sites where it tolerated regular burning, Oregon white oak also grows on sites prone to winter flooding and on sites that experience harsh summer drought. It is found on a wide variety of soil types, ranging from deep riparian soils in the Willamette Valley to shallow soils on dry, rocky outcrops.

Oregon white oak has the potential to grow on a wide range of sites, but west of the Cascades, it cannot compete for sunlight with taller, faster-growing conifers such as Douglas-fir (fig. 2). East of the Cascades, oak is found on drier forest sites where it is able to more successfully compete with conifers. Oregon white oak is tolerant of shade when young, but after it grows beyond the seedling stage, it

[1] One source for detailed information on other oak species is Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America: Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service. 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/vol2_Table_of_contents.htm. (September 10, 2009).

Warren Devine

Figure 2—Conifers such as Douglas-fir grow much faster and taller than oak trees. Invasive species, including Scotch broom (*Cytisus scoparius* (L.) Link), the green plant in the foreground, displace native herbaceous plants.

becomes shade intolerant and cannot survive long term without direct sunlight. If an Oregon white oak tree is overtopped and shaded by adjacent trees, its vigor will decline and its limbs will begin to die. There are numerous locations throughout western Oregon and Washington and southwestern British Columbia where oak trees are dying or already dead because they have become overtopped by conifers and do not receive the direct sunlight that they require. Thus, one of the major obstacles to establishment of Oregon white oak is competition from other trees.[2]

The current extent of Oregon white oak has been heavily influenced by human activity. Native peoples promoted oak through frequent burning and also transported acorns to new locations. The occurrence of oak within its range was then

[2] Information on releasing oak trees from competition is available in Harrington, C.A.; Devine, W.D. 2006. A practical guide to oak release. Gen. Tech. Rep. PNW-GTR-666. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 p. http://www.fs.fed.us/pnw/pubs/pnw_gtr666.pdf. (September 10, 2009).

substantially reduced by the landscape changes that occurred since settlement. However, the mapped native range of Oregon white oak remains quite large.[3]

Where to Plant Oak Seedlings

Planting Locations

In some instances, the area to be planted is limited in size and there is no question where to plant oak seedlings. On larger properties, it may be less obvious where to plant oak trees. Historically, the distribution of oaks looked different than it does today. In the Willamette Valley and the Puget Sound Region, frequent burning produced savannas with scattered, and sometimes very large, oak trees. Denser oak woodland stands probably existed on the fringe of such savannas, where fire was less frequent and soils were sometimes moister. If a site includes a large open space such as a prairie or savanna, planting oak trees around the edges would likely be historically accurate and also would preserve the largest area of contiguous open space for species requiring that type of habitat. However, seedlings should not be planted directly beneath the crowns of other trees, as they will not receive sufficient sunlight (fig. 3). Oaks can be planted on a wide range of soil types, although survival rates will almost certainly be lower on very dry or shallow soils and on wet soils that are seasonally flooded.

Planting Density

To estimate the desired tree spacing for a restoration planting, it may be helpful to visit natural oak stands similar in density to the one that is to be established. It also may be helpful to measure the distance between trees in these stands. Densities of natural stands range dramatically from savannas with a few scattered oaks to oak woodlands with a complete canopy of oak trees. Spacing is typically uneven in natural stands; clumps and gaps are common. As long as seedlings are not planted on a grid, their arrangement will probably not be distinguishable from a natural one once the trees begin to mature. Alternatively, if a management objective is eventual timber production, uniform spacing and relatively high density at planting is preferable. Close, uniform spacing is likely to produce taller trees with longer boles (i.e., trunks), and wider and irregular spacing encourages development of broad, spreading crowns and relatively short boles (fig. 4).

[3] A range map for Oregon white oak is shown in Stein, W.I. 1990. Oregon white oak. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America: Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service: 650–660. http://www.na.fs.fed.us/pubs/silvics_manual/Volume_2/quercus/garryana.htm. (September 10, 2009).

