Garry Oak Woodland Restoration in the Puget Sound Region: Releasing Oaks from Overtopping Conifers and Establishing Oak Seedlings

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Abstract

Garry oak (*Quercus garryana* Dougl. ex Hook.) woodlands and savannas in the Puget Sound Region have been dramatically reduced in area since the 1850s, and many remaining stands are in poor condition. This is due in part to the invasion and eventual dominance of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in many oak stands after Native American burning practices were ended. In 2001, we initiated a study at Fort Lewis Military Reservation near Tacoma, Washington, USA to examine the response of oaks to release from overtopping Douglas-fir. We tested three release treatments on individual overtopped oaks >20 cm diameter: a full release in which all competing conifers were removed, a partial release, and a control that consisted of a stand-level thinning not specifically directed toward oak release. Logging damage to oaks was minimal in all release treatments, and three years later there has been no windthrow or mortality. Released trees are now producing more acorns and have begun to rebuild their crowns through epicormic branching. The release treatments have also increased the growth of oak regeneration (trees <1.5 m in height) present on the plots prior to release. In another study, we have established six oak outplanting trials to evaluate the effects of competition control, fertilization, and browse protection on growth and survival of planted oak seedlings. Although early height growth and diameter growth have been slow, likely due to unusually dry growing seasons, survival rates averaged >90% during the first two years. During this period, we observed no growth differences due to weed control treatments or fertilization, but solid tree shelters significantly increased seedling height growth compared to mesh shelters. Our ongoing evaluations of management practices should help guide the restoration and creation of oak habitats.

Key words: *Quercus garryana*, restoration, acorns, epicormic branches, regeneration, outplanting, tree shelters, mulch.

Introduction

Garry oak (*Quercus garryana* Dougl. ex Hook.) woodlands and savannas of the Pacific Northwest have diminished significantly in area since European settlement due to agriculture, development, and the cessation of regular burning. Loss of these oak habitats adversely affects a broad range of species including the western gray squirrel (*Sciurus griseus*) that benefit from the fall and winter food source that Garry oak acorns provide. Many woodlands and savannas formerly occupied by oak trees are now dominated by overstory Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) which has regenerated in the absence of frequent fires formerly set by Native Americans (Agee 1996; Dunn 1998). Due to the species' greater maximum size and rate of growth, Douglas-fir has overtopped and suppressed the shade-intolerant oak in many areas, and without management these overtopped oaks will not survive or regenerate. This decline has drawn attention throughout the region due to the uniqueness of the oak habitat in the landscape.

Fort Lewis Military Reservation, near Tacoma, Washington, contains many examples of oak woodlands and savannas that have been invaded by Douglas-fir. Aerial photos from the early 1940s through the 1990s show a dramatic expansion of Douglas-fir forests into areas once occupied by oak. The Forestry Program at Fort Lewis is making an effort to preserve oak trees on the Military Reservation through several practices including the operation of their timber sale program. Douglas-fir trees that overtop and shade oaks are often selected for removal in a timber sale as part of periodic stand thinnings. During these harvests, loggers are directed to minimize damage to oaks.

Scientists of the USDA Forest Service Pacific Northwest Research Station, in cooperation with the Fort Lewis Forestry Program, initiated a study to examine the

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effects of releasing Garry oak from overtopping conifers (Harrington and Kern 2002). Our objective was to evaluate how oaks respond to three levels of release. Specific responses addressed in this preliminary summary include acorn production, epicormic branching, and growth of natural oak regeneration in the vicinity of the released trees.

In a separate study, we are researching techniques for establishing oaks on sites where they currently do not exist or where natural regeneration is insufficient. Here we summarize preliminary results from six trials in which we are monitoring seedlings planted under various treatment combinations in Washington. Our objective was to determine which establishment treatments increase the growth and survival of planted Garry oaks.

