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Enhancing Reforestation Success
in the Inland Northwest

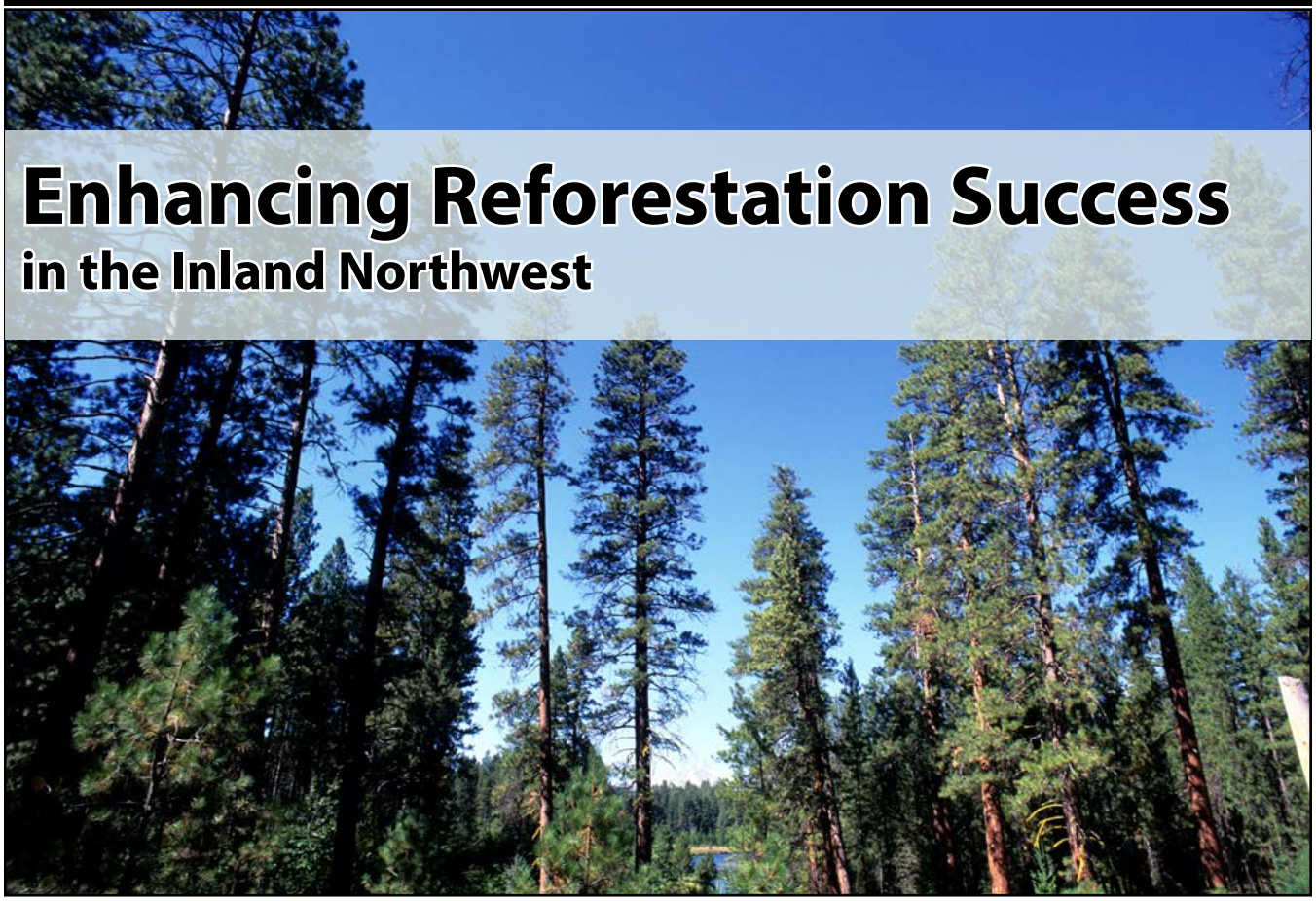

Photo by: Lynn Ketchum, © Oregon State University

P. Oester and S. Fitzgerald

This publication highlights vegetation management methods to improve conifer seedling survival and growth. It focuses on competition from grasses, shrubs, forbs, and small hardwood trees where seedlings are planted for reasons such as reforestation following harvest, interplanting, and field afforestation. The key to successful competition control is to identify the main problem plant species and its life cycle, and tailor your control strategy and timing to the target species. Table 1 (page 2) summarizes some common vegetation competitors in the Inland Northwest. See "Resources" (page 20) for more information on plant species and biology.

The vegetation control techniques discussed here include mechanical methods (such as tilling and mowing), hand-scalping, mulch mats, and the use of herbicides. These methods are used during site preparation and release. The purpose of site preparation is to improve reforestation success by modifying site conditions prior to planting. It involves using hand tools, fire treatments, herbicides, or machinery. Release is a treatment to free young trees from competing, usually overtopping vegetation and involves using manual brush removal, herbicides, and sometimes grazing.

Why control competing vegetation?

First, research throughout the Pacific Northwest and elsewhere provides strong evidence that grasses, forbs, shrubs, and hardwood trees compete aggressively with conifer seedlings for limited site resources. On drier sites

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Table 1. Common forest competitors in the Inland Northwest

Grasses, sedges, and forbs	Woody shrubs and small trees
pinegrass (*Calamagrostis rubescens*)	oceanspray (*Holodiscus discolor*)
elk sedge (*Carex geyeri*)	ninebark (*Physocarpus capitatus* or *P. malvaceus*),
Kentucky bluegrass (*Poa pratensis*)	snowberry (*Symphoricarpos albus*)
thistles (*Cirsium* spp. and *Carduus* spp.),	*Ceanothus* species (*Ceanothus* spp.), primarily snowbrush
knapweeds (*Centaurea* spp.)	bitterbrush (*Purshia tridentata*)
houndstongue (*Cynoglossum officinale*)	alder (*Alnus* spp.)
common mullein (*Verbascum thapsus*)	serviceberry (*Amelanchier alnifolia*)
St. John's wort (*Hypericum perforatum*)	hawthorn (*Crataegus douglasii*)
braken fern (*Pteridium aquilinum*)	maple (*Acer* spp.)
beargrass (*Xerophyllum tenax*)	willow (*Salix* spp.)
perennial and annual domestic grasses (*Dactylis glomerata*, *Bromus* spp., *Festuca* spp., *Agropyron* spp.)	rose (*Rosa* spp.)
	cherry (*Prunus* spp.)
	elderberry (*Sambucus cerulea*)

in Oregon, Washington, and Idaho, these competitors, especially grasses, deplete water supplies early in the growing season, aggravating already dry conditions and causing severe water stress in young trees. The competition can significantly reduce tree survival and growth rates.