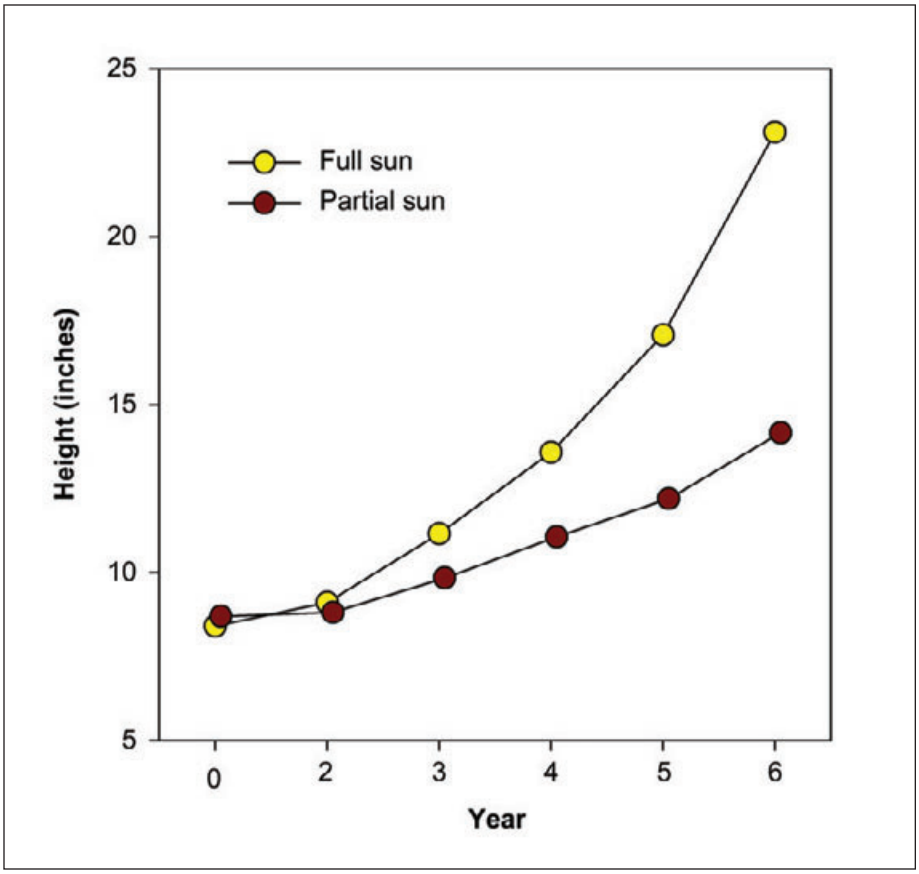

Figure 3—Oregon white oak seedlings planted in full sunlight outgrow those planted in partial sunlight.

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Figure 4—These oak seedlings were planted near the edge of an existing stand, in a random arrangement. Planting density is relatively high, in anticipation of natural mortality.

No matter how much effort is put into an oak planting, it is realistic to expect that some of the seedlings will die. Sometimes seedlings die as a result of unforeseen circumstances such as flooding, wildfire, rodent damage, or even unplanned mowing operations. For perspective, when oaks reproduce in nature, most of their acorns never even become seedlings, and most of the seedlings that become established die before they become saplings. For the purposes of this guide, an oak is considered to be "established" after it has grown large enough so that mortality from animal damage or summer drought is unlikely. An established oak has consistent height and diameter growth each year and is taller than its neighboring vegetation. When planting oak, it is not unusual to have 10 to 25 percent mortality in the first 2 years and a similar amount of mortality over the next 5 years. A practical approach is to plant two to three times as many trees as are ultimately desired in the stand. Trees can always be removed later (or, with great effort, transplanted) if too many become established.

The planting approach described here focuses a relatively large amount of effort on individual seedlings to maximize survival rate. One reason for this approach is the relatively high cost of native oak seedlings compared to, for example, Douglas-fir seedlings. Another reason for the intensive approach is that many people planting native oak seedlings are planting a relatively small number of them and have a strong interest in seeing the majority of them survive and mature.

Where to Get Oak Seedlings

Nursery Seedlings

Native bareroot and container-grown oak seedlings are produced by an increasing number of commercial nurseries in California, Oregon, Washington, and British Columbia. Some of these nurseries also carry larger seedlings, saplings, and even small trees. Usually, the price of quality nursery seedlings is less than it would cost to grow them yourself. Seedling prices differ depending on size, age, and whether they are sold in a container or bareroot. Native oak seedlings are in high demand; therefore, it is important to begin contacting nurseries well in advance of when the seedlings will be needed.

Most nurseries will have several seedling stock types available. These may include bareroot seedlings (grown in a nursery bed), plugs (seedlings grown in narrow containers), and containerized seedlings (sold in their pots). Seedlings of different ages may also be available, price increasing with age. Owing to natural genetic variation throughout a species' range, oak seedlings may grow best if they are planted in the same region from which the acorns were collected (e.g., the Puget Sound Area, the Willamette Valley, the Columbia River Gorge).

The most important thing to look for in a seedling is a good root system. In addition to one or more thick taproots, the seedling should have a large number of small lateral roots (fig. 5). These small roots provide greater surface area and increased soil contact when a seedling is planted. Better root-soil contact increases the seedling's ability to uptake water and thus improves its early growth and its chance of survival. If a seedling has only a few small roots growing from its taproot, it will probably not perform well during the first few years, and it may not survive. For bareroot seedlings, it is particularly important that they have many small roots because this additional root-soil contact helps alleviate the stress that the seedling undergoes during its first year after planting. It also is important to

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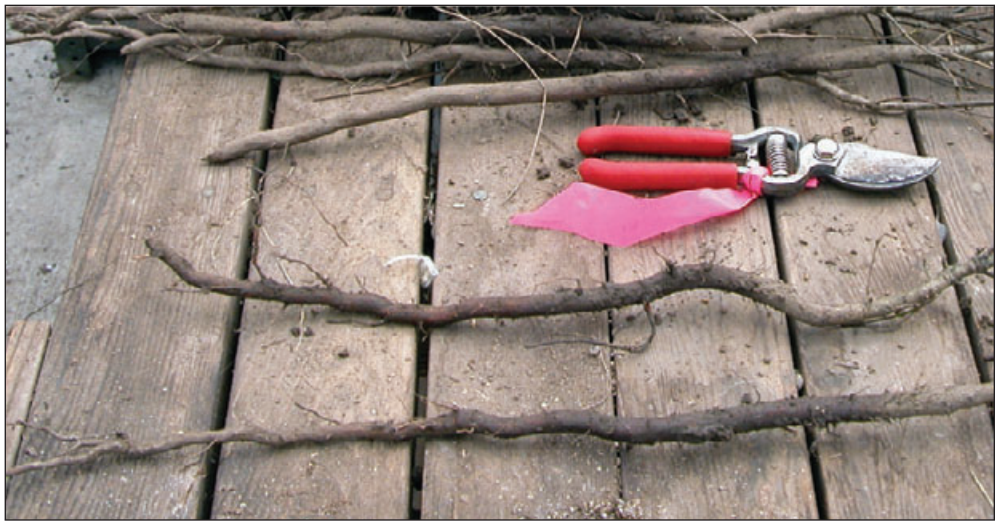

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Figure 5—An ideal root system has numerous small roots that provide good root-soil contact (above); a poor-quality root system has few of these small roots (below).

check whether seedlings grown in pots are "root bound." That is, whether the taproot is circled around the base of the pot. Circled taproots can be very hard to straighten at planting time and usually have to be pruned off (fig. 6). Clusters of small roots at the base of the pot are not a problem because they are flexible and can be spread out at planting.