Methods

Oak Release Study

Study Sites. The study is located on the Fort Lewis Military Reservation, south of Tacoma, WA. Study trees are distributed among four sites (Cherry Hill, Goodacre, Lake Joseph, and Sneesby) all of which are characterized by soils formed in deposits of the Vashon Glaciation (Kruckeberg 1991). Soils are of the Spanaway, Everett, and Nisqually series and are somewhat excessively drained. The Spanaway and Everett series consist of a gravelly to very gravelly sandy loam surface layer underlain by a very gravelly to extremely gravelly sandy loam layer. The Nisqually series is a loamy fine sand (Pringle 1990). Mean annual precipitation (measured in Tacoma) is 995 mm, but an average of only 158 mm occurs from May 1 through September 30. During 2001, 2002, and 2003, May-September precipitation was 213, 85, and 51 mm, respectively.

Prior to treatment, the overstory at the four study sites consisted of Douglas-fir (111 to 215 trees ha^{-1}), and the midstory was occupied by Garry oak (57 to 192 trees ha^{-1}). Douglas-fir on all four sites were typically 65-90 years old, and most oaks were 90-150 years old. While the oaks in this study averaged 16.0 m in height (range was 8.4 to 21.8 m), the average height of the two largest Douglas-fir near each study oak was 40.6 m (Figure 1). The four stands in this study had been operationally thinned 10-15 years prior to the study, and again during the year prior to application of our release treatments.

The most common shrubs present in the understory at the time of treatment were snowberry (*Symphoricarpos albus*), beaked hazelnut (*Corylus cornuta* var. *californica*), tall Oregon grape (*Berberis aquifolium*), and trailing blackberry (*Rubus ursinus*). Common herbaceous vegetation included swordfern (*Polystichum munitum*), long-stoloned sedge (*Carex inops*), and cleavers (*Galium aparine*). Since a goal of this project is restoration of native plant communities, all Scots broom (*Cytisus scoparius*) was cut or pulled from the vicinity of study trees after treatment implementation.

Figure 1. A study oak (dark, moss-covered stem in center of photo) overtopped by larger Douglas-fir.

Design and Treatments. At each of the four sites, 18 oaks were selected for this study. Trees were >20 cm in diameter at breast height and represented a variety of sizes and conditions ranging from partially to severely overtopped. We created a circular study plot centered around each of the 72 oaks with a radius equal to the height of the oak at the time the study was established. Although the study is focused on responses on the 72 study oaks, most of the plots contained other oaks as well which we are also monitoring.

We tested three release treatments, each of which was replicated six times per site. The three treatments were designated "full release," "half release," and "control." In the full-release treatment, all Douglas-fir (≥10.0 cm diameter) were removed from the circular study plot (Figure 2). In the half-release treatment, all Douglas-fir (≥10.0 cm diameter) within a radius of one half of the study oak's height (i.e., 50% of the treatment plot radius) were removed. The control treatment did not remove any trees to specifically release the study oak, but a small number of Douglas-fir in the vicinity of the control trees were removed in the operational thinning that took place prior to study installation. On plots receiving the half-release treatment, this thinning removed occasional trees from the region between the half-height radius and the full-height radius. In both the pre-study operational thinning and study treatment implementation, trees were cut with chainsaws and yarded with skidders by contract loggers. Release treatments were implemented from March to May, 2001.