Second, controlling competing vegetation improves seedling survival and lowers reforestation costs.

Third, controlling competing vegetation can accelerate tree growth, which shortens the time to crown closure. Rapid crown closure accelerates forest stand development, provides prompt riparian shading, increases timber production, reduces rotation lengths, and provides other forest values.

Fourth, dense grass provides good habitat for voles (meadow mice), which often girdle the base of and kill seedlings. Pocket gophers also can be a problem in grass environments. They feed on grass roots, but if trees are present, they feed on tree roots and can cause extensive seedling mortality.

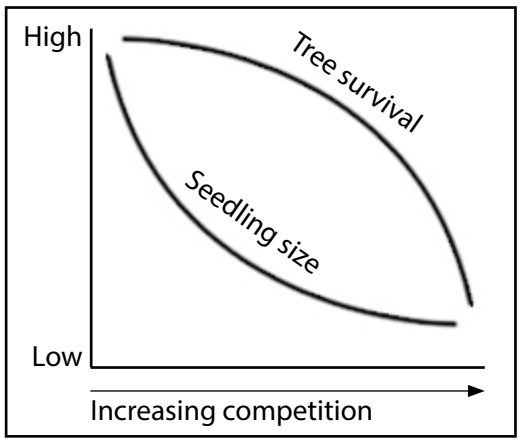

Figure 1. Competition's effect on seedling growth and survival

Finally, state forest practice regulations in Oregon, Washington, and Idaho require establishment of a minimum number of healthy, vigorous seedlings to meet reforestation standards after harvest. Managing competing vegetation early after planting can help you meet this legal obligation for the lowest overall cost.

Impact of competing vegetation

The impact of competing vegetation on seedling survival and growth is summarized in the competition threshold principle (Figure 1). It shows how relatively small reductions in competing vegetation translate into big improvements in seedling survival. Yet, when competition declines further, the survival rate tends to level off; any further reduction in competing vegetation will have less effect on improving survival. To get large increases in growth, competitors need to be reduced to below 30 percent. Competition must be reduced enough to get good survival and good growth. Otherwise, tree seedlings continue to die over time, and undesirable vegetation more fully occupies the site. As shown in Figure 1, even small increases in competition can result in large losses in growth. For westside Douglas-fir, this has been the case on even the best sites. If landowners and managers are interested primarily in good survival, then modest investments in controlling competition will meet this goal (e.g., applying large-spot treatments).

However, if maximizing growth is also an objective, then greater investments in competition control are necessary (e.g., applying full-site treatments). Seedlings set a course of growth early on and stay on that growth trajectory, which can be slow or fast depending on the competition intensity around them.

A case study: the first five years

Results of a study in the Blue Mountains of Oregon are an example of how the threshold principle (Figure 1) works. The study evaluated the effects of varying levels of grass control on the survival and growth of ponderosa pine seedlings. The results are depicted in Figures 2a–e.

Figure 2a. The complete treatment

Figure 2b. The standard treatment

Figure 2c. The large-spot treatment

Figure 2d. The small-spot treatment

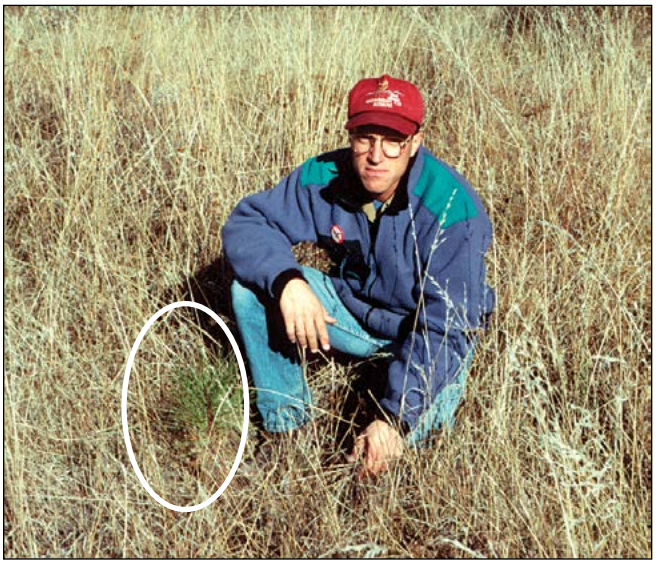

Figure 2e. No treatment (the control plot)

After planting ponderosa pine 2-0 stock (see "Common stock types" sidebar) in the spring of 1988, four different treatments of the herbicide hexazinone were applied with a backpack sprayer. The treatments were:

- Complete: Two consecutive and identical broadcast applications, the first in 1988 and the second in 1989
- Standard: A single broadcast application in 1988
- Large spot: A 5-foot-square area (25 square feet) around each tree
- Small spot: A 2-foot-square area (4 square feet) around each tree

A fifth plot of trees received no treatment and served as the control.

After 5 years, the survival rate of ponderosa pine seedlings given spot applications of herbicide more than doubled compared to those in the control plot. One or two broadcast applications increased survival an additional 30 percent over spot applications.

Differences in stem volume (a measure of seedling size and vigor) were impressive. After 5 years, spot applications allowed trees to grow three to four times larger than trees that received no treatment. Two broadcast applications, timed a year apart, yielded more than twice the stem volume of a single broadcast treatment and more than five times the stem volume of seedlings treated with spot applications.

Although the vegetation control treatments in this study initially cost more per acre than doing nothing, gains in seedling survival, growth, and quality (or vigor) offset the additional cost and translated into lower established-seedling costs (Table 2).

Established seedlings are those that survive through the end of the period, which in this study was 5 years. Established-seedling cost is the initial cost divided by the number of seedlings established at the end of the period. For example, for the small-spot application,

Common stock types

Growing method	Stock type	Total age (year)	Typical shoot height (inches) for Douglas-fir
Bareroot	2–0	2	10–12
	1+1	2	12–15
	2+1	3	18–24
Greenhouse	plug	1	8–12
Combination	plug+1	2	12–18

The first number in the stock type column refers to how many years the seedling spent in the seed bed. The second number is the number of years it was in the transplant bed. Thus, a 2+1 seedling is 3 years old, spent 2 years in a seed bed, and was lifted and placed in a transplant bed for one year.