A seedling's diameter at the base of its stem (i.e., at the "root collar") is a general indication of how well it will grow during the first few years after planting. Whenever possible, choose seedlings that have a stem at least ¼ inch (6 mm) in diameter. Seedlings of this size and larger will be better able to compete with other vegetation after they are planted.

Warren Devine

Figure 6—Without proper root management, container-grown oak seedlings can become "root-bound." In this case, the "bound" portion of the taproot will need to be pruned off before planting because it is too thick to be straightened.

Growing Oaks From Acorns

Some people choose to grow their seedlings from acorns. This can be a rewarding experience, but it will take 2 years before the seedlings are large enough to plant. Raising seedlings also requires diligence throughout the summer to ensure that they are adequately watered.

To grow seedlings, acorns should be collected in September or thereabouts, when they are yellow to brown and beginning to separate from their caps. Acorns still attached to the tree are preferable because they are usually in better condition than those on the ground. If acorns must be collected from the ground, they should be collected as soon as possible after falling. The most obvious sign that an acorn has insect damage is a tiny round hole created by weevils when the larvae exit the acorn. A standard test to cull damaged acorns is to soak the acorns in water for 24 hours just before planting them. The ones that float are much more likely to have insect damage; those that sink are usually sound. Of those that sink, larger acorns generally produce larger seedlings.

The easiest way to grow oak seedlings is in containers. Regardless of what the container is made of, it should be at least 12 inches (30 cm) tall, but it doesn't necessarily need to be wide (3 to 4 inches [8 to 10 cm] in diameter is sufficient). Initially, containers may need to be covered with a piece of screen to keep small animals

from digging up the acorns. Conventional pots can be problematic when growing oak seedlings because the seedlings' roots tend to circle when they reach the base of the pot, causing the seedling to become root bound. Some manufacturers sell pots that are designed to "air prune" the roots and prevent this problem. These pots are shaped to direct the roots toward a large opening at the base of the pot. When the downward-growing roots reach this opening, they meet an air gap and stop growing; this prevents root binding and promotes the formation of additional roots away from the bottom of the pot. An alternative solution is to use containers that have no bottom, such as milk cartons with the bases removed or sections of tube or pipe. Any grooves or ridges should run parallel to the length of the container to promote downward root growth; perpendicular grooves could cause roots to circle. Place the bottomless container on a mesh screen so that the soil does not escape (fig. 7). Below the mesh should be an air gap: the screen should not lay directly on another surface.

A standard potting soil mix or a combination of potting mix and natural soil may be used. Potting mixes are lighter, easier to work with, and provide ideal rooting conditions, but they usually do not contain the species of symbiotic fungi

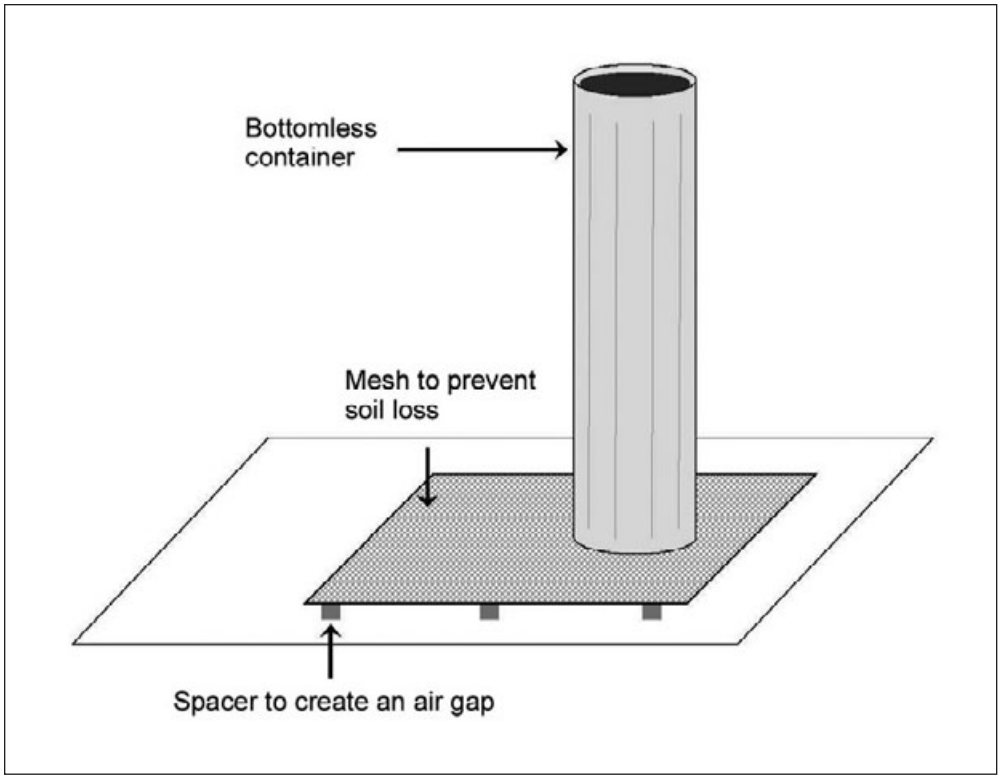

Figure 7—An example of a setup that will produce oak seedlings with a good root morphology.