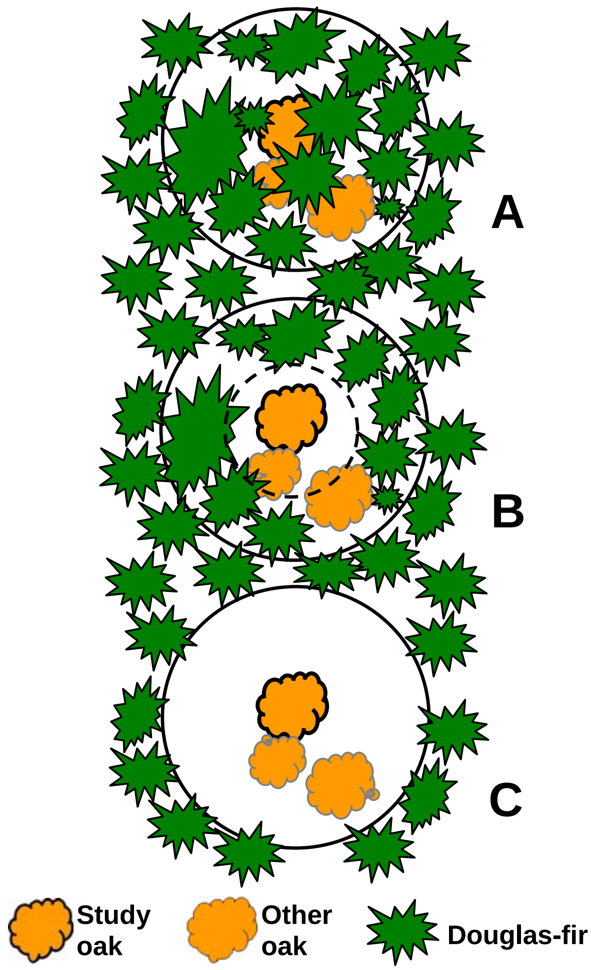

Figure 2. Examples of the post-treatment condition of the circular, oak-centered study plots in the control (A), half- (B), and full-release (C) treatments. The oak at the center of the plot is the designated study tree.

Data Collection. Acorn production of the study oaks was surveyed in September of 2003. The crown of each tree was viewed at multiple angles from the ground using binoculars. The surveyor scanned the crown of the tree until the first acorn was sighted. At that point a 60-second period began during which the surveyor tallied every mature acorn seen. Prior to data collection, the two observers verified the repeatability of this tally method on 24 oaks in a stand similar to the stands of this study.

In October 2002, we surveyed epicormic branches on all study trees. Through the formation of these new branches the oaks are beginning to rebuild their crowns after years of gradual dieback. We recorded the total number of epicormic branches on each tree in two categories: pre-treatment and post-treatment. Epicormic branches originating from the tree's stem and first-order limbs below the live crown base were included in the survey.

In October 2002, we measured the current year's annual height growth increment for 289 naturally regenerated oaks and 166 naturally regenerated Douglas-fir ≤1.5 m in height that were present in the study plots prior to treatment.

Oak Outplanting Trials

We are currently monitoring six outplanting trials that we established between 2001 and 2004 at Fort Lewis Military Reservation (Pierce Co., WA), Glacial Heritage Preserve (Thurston Co., WA), and near the town of BZ Corner in Klickitat Co., WA. Plantings at each site consist of 40 to 100 seedlings (Figure 3). Planting stock was one- and two-year-old *Quercus garryana* grown in a 1:1:1 peat:perlite:vermiculite mixture in 10-cm square x 35-cm-deep tree pots.

Figure 3. Establishing a Garry oak outplanting trial. Rocks extracted during planting provided additional anchoring of the plastic mulch.

In these outplanting trials we are testing various combinations of competition (herbaceous vegetation) control, browse protection, and fertilization. Competition control treatments consist of 0.91- and 1.22-m-square perforated plastic mulch (Brush Blankets®, Arbortec Industries, Mission, BC, Canada), manual removal of all vegetation around each seedling to 30- and 60-cm radii, and no weed control. Browse protection treatments are 0.1-m diameter x 1.0-m high solid tree shelters (Tubex Limited, Aberaman, South Wales, UK), wire mesh cylinders 0.3 m diameter x 1.2 m high, and 0.91-m tall plastic mesh cylinders. Solid tree shelters are supported with bamboo or wooden stakes and mesh cylinders are supported with bamboo stakes or steel fence posts. We used 14 grams of slow-release Osmocote Plus (Scotts-Sierra Horticultural Products Co., Marysville, OH), containing a 15-9-12 N-P-K mix plus micronutrients as the fertilization treatment. Fertilizer was placed in the bottom of the hole at planting, with a layer of soil 3-5 cm deep between the fertilizer and the seedling roots.