Adapted from *Selecting and Buying Quality Seedlings*, EC 1196

Table 2. Cost per established seedling under five levels of grass control, based on survival of the excellent- and good-vigor ponderosa pine seedlings after the fifth growing season [a]

Treatment	Total cost per acre [b]	Established seedlings per acre [c]	Cost per seedling
Complete	$329	181	$ 1.82
Standard	$238	165	$1.44
Large spot (5 x 5 ft)	$197	118	$1.67
Small spot (2 x 2 ft)	$189	108	$1.75
No treatment (control)	$147	19	$7. 74

[a] After 5 years, surviving trees were rated for their vigor as excellent, good, or poor. The table uses the sum of the percentages of good and excellent seedlings given each treatment—complete, 95%; standard, 91%; large spot, 83%; small spot, 85%; and control, 34%. See Oester et al. (1995) for an explanation of vigor analysis.

[b] Cost assumptions:

- 300 trees per acre
- Ponderosa pine seedlings cost $235 per thousand.
- Planting costs are $0.25 per seedling.
- Hexazinone costs $58 per acre for broadcast applications (with a backpack sprayer), $10 per acre for large-spot applications, and $2 per acre for small-spot applications.
- Application costs range from $33 per acre for broadcast to $40 per acre for spot spraying.

[c] Established seedlings per acre = 300 x survival percentage x percentage in vigor class

the initial cost was $189 per acre and the number of established trees at the end of five years was 108. Thus, the established-seedling cost is $189 divided by 108, or $1.75 per tree. The standard treatment (one broadcast herbicide application) shows the lowest cost per established seedling ($1.44 per seedling), if we ignore the poor-vigor trees and consider only the excellent- and good-vigor trees in the analysis (Table 2, page 4). The complete treatment (two consecutive and identical broadcast applications in 1988 and 1989) was designed to illustrate the growth potential for ponderosa pine growing in a competition-free environment and was not intended as a typical or practical treatment option.

The vegetation control treatments in this comparison resulted in different sized trees (Figures 2a-e, page 3) with a different cost per seedling at the end of 5 years (Table 2, page 4). To get an idea of how treatment costs relate to growth, we can compare cost per unit of volume (Table 3). Controlling competition, in this case grass, may cost more initially, but the additional dollars spent result in greater increments of not only survival but growth. Each dollar invested in the spot sprays, for example, resulted in 13 to 19 times greater growth than no treatment. Another way to evaluate these treatment options is to look at the time it takes for trees to reach merchantable size. Reducing competition at planting time on dry sites in eastern Oregon resulted in a 5- to 12-year reduction in the time it takes trees to reach 8 inches diameter at breast height or DBH (Table 3) compared to doing nothing. Finally, another economic consideration is the additional replanting cost associated with poor survival. With no treatment, survival rate was low enough to trigger additional planting from a legal requirement (i.e., Forest Practices Act).

A case study: 20 years after planting

Work on this study has continued to determine 20-year trends. After 20 years, individual tree volume and volume per treatment area continued to diverge or widen over time (Figures 3 and 4). Survival between 5 and 20 years after planting decreased for all treatments at about the same rate, suggesting that differences in survival due to treatment effects were realized by the fifth year after planting. Mortality after year 5 was likely due to other variables such as rodent damage, soil depth, climatic influences, and cattle grazing. Initial

Table 3. Cost per cubic foot of wood produced per seedling at the end of 5 years and time (years) to merchantable log size (8 inches DBH)

Treatment	Dollars per cubic foot of wood	Years to 8" DBH
Complete	$63	20
Standard	$108	24
Large spot	$298	26
Small spot	$426	27
No treatment	$5,520[1]	32

[1]The cost is high in comparison to the other treatments because seedlings were much smaller with no treatment compared to other treatments (3 to 4 times smaller than the spot applications), and only 19 trees survived per acre making the cost per seedling $7.74 (Table 2, page 4). The combination escalates the cubic foot cost exponentially.

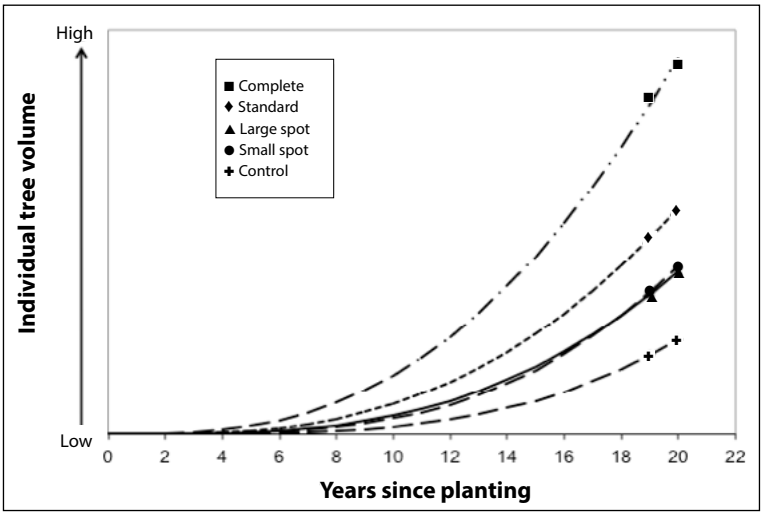

Figure 3. Changes in individual tree volume growth to age 20 by treatment

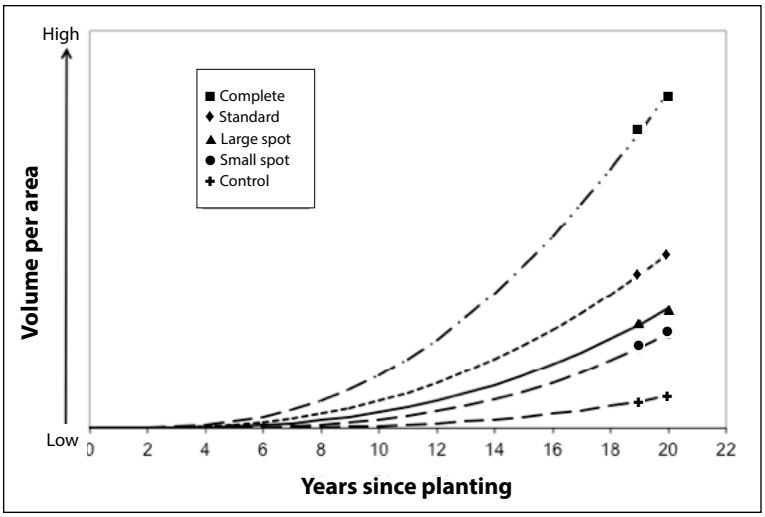

Figure 4. Changes in volume growth per treatment area (acre) to age 20 by treatment

control of competing vegetation increased the likelihood of seedling survival and increased tree size after 20 years.