(mycorrhizae) that naturally grow on oak roots in their native environment. Thus, seedling growth may benefit from the addition of soil containing these fungi. From an oak stand or other forested area, collect soil, including all of the small roots that are in it, from within a few inches (centimeters) of the surface (mycorrhizae are usually invisible to the naked eye). A small handful of this soil can then be added to each pot at planting.

Oregon white oak acorns are ready for planting in the fall as soon as they are collected and soaked in water for 24 hours. Place the acorns on their side and cover them with about ½ inch (1 cm) of soil. A taproot will begin to grow within a few weeks, and a shoot will appear in spring. Any acorns that have not germinated after 1 to 2 months can be discarded and replaced with stored acorns at that time. Acorns can be stored under refrigeration for 3 months or more, but the likelihood of germination and mold growth increases over time. To store acorns, dry them, place them in plastic bags, and refrigerate. For longer storage, rinse acorns in a 5-percent bleach solution first, and ensure that the refrigerator is set as close to 33 °F (1 °C) as possible.

After acorns are planted in containers, the soil should be checked regularly, particularly during summer months, to ensure that it does not become too dry. When the containers are irrigated, ensure that the soil is saturated throughout, although the pots should not rest in standing water. Seedlings should be fertilized regularly throughout the growing season. After the first summer, some seedlings may appear large enough to plant; but in the long run, survival and growth rates will be higher if the seedlings are grown for 2 years before they are planted in the ground.

When to Plant Oak Seedlings

The best time to plant oak seedlings is after rains have moistened the soil in the fall and before temperatures begin to warm in early spring. When a seedling is planted in fall or winter, rather than in spring, its roots have more time to become established and it will have a better chance of surviving its first summer. An experiment showed that seedlings planted by the end of February had greater root growth by the beginning of summer compared to seedlings that were planted later in the spring. Seedlings planted in the fall have even more time to become established. If planting in fall, first dig a hole at least as deep as the planting hole and feel the soil to ensure that there has been enough rainfall to moisten it. Spring plantings can be just as successful as earlier plantings, but there is a greater chance that summer irrigation will be necessary owing to the fact that seedling root systems may not be as well established before the soil dries out in the summer.

The Planting Process

Small-scale plantings are often done by hand, but large-scale plantings in soil that is rocky or difficult to dig requires a large number of planters or a powered auger. An advantage of using a powered auger is that the soil can easily be loosened to a greater depth than would normally be achieved with hand tools. This allows the seedlings' roots to more quickly grow into deeper soils that retain more moisture in summer.

Begin planting by using a shovel, mattock, or other tool to remove any vegetation from the immediate vicinity (within about 6 to 12 inches [15 to 30 cm]) of the planting spot. Then, dig a planting hole several inches (centimeters) deeper and several inches wider than the seedling's root system. Depending on soil type and personal preference, a shovel or post-hole digger may work best. If the excavated soil is temporarily placed on a tarp or plastic sheet, less soil will be lost before it is time to backfill. If planting a containerized seedling that is root-bound, prune off any bound portion of the taproot. If a circled taproot is planted, growth will be severely hampered. If a bareroot seedling has a thick cluster of small roots, gently spread these apart.

Hold the seedling in place with the root collar (the point where the taproot becomes the stem) just below ground level, so that you can backfill around the roots. For bareroot seedlings, the roots should dangle freely and should not be bent ("J-rooted"). Backfill the hole, creating direct contact between seedling roots and moist soil; this contact is vital to the seedling's survival. When backfilling the hole, be aware that the deeper the hole is, the more the soil is likely to settle. Pack the soil firmly. If the soil is very rocky, additional topsoil should be taken from a nearby location to avoid backfilling the hole with a large number of rocks. The root collar of the planted seedling should be at, or slightly below, groundline.

On dry sites, it may be beneficial to create a shallow basin around the seedling at the time of planting. This will help to direct rainwater or irrigation water toward the seedling. A basin can be made by simply creating a slight depression 1 to 2 feet (30 to 60 cm) in diameter and optionally adding a low berm 2 to 3 inches (4 to 8 cm) high around its perimeter.

Special care must be taken when planting bareroot seedlings. Exposing bare seedling roots to warm temperatures or dry air at any time prior to planting can severely damage the seedlings. Leave bareroot seedlings in storage, keeping them damp and cool, until they are ready to be placed in the ground. Always follow the nursery's storage recommendations if the seedlings are not planted soon after purchase.

Helping Seedlings Become Established

The planting of tree seedlings or seeds, as opposed to natural regeneration of trees, has historically been called **artificial regeneration** by foresters. With this in mind, there are a number of treatments, some rather artificial in appearance, that are commonly used to help planted seedlings become established. Major obstacles to seedling establishment include competition from other vegetation, damage from wildlife, and insufficient soil water before roots become fully established.

Vegetative Competition

Virtually every planted seedling will be negatively affected to some extent by competition from adjacent vegetation. Especially in their first year, oak seedlings are at a disadvantage because their roots are shallower and less developed and their tops are shorter than those of most neighboring plants. Seedling survival and early growth rates are nearly always improved by temporarily reducing vegetative competition (fig. 8). The most common techniques used for vegetation control are mulching, manual removal, and chemical control (i.e., herbicide). Typically, one of these three treatments is applied, but two may be combined for even greater control of competition.

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Figure 8—Two approaches to vegetation control: manual removal (left, photo taken in August of the first summer after planting) and plastic mulch (right, photo taken in February).