Height, stem diameter (at 3 cm above root collar), survival, and seedling condition were recorded at planting and after each subsequent growing season.

Results and Discussion

Oak Release Study

Release Treatments. Release treatments were implemented with little damage to the study oaks. Few trees had broken limbs and only two of the oaks had bark scraped from the bole. The contract loggers were aware that the objective of the harvest was to preserve the oaks and were able to skillfully remove the Douglas-fir from around the study trees with minimal damage.

The average numbers of Douglas-fir removed per study plot were 15, 6, and 2, for the full-release, half-release, and control treatments, respectively (Figure 4). During the three years after release (2001-2003), no mortality or windthrow has been observed among the study trees.

Acorn Production. We observed a greater number of acorns per tree in the full-release treatment than in the half-release or the control treatments at all four sites in 2003 (Figure 5). A similar trend was observed among the study oaks in 2002 (data not shown). In 2001, the first growing season after release, there was no apparent difference in acorn production among the three treatments. The increase in acorn production following release is expected since crown competition is negatively related to acorn production in Garry oak (Peter and Harrington 2002); however, the fact that this response is occurring so soon after release was unanticipated. It is apparent that the capacity for seed production is not eliminated in trees that have been in an overtopped condition for many years. The dramatic increase in resources (sunlight and presumably soil water) following release was sufficient to increase acorn production in the second and third years after release.

The generally low acorn production that we observed was likely due to the effects of Douglas-fir competition. Nearby oaks that were predominantly open-grown averaged 9.6 acorns/tree in 2003 (David Peter, personal communication, 2004). The low acorn production also may have been due in part to low growing-season precipitation in 2003 (32% of average). The relatively higher acorn production at Goodacre may have been due to the fact that the oaks at that site had, on average, slightly larger crowns than the oaks at the other sites prior to the initiation of this study. The larger crowns are the result of less dieback, likely due to somewhat less Douglas-fir competition than at the other sites.

Figure 4. A recently released study oak (center of photo) that received the full-release treatment. Several nearby oaks also benefited from the release.

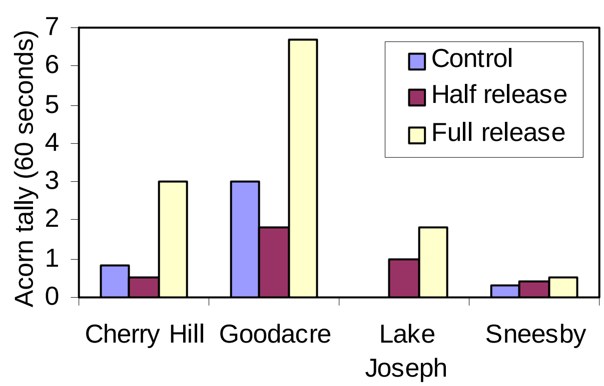

Figure 5. Acorn production (60-second tally) for three release treatments on four sites.

Epicormic Branching. The study trees exhibited a large number of older epicormic branches that were present prior to treatment implementation. These branches likely formed in response to previous stand thinnings.

At the end of the 2002 growing season, none of the trees receiving the control treatment had formed new epicormic branches (Figure 6). While some of the trees in the half-release treatment had new epicormic branches, combined data from all sites showed that the greatest percentage of oaks with new epicormic branches were those in the full-release treatment.

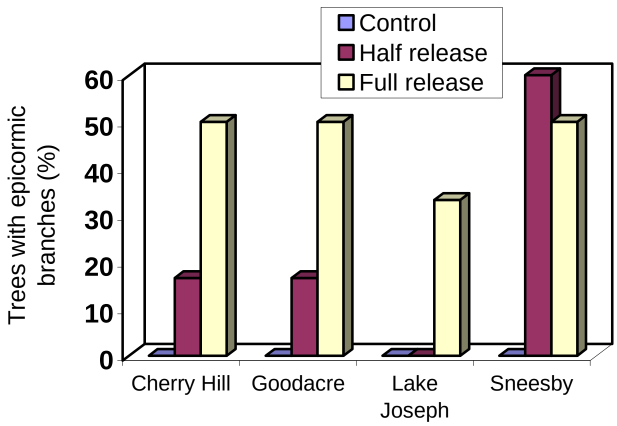

Figure 6. Percentage of trees with epicormic branches two growing seasons after release treatments.