Following vegetation control with different levels of competition, long-term growth trends can take one of two forms (Figure 3, page 5): Trees can have either parallel (e.g., spot treatment) or diverging (e.g., complete treatment) growth trends after initial treatment. Growth trajectories tend to become parallel after crown closure, when competition between trees intensifies. Although the growth trends in the study still appear to be diverging, full crown closure has not occurred, and for some of the treatments may never happen because of low survival and low tree density. Thus, volume per acre and tree quality in areas with no treatment and spot treatments will not equal that of the broadcast treatment area because of the large differences in survival. This study shows that controlling competition early provides for good survival and growth, keeps costs low, and sets seedlings up for advantageous growth trajectory.

Comparing vegetation management methods: mechanical, scalping, mulch mats, and herbicides

Mechanical methods

There are several mechanical options for reducing grasses and woody shrubs (Table 4, page 7), including using brush rakes or tilling to remove roots and reduce established vegetation. These methods, however, can expose mineral soil, which can be invaded quickly by seed blown in from surrounding areas and by germination of previously dormant seed already in the soil. Mechanical tilling in strips temporarily controls vegetation, and adding mulch mats or mulch materials delays vegetation recolonization (though it may create habitat for voles next to the tree). Other management methods to consider are mowing grasses or shrubs, and manually or mechanically slashing shrubs. Mowing grass and herbs alone is not effective in reducing moisture competition but may reduce vole problems, if mowing is close to the ground and frequent.

Considerations when using mechanical methods

- Areas of exposed mineral soil are particularly vulnerable to unwanted vegetation growth from seeds already in the soil or blown in from other areas.
- Some methods must be repeated often.

Scalping

Hand or mechanical scalping immediately around the seedling is widely used to control grass competition at planting. Scalping can be effective on easy sites, where grasses are scattered or shallow-rooted. However, when heavier grass sod covers sites, especially in warm, dry areas, scalping becomes more labor intensive and expensive. Data on scalping effectiveness are scarce, but available information suggests that unless scalps are very large (at least 3 to 4 feet square), scalping does little to improve performance of new seedlings (Figure 5). The cost of a large scalp for a single tree can easily reach $1.25 or more. Scalping may also remove topsoil and nutrients immediately adjacent to the seedling.

Photo by: Steve Clements, © Oregon State University

Figure 5. The hoedad, hazel hoe, or Pulaski are good scalping tools. This figure shows workers using Pulaskis.

Photo by: Steve Clements, © Oregon State University

Figure 6. An effective scalp is at least 3 feet square and deep enough to remove competitors' roots.

Table 4. Comparison of site preparation methods for vegetation types
from A *Guide to Riparian Tree Planting in Southwest Oregon* (EM 8893)

Treatment	Effectiveness: duration*	Cost per acre per application[1]	Comments
Grasses and herbaceous vegetation			
Herbicides: applied with vehicle and boom spray or hose, or with backpack or hand sprayers	High: 1–2 years	$60–$170	• Can apply as a broadcast spray, or in strips or spots • Relatively inexpensive and easy to apply Note: Backpack applications are hard work. • Safe, if label directions are followed • May affect nontarget species • Restrictions apply in riparian areas. • Dead plant material temporarily protects soil and delays plant reinvasion from seed. • Trees have good survival and growth rates. • Some people have environmental concerns about herbicide use.
Mechanical: tilling	High: 2–4 months	$90–$185	• Plants germinating from seed rapidly reinvade exposed soil.
Mechanical: mowing	Low: 1–4 weeks	$45–$140	• Must be repeated often • Mowing does not stop moisture competition but may reduce rodent problems.
Manual: scalping and hoeing	Medium: 3–6 weeks	$115–$350	• Plants germinating from seed rapidly reinvade exposed soil.
Mulch mats	Medium–High: 1–2 years	$170–$900	• Must be well secured and lie flat on ground • Hard work and high maintenance effort • Can damage seedlings on steep slopes if mats slide or if wind lifts mats and they cover seedlings • May harbor rodents • Trees have good survival and growth rates if mats are installed properly.
Woody shrubs			
Herbicides: applied with vehicle and boom spray or hose, or with backpack or hand sprayer	High: 1–3 years	$60–$230	• Complete spray coverage is most effective. • Dead plant material provides temporary soil protection and delays plant reinvasion from seed.
Herbicides: cut-stem or basal bark treatment	High: 1–3 years	$50–$115	• Water-soluble formulations are applied to cut-stem surfaces. • Oil-soluble formulations are applied to bark. • Standing dead material provides shade; debris and leaf litter cover soil.
Mechanical: grubbing roots, raking	High: 1–2 years	$500–$900	• Plants germinating from seed rapidly reinvade exposed soil.
Mechanical: mowing	Low: 1–4 weeks	$80–$185	• Doesn't kill roots, which rapidly resprout • Must be repeated often
Manual: slashing	Low: 1–6 weeks	$345–$575	• Doesn't kill roots, which rapidly resprout • Must be repeated often
Manual: grubbing roots	High: 1–2 years	$1,150–$2,300	• Exposed soil is rapidly reinvaded by weeds germinating from seed.

*Effectiveness is the success in reducing competition for site resources. Duration is how long competition is significantly reduced.

[1]Costs updated to 2015, based on a combination of Consumer Price Index changes and discussions with local contractors and university economists.

Considerations when using scalping

- Scalping requires the proper tool. Shovels are poor scalping tools, but hoedads, hazel hoes, or Pulaskis work well (Figure 5, page 6). Mechanical scalping with equipment, such as a dozer blade or something an owner builds to fit on a tractor, can also work well and cost less than manual labor.
- To be effective, scalps need to be at least 3 feet square or larger, and grass roots must be removed (Figure 6, page 6).
- Scalping becomes very expensive if sod is heavy.
- Manual grubbing of roots to remove shrubs is possible, but expensive.
- Plants reinvade the exposed mineral soil in the scalped area more rapidly than areas treated with herbicides or plastic mats. These areas may require at least one retreatment within the first year or two.
- Using mulch mats or other mulch materials after scalping can prolong relief from competition from grasses.

Mulch mats

Mulch mats (Figure 7) are an alternative vegetation management method for landowners concerned about using herbicides or in areas where herbicides are restricted (e.g., areas adjacent to streams, wetlands, and lakes). The key characteristics for four types of available mulch mats are summarized in Table 5 (page 9).