Many types of mulch are effective for controlling competition around planted seedlings. A variety of materials can be used including a thick layer of organic matter, plastic sheeting, woven and nonwoven landscape fabrics, and plastic mats specifically designed for seedlings. Several trials in the region have shown that perforated plastic mats (often called “Brush Blankets” ® or “weed mats”) work

well if installed correctly.[4] Other mulching materials also work well assuming they prevent growth of most or all of the competing vegetation and last for at least 2 or 3 years. If synthetic materials are used, first remove any sticks or sharp objects that might poke through or tear the material. Additionally, the hole from which the seedling protrudes must be as small as possible, otherwise a bouquet of vegetation will emerge surrounding the seedling (fig. 9). Anchor the edge of the synthetic mulch firmly to the ground with landscape staples or rocks. A potential disadvantage of weed mats is that they can be a favored habitat for voles (*Microtus* spp.), which may damage seedlings. Where voles are a problem, tree shelters or other seedling protection should be used (see "Protection from Rodents" section).

James Dollins

Figure 9—Because the opening in the center of this plastic mulch was larger than necessary, the emerging grasses created a significant amount of competition close to the seedling.

Seedlings will benefit from any size mulch, but mulch that extends at least 2 feet (60 cm) from the seedling in all directions (i.e., 4 feet [122 cm] in diameter) is ideal, as it suppresses most competition and reduces the likelihood that tall grasses and other plants will overtop the seedling. A field of large plastic mats is, however, visually unattractive to some people, and they may choose to cover synthetic mulch with organic materials or to use only organic mulch instead. The combination of synthetic and organic mulch is popular for landscaping and effective, but it may be prohibitively expensive in large-scale plantings. If purchasing synthetic mulch, it is usually more cost-effective to obtain it from the manufacturer or from a forestry or landscaping supply company rather than from a retail outlet.

In contrast to mulching, manual removal of competing vegetation requires little material cost but usually involves a significant amount of labor. Before planting, use a hand tool such as a hoe or pulaski to remove all vegetation from a circular area 3 to 4 feet (91 to 122 cm) in diameter. Ensure that the thicker roots, especially of grasses, are removed to reduce the likelihood of sprouting. After the area is cleared, plant the seedling in the center. Followup weeding, at least once per year, is beneficial on most sites.

[4] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

A variety of herbicides can be used, either before or after planting, to eliminate competing vegetation near oak seedlings. For large-scale plantings, chemical control of vegetation would likely be much more cost-effective than mulching or manual removal. Herbicide may be applied as the sole method of vegetation control, or it may be applied prior to mulching. A backpack or canister sprayer may be most effective for "spot applying" herbicide to vegetation near each seedling location. Follow the label instructions carefully to avoid damaging the seedlings, particularly if applying herbicide after planting. See the "Additional Resources" section for more information on herbicides.

Protection From Browse

Tree shelters are commonly used to protect seedlings from a variety of animal damages including browse by deer, elk, or cattle, and clipping by rabbits. If the base of the shelter is buried in the soil, it also may help protect the seedling from burrowing rodents. On many sites, the likelihood of animal browse makes tree shelters a necessity. Solid-walled plastic tree shelters have an additional benefit: they almost always increase the height growth rate of seedlings during their first few years after planting (fig. 10). This is beneficial in that the seedlings more quickly grow above the reach of animals.

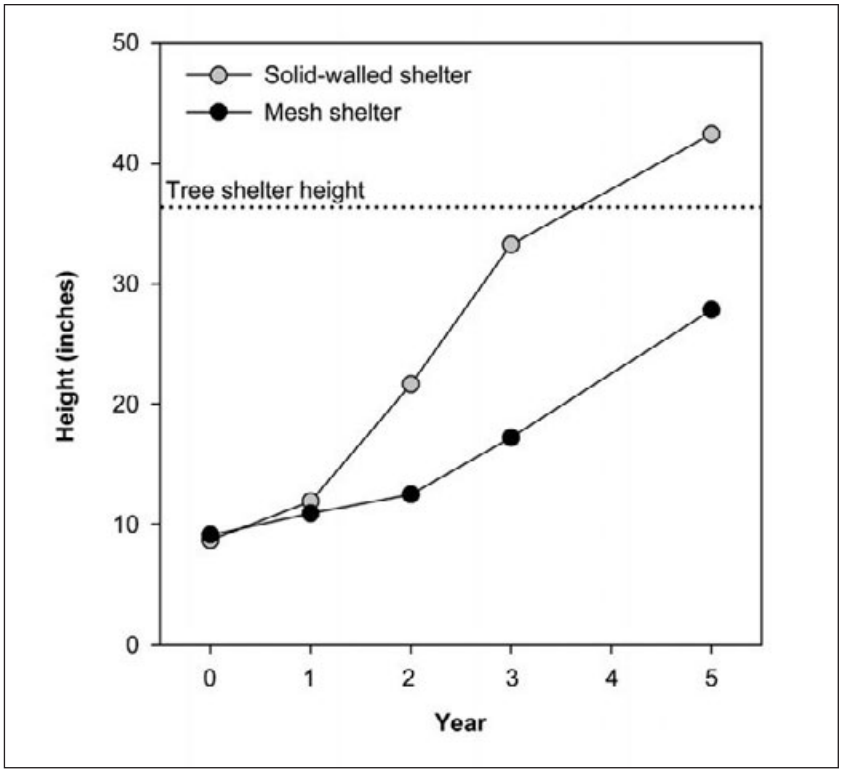

Figure 10—During the first few years after planting (year 0), height growth is increased for seedlings grown in solid-walled tree shelters.