This post-release epicormic branching indicates that the trees are beginning to respond to release through the formation of new branches that are effectively increasing crown size (Figure 7). Because many of the oaks in this study have very small crowns following decades of shading and dieback, the formation of additional branches is an important step in increasing the trees' photosynthetic capacity. Observations of other oaks at our study sites suggest that while some of the epicormic branches that form initially may die in subsequent years, others will persist and become important components of trees' crowns. Dale and Sonderman (1984) observed *Quercus alba* with 16-year-old epicormic shoots that had developed into small limbs.

The epicormic response of the half-release treatment showed less consistency among sites than that of the full-release treatment. This may have been due to the fact that the half release provided a smaller canopy gap than the full release; thus, the amount of light in the half release was variable and influenced by factors such as aspect and the density of the Douglas-fir immediately beyond the release radius. For example, half-release trees at Sneesby that were growing on a south-facing slope formed many epicormic branches.

Natural regeneration. Oak regeneration (≤1.5 m tall) that had naturally established prior to treatment had greater height growth on the full- and half-release treatment plots than on control plots in the second year after release (Figure 8). Douglas-fir regeneration (≤1.5 m tall) growing on full-release plots had greater height growth than that on half-release and control plots. However, the magnitude of Douglas-fir growth under full release exceeded that of oak under the same treatment. Although height growth for both species was relatively small, the Douglas-fir is growing at a faster rate than the oak. Following full release, the growth advantage of Douglas-fir is increased. Thus, control of understory Douglas-fir, in addition to that in the overstory, would be necessary to prevent future oak suppression and a return to the pre-release forest condition.

Figure 7. A new epicormic branch that formed after release (above), and numerous post-release epicormic branches on the stems of oaks in a full-release plot (below).

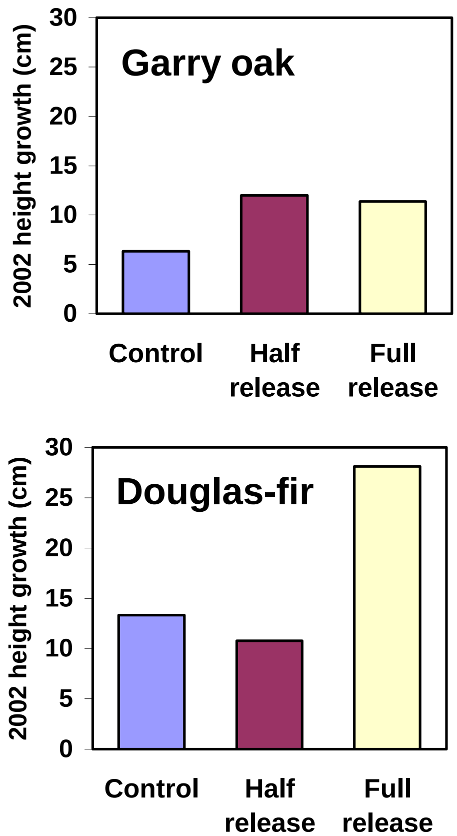

Figure 8. Height growth of natural oak and Douglas-fir regeneration (≤1.5 m in height) in the second growing season after three release treatments were applied.

The Future of Oak Release. These preliminary findings suggest that release will result in positive changes for overtopped oaks. Increased acorn production will benefit many wildlife species that feed upon seeds and will promote the natural regeneration of oaks. Formation of new branches on the study trees and the increased growth of understory oaks indicates that release has increased their vigor. Although it has been suggested elsewhere that suppressed oaks should be released slowly or incrementally, our data indicate that the oaks' response to full release was more favorable than the partial, or half release. There are other advantages of achieving a fully released condition in a single stand entry rather than multiple stand entries. The time spent preparing timber sales is reduced, as is soil disturbance and the number of opportunities for the introduction of seed from exotic plant species. Furthermore, partial releases remove a relatively small volume of merchantable timber, and thus, may be uneconomical.