Black plastic sheets, newspaper, straw, and wood shavings are less expensive than mulch mats and do a good job of controlling competing vegetation. However, these materials tend to be less resistant to wind and break down more rapidly. Some materials (particularly straw) may harbor seeds, and others (wood shavings and straw) are more difficult to put down.

Mulch mats must be installed properly to perform well. The corners have to be weighted well or staked, and the hole for the tree has to be small enough to prevent vegetation growth from protruding (Figure 8).

Considerations when using mats

- Mats are useful in riparian or wetland areas where herbicides are restricted.
- Due to the expense (both of material and labor), purchase a mat that will last at least 2 years.
- Purchase cost should not be the only criterion for selecting mats. Installation and maintenance costs, and durability are also important.
- Select sites without large rocks or woody debris, for easy installation.
- Mats work well for low grass and forb control, but shrubs and large, mature bunch grass make them difficult or impossible to install.
- Rocky soils limit use of wire staples to hold mats down. In these conditions, use woody debris and rocks for weight. If using rocks as weights, keep them away from seedling root collar because they absorb heat and can cause tree tissue damage.
- Mats may blow loose on windy, exposed ridges, potentially damaging seedlings and requiring more maintenance.

Figure 7. Mulch mats are an option for managers concerned about using herbicides or in areas next to streams or lakes, where herbicides are not allowed.

Figure 8. Mulch mats must be properly installed to function well. Corners must be staked or weighted, and the center opening must be small enough to keep plants from growing around the seedling. Note: The opening in this mat is too large.

Table 5. Mulch mat characteristics

Mat type	Approx. cost [a]	Application time	Comments	Total cost per seedling [b]
PAK ground cover	$1.75	1–1.5 min/mat	Heavyweight woven fabric; durable; holds up well (lasts 2 years or more)	$3.08
Arbotech (4'X4')	$1.76	1-1.5 min/mat	Light polyethylene sheet; durable; lasts 1–2 years	$3.09
Vispore	$0.95	1-1.5 min/mat	Light porous material; easy to handle and lay out; rips easily; lasts 1–2 years	$2.28
Kraft asphalt laminated	$0.70	Less than 1-1.5 min/mat	Heavy asphalt or kraft paper; easy to install; breaks down quickly; pulls up easily in wind; lasts 1 year at most	$2.03

[a] Mat size is 3 square feet, unless otherwise specified. Includes cost of ground staples: five per mat @ 5¢ per staple = 25¢. Larger mats are more expensive. There is cost savings for buying in larger quantities. No labor cost is included.

[b] Total cost including mat installation and maintenance, assuming: $26 per hour labor (including worker compensation and benefits); 10 hours to install 300 mats; and 1 to 3 years of maintenance at 22¢ per tree per year.

- Minimum mat size is 3 feet square (9 square feet); however, 4 feet square (16 square feet) or larger is recommended for drought-prone sites.
- Watch for signs of rodents under the mat; they can damage seedlings.
- Avoid using black mats on hot, dry, south and southwest exposures.
- Mats may slide on steep slopes and damage seedlings.
- If installation areas are close to roads, labor cost for carrying materials is minimized.

Herbicides

Herbicides can be applied after harvest, but before seedlings are planted, to reduce initial vegetative competition and prepare the site. Herbicides can also be applied a year or two after planting to release seedlings from competing vegetation that may have reinvaded since the time of site preparation and planting. Seedlings should be fully dormant when conducting a release spray over them. Generally, herbicides are less expensive compared to most other management options and have the advantage of leaving topsoil and organic matter in place.

Hexazinone, atrazine, glyphosate, imazapyr, 2,4-D, metsulfuron, clopyralid, and sulfometuron are common herbicides used to control grasses, forbs, shrubs, and undesired trees for reforestation in the Inland Northwest. Triclopyr, fluroxypyr, picloram, and aminopyralid are also available for controlling a variety of vegetation types. For a more in-depth review of herbicides, including target species controlled, application timing, carrier options (water or oil-based), application rates, and herbicide combinations see the *PNW Weed Management Handbook* (listed in "Resources," page 20). For information on products, labels, and registration go to:

- Agrian label lookup (http://www.agrian.com/home/label-lookup/overview)
- Pesticide Information Center Online (http://cru66.cahe.wsu.edu/LabelTolerance.html)

Herbicides can be used alone or sometimes in combinations. For example, depending on your objective, 2,4-D products are relatively inexpensive and work very well to control broadleaf plants; however, some are restricted-use. In some cases, 2,4-D in a mixture with glyphosate, hexazinone, or sulfometuron can be effective as a site preparation treatment on grass, forbs, and shrubs. Basic herbicide options are summarized in Table 6 (page 11).

Herbicides are applied in a variety of ways. Water-carrier formulations such as liquids, dry flowables, and dispersible granules are applied using aerial equipment (e.g., helicopter) or ground equipment (e.g., backpack

Figure 9. Backpack sprayers, for spot sprays or broadcast applications, are an effective, cost-effective way to apply water-based herbicides. Sites with gentle terrain and little slash or other obstacles are good candidates for this method.

Figure 10. A good target for spot vegetation control with a backpack sprayer is a 4- or 5-foot square around the seedling.

sprayers, all-terrain vehicles with spray tanks). For ground treatments, particularly spot sprays with backpack sprayers, a dye can be added to identify spray location.

Productivity with a backpack sprayer is about 3 to 5 acres per day using spot spray or broadcast techniques. A backpack sprayer is appropriate for sites on gentle terrain with little slash or other obstacles (Figure 9). A reasonable target size for spot applications with a backpack sprayer is a 4- to 5-foot square around the seedling (Figure 10).

To improve consistency in spot applications, use a device that meters out a precise spray volume. The MeterJet, which attaches to the wand on a backpack sprayer, reduces calibration inconsistencies and helps prevent over or under application of herbicides.

Aerial applications usually are too expensive for small acreages. However, owners of adjacent parcels who combine their vegetation control projects can reduce costs significantly by spreading the fixed costs over more acres.