There are a wide variety of tree shelters commercially available. Types include solid-walled shelters, solid-walled shelters with vent holes, fine-mesh shelters made of synthetic cloth, and mesh-walled shelters often called Vexar® shelters. Alternatively, some people choose to construct their own tree shelters. Although the cost of a homemade shelter is often higher than that of a commercial model, homemade shelters allow customization of the dimensions and materials. Shelters can be constructed from a wide variety of materials, including mesh fencing, chicken wire, plastic mesh, and netting (fig. 11).

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Figure 11—Five types of tree shelters. Clockwise from top left: a commercially available solid-walled shelter, a mesh-walled Vexar® shelter, and three homemade shelter designs.

In selecting a shelter for oak seedlings, there are several key points to remember. First, the shelter should be tall enough to allow the seedling to "escape" most animal damage. For example, in a 3-foot (91-cm)-tall shelter, the seedling may grow well for its initial 3 feet, but it then may be browsed by deer for several years after it emerges from the top. Although solid-walled shelters increase the rate of seedling height growth, stem diameter growth is not increased, and the result is a tall, spindly seedling. This effect is even greater with very tall shelters (i.e., 5 feet [152 cm]). Thus, the seedlings usually require the continued support of the tree shelter for a few years after they emerge from the top of the shelter (fig. 12). One solution

James Dollins

Figure 12—After removal of the solid-walled tree shelter, it was apparent that this tall, slender oak seedling lacked normal branch development of a seedling its size. Seedlings like this one require the continued support of a tree shelter for 2 or 3 more years while the stem thickens and branches develop above the top of the shelter.

to the problem of the overly slender seedling is to use a shelter that is sufficiently wide for the seedling to develop a more branchy form. A wide mesh shelter also allows the seedling to sway in the wind, which leads to a thicker, sturdier stem. For example, 12-inch (30-cm)-diameter mesh shelters allow seedlings to develop natural-looking branches and strong stems. However, shelters of this width must be homemade, as commercial shelters more than 6 inches (15 cm) in diameter are uncommon. If solid-walled plastic shelters are used, it is important to bury the base in the soil. Otherwise, the shelter could create a chimney effect, and the flow of hot air could dry out the seedling in summer. The color of solid-walled shelters will affect the amount of sunlight that seedlings receive. Darker colors, including blue, should not be used if the seedlings are already receiving shade from nearby trees; the combination of a dark-colored shelter plus shade will impede photosynthesis. Most types of tree shelters, except those that are designed to degrade in sunlight (such as Vexar® shelters), can be reused.

The type of stake used to keep the tree shelter upright is an important decision. Generally, the longer lasting stakes are more expensive but have lower maintenance and replacement costs. The stake should be long enough to extend at least 1 foot (30 cm) beneath the soil surface, and the aboveground portion should be nearly as tall, or taller than the shelter. Secure the shelter to the stake at the bottom and top. Bamboo stakes are inexpensive, but they will rot over time, and two bamboo stakes are needed to secure heavier shelters. Wooden stakes, particularly those made of hardwood, last longer than bamboo. Metal fenceposts or rebar are expensive but

also are extremely durable and reusable. Consider the amount of wind that the site receives; solid-walled shelters catch the wind more than mesh shelters and thus put more strain on the stake. Round, lightweight garden stakes tend to work themselves loose from the ground over time if they are used to support solid-walled shelters.

For protection from animal browse, an alternative to tree shelters is animal repellant. Several commercial options are available. Repellants must be applied in spring and summer as soon as any new growth is present because young leaves are most palatable to deer and elk.

Protection From Rodents

Gophers (*Thomomys* spp.), voles, and other rodents have the potential to destroy planted seedlings, particularly when the rodent population density is high in the planting area (fig. 13). The likelihood of damage from gophers can be predicted by the presence of mounds. If there is evidence of rodent activity in the planting area, installing barriers around individual seedlings can significantly reduce rodent-caused mortality. Because gophers chew the seedling at groundline or below, a barrier to prevent damage must extend 8 inches (20 cm) beneath the soil. Lightweight plastic mesh (Vexar®) tubes, installed around the roots of seedlings at the time of planting, have successfully deterred rodents without causing root deformity. This material is designed to decompose over time; heavier-weight plastic mesh or wire mesh does not decompose and must be removed before root growth becomes constricted.

James Dollins

Figure 13—This seedling was severed below ground by a gopher. After this type of damage, the seedling's root system is unlikely to re-sprout.

Voles typically girdle seedlings aboveground; therefore, seedlings can be protected from voles by tree shelters. To keep voles out, the base of the tree shelter should be buried 2 to 3 inches (5 to 8 cm) in the soil. If tree shelters are not used, vole damage can be reduced by installing a section of plastic tube or pipe around the lower stem or by using spiral tree guards or 8-inch (20 cm)-tall tree protectors. Voles nest and seek refuge from predators in dense ground vegetation. Removal of this vegetation from a site is not always desirable or practical, but in some cases, removing it from the vicinity of the planted seedlings can help reduce seedling damage.

Irrigation

West of the Cascade Range, the need for irrigation depends on a variety of factors including the dryness of the site, the amount of competing vegetation, and the planting date. Irrigation of large-scale planting projects can be labor-intensive and expensive; thus, it is important to reduce the need for irrigation by planting seedlings with large, healthy root systems, by controlling competing vegetation, and by not planting too late in the spring. But irrigation may still be necessary for seedling survival on very dry sites, such as those with sandy, gravelly soils and those receiving very little summer rainfall. Abnormally dry spring or summer conditions during the first year after planting may also necessitate irrigation. Observe seedlings closely during their first spring and summer; if there are signs of moisture stress, such as browning of the leaves, they should be watered soon. The frequency of irrigation depends on how quickly the soil dries out; rapidly draining, sandy soils may become dry in as little as 1 week. After 1 to 2 years of growth, seedling roots become established, and seedlings are less likely to die from moisture stress. East of the Cascades, where soil water is less available, irrigation for 1 or more years after planting is more likely to be necessary than west of the mountains.