We will continue to follow this study, and we have already documented a variety of other responses to release including tree diameter growth, air temperature, relative humidity, soil moisture, and the cover and composition of understory vegetation. We also have recently installed a sub-study examining the combination of fertilization and release that may provide an indication of whether added nutrients improve recovery of released trees.

Oak Outplanting Trial

First-year survival in our outplanting trials was generally high (>90%). Although height growth during the first year was often small (<10 cm), some individual seedlings grew more than 40 cm. Growing season precipitation was 58% of average in 2002 and 32% of average in 2003, and the growth of the oak seedlings in our outplantings was likely reduced by the droughty conditions.

From our early observations, it appears that while both solid and mesh shelters can be effective in preventing browse damage, solid tree shelters provide a superior environment for growth of Garry oak seedlings on glacial outwash soils. Solid tree shelters increased seedling height growth in all trials in which they were tested. Basal diameter growth did not differ between seedlings with solid shelters and those with mesh browse protection. During the second year after establishment, a significant number of the solid tree shelters that were supported by bamboo stakes fell over. This was likely due to a combination of wind and the fact that bamboo stakes could not be driven deep into the gravelly soil present at several of the sites. Bamboo stakes also had begun to rot and were not sufficient to hold the shelters upright for two years. In the future we will use metal or sturdy wooden stakes.

Thus far in our trials, we have not observed any differences in height or diameter growth among seedlings with plastic mulch, manually removed weeds, or no weed control. We also saw no increase in growth of fertilized seedlings in their first year. The lack of growing-season precipitation, in combination with the droughty soils, may have limited growth to the extent that treatment effects were not detectable. It is also possible that treatments are benefiting root growth and the effects on aboveground growth may appear in later years.

Both plastic mulch and manual vegetation removal eliminated most of the competing vegetation around seedlings during the first year (Figure 9), and soil analyses indicated that there was no difference in soil water content between the two treatments (data not shown). We observed that plastic mulch and vegetation removal treatments require follow-up maintenance. The plastic mulch remained generally intact two years after installation, but in some cases, significant amounts of herbaceous vegetation grew through the center opening around the seedling. In the future we will minimize the size of this opening by taping closed any unnecessary gaps during the installation process. Manual removal of vegetation is labor-intensive and the rate of vegetation

Figure 9. Effects of controlling competition with plastic mulch (above) and manual vegetation removal (below). Photos were taken in August after outplanting in January.

encroachment requires that it be repeated annually. However, vegetation removal is visually preferable to plastic mulch, and is sometimes used for this reason on sites where a more natural appearance is desirable. Similarly, mesh tree shelters, especially wire, are much less visible than the solid variety.

We are presently conducting a study on the effects of planting date on first-year root growth. This research was initiated to determine whether there is an advantage to planting oaks in late fall or winter rather than in the spring.

From our early observations, it appears that larger Garry oak seedlings will exhibit greater growth in the first years after outplanting. When available, we select seedlings ≥6 mm in basal diameter for our outplanting trials.

To expand our knowledge base of Garry oak establishment techniques, we have recently initiated a Garry oak regeneration survey. Individuals and agencies who are planting oak seedlings volunteer to participate in the survey by reporting to us their establishment practices and the type of site on which they are planting. Participants measure their seedlings annually and send us the growth data. Our objective is to compile and analyze data from a broad range of cultural treatments and sites. We will then drawn conclusions and make recommendations on the best techniques for establishing Garry oaks. Individuals and groups interested in participating in this survey may contact the authors for additional information or visit our website at http://www.fs.fed.us/pnw/olympia/silv/oak-studies/oak-planting.shtml.

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