Considerations when using herbicides

- Applying herbicides at the proper rate is essential. Over or under application of herbicides can result in poor vegetation control, tree damage, or tree death.
- Some conifers are more susceptible than others to herbicide damage. For example, ponderosa pine is prone to injury from triclopyr, 2,4-D, imazapyr, and sulfometuron. Larch is prone to injury from hexazinone, 2,4-D, triclopyr, and glyphosate.
- Site preparation and release herbicide treatments are different. Releasing conifers from competing vegetation requires careful attention to herbicide selection, timing (usually when conifers are dormant), and application rates. Site preparation options are more flexible (because the seedlings have not been planted yet) but also require careful attention to aligning the herbicide with the combination of target vegetation, the target vegetation's season of vulnerability, and application rates. In addition, if soil-active herbicides are used, there can be a risk of seedling damage. Some tree species are more susceptible than others, and delaying planting after application to avoid seedling injury needs to be factored into decisions.
- Some typical site preparation herbicides include Atrazine 90 or Atrazine 4L, Accord XRT II (glyphosate with a wetting agent/surfactant), Chopper Gen2/Polaris SP (imazapyr), Escort XP (metsulfuron), Garlon 4 (triclopyr), Oust XP (sulfometuron), Oust Extra (sulfometuron and metsulfuron), 2,4-D, and combinations of these. Some of these herbicides can also be used for release, but rates, formulations, and timing will be different.
- Herbicides can be either foliar or soil-active or both (see Table 6, page 11).

Table 6. Common forestry herbicides for controlling competing grasses, forbs, and shrubs in the Inland Northwest

Active ingredient	Some product(s)	Action in plant	Forestry use SP=site preparation R= release	Application time	Mode of action
atrazine	Atrazine 90, Atrazine 4L	Inhibits photosynthesis	Selective herbicide: grasses and forbs SP or R	Late summer, fall, winter, and early spring	Root uptake; some foliar activity
aminopyralid	Milestone VM Plus	Growth regulator	Selective herbicide: broadleaf weeds (e.g., knapweeds, sulfur cinquefoil) and competing hardwoods SP, directed release, stump treatment, tree injection	Summer to early fall	Absorbed primarily through foliage; some soil activity
clopyralid	Transline	Mimics plant hormones	Highly translocated, selective herbicide: thistles and knapweeds SP or R	Summer to early fall	Absorbed primarily through foliage; some soil activity
fluroxypyr	Vista XRT	Mimics natural plant hormones	Selective herbicide: many annual and perennial broadleaf plants SP or R	Spring and summer, when plants are actively growing	Absorbed primarily through foliage
glyphosate	Accord XRT II, Rodeo	Inhibits amino acids protein synthesis	Nonselective, translocated herbicide: grasses, forbs and shrubs SP or R Also, tree injection/stump treatment on hardwoods	Spring, summer, or fall	Absorbed through foliage
hexazinone	Velpar L, Velpar DF, Velossa	Inhibits photosynthesis	Selective herbicide: grasses, forbs, small shrubs SP or R Caution: Some conifer species (e.g., larch, redcedar, and white pines) are sensitive.	Spring or fall	Root activity; some absorption through foliage
imazapyr	Arsenal AC, Chopper Gen 2, Polaris AC or SP	Enzyme inhibitor used in amino acid synthesis	Nonselective herbicide (applied pre- or post-emergence): grasses, forbs, some shrubs SP or directed release Also, tree injection/stump treatment on hardwoods	Spring, summer, or fall	Readily absorbed through foliage and roots
metsulfuron	Escort XP	Enzyme interference	Selective, post-emergence herbicide used at low rates for broadleaf plants and shrub control; good bracken fern control SP only	Spring or summer	Primarily root activity
picloram	Tordon 101, Tordon K	Mimics plant hormones	Selective herbicide: shrubs and small trees SP only	Spring, summer, and fall	Foliage and root uptake; persistent
sulfometuron	Oust XP	Enzyme interference; stops cell division	Broad spectrum herbicide for pre- or post-emergence: grasses, forbs and some small shrubs SP or R	Spring or fall (best)	Root uptake; some absorption through foliage

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Table 6. Common forestry herbicides for controlling competing grasses, forbs, and shrubs in the Inland Northwest (cont'd)

Active ingredient	Some product(s)	Action in plant	Forestry use SP=site preparation R= release	Application time	Mode of action
triclopyr	Garlon 3A (amine formulation), Garlon 4 (ester formulation)	Mimics plant hormones	Selective herbicide, controls woody and broadleaf perennial plants; grasses not affected SP or R Caution: Some conifer species (e.g., ponderosa pine and larch) are sensitive. Amine formulation for stem injections/ stump treatments on hardwoods Also, basal bark with ester formulation	Spring, summer, and fall	Absorbed through foliage and bark
2,4-D	Many amine and ester formulations	Mimics natural plant hormones	Selective herbicide: many annual and perennial broadleaf plants SP or R Caution: Some conifer species (e.g., ponderosa pine and larch) are sensitive. Tree injection/stump treatments with amine formulation	Spring and summer, when plants are actively growing	Absorbed primarily through foliage
aminopyralid and metsufuron	Opensight	Growth regulator and enzyme interference	Selective post emergence herbicide for broadleaf weeds and shrub control SP only	Summer and fall	Absorbed through foliage and soil/root activity
sulfometuron and metsulfuron	Oust Extra	Enzyme interference; stops cell division	Broad spectrum herbicide SP	Spring or fall	Root uptake; some foliage absorption
triclopyr amine and aminopyralid	Capstone	Mimics plant hormones and growth regulator	Controls woody and broadleaf plants and selected weed species such as knapweeds; grasses not affected SP Directed sprays and trunk injection/ stump applications	Summer and fall	Absorbed through foliage and bark
picloram and 2,4-D	Pathway	Mimics plant hormones	Selective herbicide: shrubs, small trees, and annual and perennial broadleaf plants SP or R (trunk injections/cut stump)	Spring and summer, when plants are actively growing, except for trunk injections and cut-stump applications, which should be done in summer and fall	Foliage and root uptake; persistent
hexazinone and sulfometuron	Westar	Inhibits photosynthesis and enzyme interference; stops cell division	Broad spectrum herbicide for pre- or post-emergence: grasses, forbs, and some small shrubs SP or R, depending on conifer species (some species are sensitive to damage)	Spring or fall	Soil active herbicides; some absorption through foliage

They can also be absorbed through bark or used as hack-and-squirt or stump treatments. Accord XRT II/Rodeo, 2,4-D, Garlon, and Transline are absorbed through the foliage, whereas atrazine, Oust, and Velpar are soil-active and require rain to move the herbicide into the root zone of the vegetation.

- Companies frequently change product names and formulations. Be sure to check labels carefully for information on target species controlled, application rates, and timing.