Fertilization

Although fertilization substantially increases the growth rate of potted seedlings, fertilization after planting often does not result in a growth increase. Availability of soil water is generally a more important factor than nutrients. If fertilizer, either manufactured or organic, is used after planting, it should be applied in late spring or early summer and placed close to the seedling at the manufacturer’s recommended rate.

James Dollins

Figure 14—Where a young oak tree was removed 4 years earlier, a number of vigorous sprouts have emerged from around the stump.

Oaks From Sprouts

Oregon white oak trees often originate from stump sprouts, and root sprouts also have been reported. If oak trees are growing in a ring or in a tight clump, that is an indication that they probably originated as sprouts from a single stump. Stump sprouts usually appear when an existing tree has been cut or severely damaged (fig. 14). Because sprouts grow from an existing root system, they have a substantial advantage over seedlings grown from acorns. Growth rates of sprouts are usually much faster than those of planted seedlings. Thus, if sprouts are present on a site, they offer the fastest route to establishing oak trees. Given their existing root systems, they can usually outcompete other vegetation, although browse damage is a possible threat.

In some cases, oak saplings or young trees are inadvertently damaged during restoration activities. We have found that when small, badly damaged trees are cut near the base, they usually form vigorous sprouts that grow more rapidly than the original tree had been growing. After the damaged tree is removed, the water and nutrients taken up by the root system are diverted to the new sprouts. When

a cluster of sprouts is several years old and one or two of the sprouts are clearly dominant, the less vigorous sprouts may be pruned off.

After Planting

Maintaining Oak Plantings

Visiting each seedling at least once per year is important for maintenance. These visits may include the following activities:

- Remove any competing vegetation that has established very close to seedlings.
- Ensure that tree shelters are upright, stable, and likely to remain so for another year.

Warren Devine

Figure 15—After the initial establishment period, oak growth rates increase significantly. These trees were planted 8 years ago.

- Check that new seedling shoot growth, particularly the terminal shoot (or "leader"), is not ensnared in the wall of the tree shelter. This is a common problem, especially for narrow shelters and shelters with mesh walls. For each seedling, verify that the terminal shoot is pointing upward.
- Maintain mulch that has been disturbed or damaged. The effectiveness of mulch or other competition control treatments will gradually deteriorate over time, but the seedlings' need for competition control also will decline. However, sometimes quick repairs or maintenance can prolong the lifespan of the vegetation control treatment.
- Check for animal damage. Browse damage by deer or elk is easy to assess, but rodents may damage the seedling stem belowground. If a seedling is in poor health for no obvious reason, gently tug on the stem. The seedling will come out of the ground easily if the stem or roots have been severed belowground. Unanticipated animal damage may require additional seedling protection measures, such as those described in the earlier section. A variety of insects may feed on or otherwise damage oak seedlings, although in many cases the damage is not severe enough to seriously impact seedling health and survival. State or provincial agricultural extension agents provide pest identification services.
- Apply additional fertilizer if desired (in late spring or early summer).

Growth Rates

Early growth of planted oak seedlings is often unimpressive because seedlings allocate more of their resources to development of root systems than to stem growth. It is not unusual for some seedlings to grow less than 3 inches (8 cm) in height annually during the first year or two after planting. However, during the second to fourth years postplanting, seedling growth rates usually begin to increase, and the amount of annual growth becomes more consistent (fig. 15).

Growth rates differ widely among sites and among seedlings planted on the same site. Assuming they are receiving full sunlight, growth rate is positively related to the amount of soil water available to seedlings during the summer. Vegetation control increases soil water availability to some extent, but the amount of soil water is heavily influenced by factors such as soil texture, precipitation patterns, and hydrology. Soil properties may differ over small distances, and some seedlings grow significantly faster than other seedlings planted nearby. Although early growth rates are quite variable, even within the same site, this variation decreases over time after the seedlings become established.

Cost-Share Programs

In the United States, federal cost-share programs have been implemented as part of the Farm Bill to assist landowners in the development and restoration of wildlife habitat. Some of these programs apply to restoration of Oregon white oak woodland and savanna habitats. The program best suited to landowners restoring oak habitat is the Wildlife Habitat Incentives Program (WHIP). This program is designed to improve wildlife habitat that has been negatively affected by agricultural activities, urban development, or invasive species. Landowners whose WHIP application is accepted work with a representative from the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) to create a 2- to 10-year habitat management plan for their property. Landowners receive technical assistance and up to 75-percent cost share. Management activities covered by WHIP include planting of native species and control of invasive plants.

A second federal cost-share program that may be available to agricultural producers or forest landowners is the Environmental Quality Incentives Program (EQIP). This program includes assistance for the protection of habitat for at-risk species. The specific activities and habitats covered are determined at the local level by the NRCS. Like WHIP, assistance is provided under a multiyear contract, and cost share may be as high as 75 percent. For additional information on these U.S. cost-share programs, contact the NRCS.

USDA Natural Resources Conservation Service
Find the nearest NRCS office online at:
http://offices.sc.egov.usda.gov/locator/app?agency=nrcs
Learn more about NRCS cost-share programs at:
http://www.nrcs.usda.gov/programs/whip/
http://www.nrcs.usda.gov/programs/eqip/

Washington State NRCS Office
316 W Boone Ave., Suite 450
Spokane, WA 99201-2348
Phone: (509) 323-2900
Fax: (509) 323-2909

Oregon State NRCS Office
1201 NE Lloyd Blvd., Suite 900
Portland, OR 97232
Phone: (503) 414-3200
Fax: (503) 414-3103

California State NRCS Office
430 G Street #4164
Davis, CA 95616-4164
Phone: (530) 792-5600
Fax: (530) 792-5790

Environment Canada's Habitat Stewardship Program (HSP) works to protect species at risk and conserve their habitat. For Canadian restorationists, HSP may provide cost-share for planting oak if the project is part of a restoration effort that benefits one or more species at risk. The oak ecosystems of British Columbia have been a priority of this program in recent years. The HSP is operated through the Canadian Wildlife Service.

Canada's Habitat Stewardship Program
http://www.cws-scf.ec.gc.ca/hsp-pih/default.asp?lang=En&n=59BF488F-1
In British Columbia, contact:
Pacific Wildlife Research Centre
Environment Canada
Canadian Wildlife Service, Pacific and Yukon Region
5421 Robertson Road, RR 1
Delta, BC V4K 3N2
Kin.Mak@ec.gc.ca
Phone: (604) 940-4721

Additional Resources

Information on Planting Oak

Cullington, J.; Dunster, K.; Goulet, L.; Junck, C.; Irwin, G.; Masson, C. 2009. The Garry oak gardener's handbook. 2nd ed. Victoria, Canada: Garry Oak Ecosystems Recovery Team Society. 56 p.

This is a guide to creating a garden with oak and associated native plants at a relatively small scale. Available at http://www.goert.ca/pubs_general.php.

McCreary, D.D. 2001. Regenerating rangeland oaks in California. Agriculture and Natural Resources Publication 21601. Oakland, CA: University of California. 62 p.

This is a very detailed guide with information that is also applicable to the Pacific Northwest. Available through University of California Agriculture and Natural Resources at http://anrcatalog.ucdavis.edu/.

Vesely, D.; Tucker, G. 2004. A landowner's guide for restoring and managing Oregon white oak habitats. Salem, OR: U.S. Department of the Interior, Bureau of Land Management. 65 p.

This comprehensive guide has a section on planting oak. Request a copy by emailing your name and address to or080mb@or.blm.gov or view online at http://www.oregonoaks.org/documents/landguide.pdf.

Herbicide Information

Center for Invasive Species and Ecosystem Health. 2009. Weed control methods handbook: tools and techniques for use in natural areas. http://www.invasive.org/gist/handbook.html. (September 10, 2009).

A comprehensive online guide to herbicide use and other methods of vegetation control, with detailed information on specific chemicals.

Hillmer, J.; Liedtke, D. 2003. Safe herbicide handling in natural areas: a guide for land stewards and volunteer stewards. Dublin, OH: Ohio Chapter, The Nature Conservancy. 20 p.

A brief overview of herbicide use for restoration purposes; some discussion of specific chemicals. Go to http://www.invasive.org/gist/products/library/herbsafe.pdf to download the document.

Miller, T.L. 2009. EXTOXNET—The Extension Toxicology Network. http://extoxnet.orst.edu/tics/ghindex.html. (September 10, 2009).

A comprehensive collection of toxicology information on a wide range of pesticides (including herbicides).

Ramsay, C.A.; Foss, C.R.; Hines, R.L. 2007. Private applicator pesticide education manual. Pullman, WA: Washington State University Cooperative Extension. 138 p.

A comprehensive guide to herbicide use, including Washington and federal laws; does not describe specific chemicals. Available for $13.50 from http://pubs.wsu.edu or 1-800-723-1763.

Working Groups

Garry Oak Ecosystems Recovery Team (GOERT)
209–606 Courtney Street, Victoria, BC V8W 1B6 Canada
Phone: (250) 383-3427
http://www.goert.ca/
Email: info@goert.ca

Oregon Oak Communities Working Group
http://www.oregonoaks.org/
Email: oregonoaks@comcast.net.

The South Puget Sound Prairie Landscape Working Group
http://www.southsoundprairies.org/

Related Research Papers

Devine, W.D.; Harrington, C.A.; Leonard, L.P. 2007. Post-planting treatments increase growth of Oregon white oak (*Quercus garryana* Dougl. ex Hook.) seedlings. Restoration Ecology. 15(2): 212–222.

Fuchs, M.A.; Krannitz, P.G.; Harestad, A.S. 2000. Factors affecting emergence and first-year survival of seedlings of Garry oaks (*Quercus garryana*) in British Columbia, Canada. Forest Ecology and Management. 137: 209–219.

Hibbs, D.E.; Yoder, B.J. 1993. Development of Oregon white oak seedlings. Northwest Science. 35: 65–77.

Acknowledgments

We are grateful to the volunteers who collected data from their oak plantings: Tanya Braumiller, Dick Hopkins, Hugh Snook, Eric Hendricks, Harold Hertlein, Cindy Miner, Rich Wolfe, and Bill Wood. We also thank Lathrop Leonard for his oak planting research on Fort Lewis. We thank David Peter, Marty Chaney, Rachel Maggi, Jim Evans, Laura Blume, and Douglas McCreary for manuscript reviews.

Reese Lolley

Pacific Northwest Research Station

Web site	http://www.fs.fed.us/pnw
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890

U.S. Department of Agriculture
Pacific Northwest Research Station
333 SW First Avenue
P.O. Box 3890
Portland, OR 97208-3890