Commonly used herbicides

Atrazine controls annual grasses and some forbs, and is best suited for sites recently harvested or scarified (mechanical removal of competing vegetation and debris resulting in soil disturbance). Atrazine 90 and Atrazine 4L are products typically used on forest sites. Atrazine is a soil-active herbicide and needs adequate rain (more than hexazinone or sulfometuron) to move the product into the grasses' root zone. Although atrazine is relatively inexpensive, its use in the Inland Northwest has been limited by availability (most atrazine products are restricted-use and a private pesticide applicator's license is required to buy and use them), a narrower spectrum of susceptible plant species, and a shorter duration of control, compared to other choices. Atrazine is typically applied in late summer or fall for site preparation or release in the Inland Northwest. It is becoming more difficult to buy, and its future availability is uncertain.

Chopper Gen 2 and **Polaris SP** are two formulations of imazapyr with an oil carrier that are used for site preparation or as a directed spray, primarily in late summer or fall. For release or directed sprays, use products such as Arsenal AC or Polaris AC that have a water carrier and are safer around conifers. Imazapyr provides good control of a variety of forbs, grasses, and evergreen and deciduous brush. Imazapyr in a water carrier also works well for hack-and-squirt or cut-stump treatments.

Metsulfuron (**Escort XP**) is soil-active and is used for site preparation control of blackberries (*Rubus* species), ferns, snowberry, and deciduous shrubs. It can harm conifers if applied directly over seedlings. Until more is known about residue breakdown, this herbicide should be considered safe for sites prepared for planting only in moderately high rainfall areas and when trees are planted at least 6 months after treatment. Metsulfuron does not control thistles, so adding clopyralid or 2,4-D may be needed. This herbicide is very effective on brush species in the Inland Northwest and can be used effectively with directed application by hand.

Use herbicides safely!

- Wear protective clothing and safety devices as recommended on the label. Bathe or shower after each use.
- Read the pesticide label—even if you've used the pesticide before. Follow closely the instructions on the label (and any other directions you have).
- Be cautious when you apply pesticides. Know your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide use.

Picloram (**Tordon K, Tordon 101**) is typically used only for site preparation because it can harm conifers if applied directly over them. It has soil residual effects, so caution is necessary when planting conifers following application. Pathway (picloram and 2,4-D) is commonly used for trunk injections and cut-stump treatment. Picloram is a restricted-use herbicide. There are also restrictions on grazing treated areas. Recently, this herbicide has shown limited use.

A combination of **aminopyralid** and **triclopyr amine** (**Capstone**) has a forestry label for use in site preparation, directed spray, and cut-surface applications, and controls broadleaf weeds (e.g., knapweeds) and competing hardwoods. For site preparation only, aminopyralid and metsulfuron (Opensight) have special local needs labeling in Oregon, Washington, and Idaho. Another option is Milestone VM Plus (Aminopyralid) for site preparation, directed release, cut stump, and tree injection. Aminopyralid has some soil activity, so use caution around conifers present on the application site.

Clopyralid (**Transline**) is particularly effective on elderberry, thistles, knapweeds, and other composite and leguminous weeds during active growth. Transline can burn larch when it is newly flushing in the spring. Otherwise, this herbicide can be applied over actively growing conifers. Transline is often mixed with Oust XP (applied over dormant conifers) for more complete control of grasses and forbs.

Westar herbicide is a dispersible granule that is mixed with water and is absorbed through roots

and foliage. It is a combination of hexazinone and sulfometuron, and is recommended to control or suppress many broadleaf plants and grasses in forestry sites. It can be applied prior to planting or over the top of dormant seedlings. Precautions mentioned for hexazinone and sulformeturon apply to Westar. Read and follow all label directions.

Triclopyr has an ester and an amine formulation. Garlon 4 is the ester formulation and is registered for site preparation and release (over dormant trees). Garlon 3A is the amine formulation; it is non-volatile and is a good choice for blackberries and forbs, and as a hack-and-squirt treatment on competing trees. Garlon 4 is used for controlling blackberries, maple, willows, cherry, alder, wild rose, and evergreen brush such as ceanothus. It can be applied aerially by helicopter, as well as by ground-based backpack or boom sprayer. It is also effective when mixed with oil (e.g., diesel fuel, No. 1 or No. 2 fuel oil, kerosene, or a substitute, such as widely available crop oils) and used for basal applications (when herbicide is applied to the lower bole of a shrub or tree). Conifers generally have good tolerance to triclopyr as a release application, except for pine, larch, and noble fir, which are susceptible to injury.

Fluroxypyr (**Vista XRT**) is used occasionally and is registered for selective control of annual and perennial broadleaf weeds; it is also used for brush control in pine plantations and in other non-crop areas. For applications in pine plantations, take care to prevent over-the-top spraying during active terminal growth and try not to spray seedlings less than 4 years old. Directed-spray applications (when herbicide is directed away from seedling to control application and prevent injury) may be made during periods of active growth, but care should be taken to avoid spray contact, including drift, with actively growing foliage.

A typical site preparation technique on moist, mixed conifer sites in the Blue Mountains of Oregon is a combination of atrazine, Accord XRT II, and Polaris SP/Chopper Gen 2 in the late summer. Release treatments depend on the conifer species and competing vegetation. For example, if releasing pine or Douglas-fir in a grass-dominated area, then Velpar L or DF is used. In a similar situation, if larch is part of the species mix, then a

Table 7. Selected herbicide products, minimum container size, and cost per seedling and per acre

Product	Smallest container	Cost/ container (per gal, lb or oz)	Approximate cost/seedling (per acre) for large-spot or directed spray[1]	Cost per acre for broadcast[2]
Velpar L or DF	2.5 gal jug/4 lb bag	$240 ($96/gal)/$144 ($36/ lb)	$0.17-0.27 ($52–81)[3]	$121
Accord XRT II/Rodeo	2.5 gal jug	$65 ($26/gal)	$0.15–0.25 ($43.40–71.40)[4]	$35
Oust XP	3 lb jug	$336 ($7/oz)	$0.15–0.24 ($45–73)[5]	$53
Polaris SP	2.5 gal jug	$218 ($87/gal)	$0.14–0.24 ($42.40–72.40)[6]	$47
Garlon 4	2.5 gal jug	$243 ($97/gal)	$0.15–0.25 ($46–74)[7]	$74
Low Vol 6 (2,4-D)	2.5 gal jug	$75 ($30/gal)	$0.14–0.24 ($43–71)[8]	$33
Atrazine 4L	2.5 gal	$53 ($21/gal)	$0.15–0.24 ($44.30–73.30)[9]	$46
Escort XP	8 oz bottle	$120 ($15/oz)	$0.15–0.24 ($45.30–73.30)[10]	$55
Transline	0.5 gal jug	$108 ($215/gal)	$0.15–.24 ($44.20–72.20)[11]	$45
Oust XP + Transline	varies (see above)	varies (see above)	$0.16–0.25 ($47.30–75.30)	$98
Atrazine, Accord XRT II, Polaris SP	varies (see above)	varies (see above)	$0.16–0.25 ($47.40–75.40)	$128

[1]$26 per hour labor rate, 4 feet by 4 feet spot application (11% of an acre), 300 trees planted per acre, backpack sprayer treating 3-5 acres per day

[2]Same rates as spot or directed spray, $25 per acre for helicopter assuming large acreage (small acreage could be $30+ per acre)

[3]1 gallon per acre [4]2 quarts per acre directed spray or spot spray using seedling protection with stove pipe

[5] 4 ounces per acre [6] 1 quart per acre [7] 1.5 quarts per acre [8] 1 quart per acre [9] 4 quarts per acre [10] 2 ounces per acre [11]12 ounces per acre

combination of Oust XP and Transline is effective. Oust XP controls the grasses and Transline takes care of the forbs. Minimum container size and cost comparisons of selected herbicides are available in Table 7.

A closer look at three key herbicides: hexazione, glyphosate, and sulfometuron

Hexazinone

Hexazinone is a pre-emergent or soil-active herbicide for controlling grasses, forbs, and small shrubs. It is appropriate for site preparation or release treatments. This product is formulated to mix with water and apply as a liquid. A new product, Velossa, is more concentrated than Velpar L and does not have an ethanol carrier, so it is a little safer to use and easier to ship.

Rates

Use lower rates on coarsely textured soils (e.g., sandy or sandy loam) and on soils low in organic matter. Higher rates are appropriate on finely textured soils (e.g., clay loam) and on soils high in organic matter. In releasing pine, for example, most residual and ash soils in northeast Oregon require about 4 quarts or 2 pounds of active ingredient per acre of Velpar L or Velpar DF. These rates will do a good job of controlling harder-to-kill pinegrass, bluegrass, orchardgrass, and elk sedge.

Use higher rates for hard-to-kill vegetation (see label for specific rate recommendations) but remember to consider tree species' tolerance. For example, Douglas-fir is only moderately tolerant of hexazinone and cannot withstand the same rates as ponderosa pine. Overdosing may kill trees.

Timing

Results are best when grasses are less than 2 inches high and when at least 0.5 inch of rain falls within two weeks after application. The moisture is necessary to move the hexazinone into the soil.

Apply in the fall or spring. In the fall, apply when the soil is moist but not frozen. Then in the spring, plant seedlings in treated soil. When spot treating, remember to mark treated areas with wire flags, paint, or other devices so you can find the locations again in the spring. For spring applications, apply hexazinone soon after planting, while seedlings are dormant.

Application considerations

Applications can be made over the tops of dormant seedlings; be sure seedlings are not actively growing and buds are firm and tight. In first-year plantings, treat only transplant stock that is 2 years old (2-0, 1-1) or older, except bare root 1-0 ponderosa pine and Jeffrey pine (see "Common stock types" sidebar, page 4). Apply only if rain has settled soil around the seedling's base and root system to avoid applying herbicide directly to roots.

Hexazinone controls the following grasses and sedges: bluegrass, bromegrass, elk sedge, fescue, foxtail, orchard grass, pinegrass, and ryegrass. Hexazinone also controls shrubs and woody competitors, including ash, aspen, birch, ceanothus, chokecherry, dogwood, juniper, hawthorn, ninebark, poplars, spirea, sumac, wild cherry, and willows. Control is good if the shrubs or other woody vegetation are small, young plants. Add clopyralid (Transline) to control thistles and knapweeds in site preparation, or aminopyralid (Milestone VM Plus) to control selected invasive weeds such as knapweeds and sulfur cinquefoil.

Tree species most tolerant to hexazinone are ponderosa pine, Scotch pine, noble fir, Austrian pine, Jeffrey pine, lodgepole pine, grand fir, and white fir. Douglas-fir and Engelmann spruce are moderately tolerant. Tolerance is poor for western larch, western white pine (all five-needle pines), and western redcedar; do not use hexazinone for vegetation control around these species.

Be careful when spraying sites with more than one soil type. For example, in areas where coarse and fine soils intermingle, you need to adjust the application rate. If you cannot determine where soils change from one type to another, do not spray; use alternative vegetation controls instead.

Herbicide solubility varies with water temperature: It is 1 percent soluble at about 50°F and 3 percent soluble at 80°F. In cooling water, crystals can form and plug nozzles.

Poor control may result if:

- Heavy duff or slash covers the site
- Soils are poorly drained
- Soil is saturated with water, and rain falls within 24 hours
- Soils are high in organic matter (greater than 5 percent)

Trees can be injured if:

- Their vigor is poor
- Soils contain little organic matter
- Foliage is sprayed after budbreak
- Trees are growing in a depression, where hexazinone may concentrate

Injury can include needle loss and/or chlorotic, bottlebrushed, or twisted needles.

Glyphosate

Glyphosate (commonly known as Roundup) is a non-selective herbicide marketed for forest sites and labeled as Accord XRT II. Accord XRT II contains a surfactant, a material added to enhance spreading, wetting, and dispersibility to increase herbicide effectiveness. Rodeo is another glyphosate herbicide for forestry applications. Rodeo is a water-soluble liquid, has no surfactant added, and is generally used for early applications because it poses less potential damage to conifers in release treatments. Accord XRT II is used for applications later in the growing season. Glyphosate can be used to treat annual and perennial grasses, forbs, and many shrubs. The product is sprayed by backpack sprayer or helicopter.

Rates

For site preparation—broadcast or spot applications:

- Apply 1.5 to 3 quarts per acre in spring or summer.

For release—broadcast:

- In late summer or fall, apply 1 to 1.5 quarts per acre over dormant conifers. In spring, before budbreak, use 1 quart per acre. Volume of water can be the minimum shown on the label.
- Do not use a surfactant for release sprays. This makes Rodeo a good choice.
- Apply a release spray only over trees that have been established more than 1 year.
- Use directed spray (when herbicide is directed away from seedling to control application and prevent injury) with a backpack sprayer: 2 percent for woody shrubs and trees, and 1 to 2 percent for grasses, forbs, and sedges.

Timing

For grasses, control is best when target plants are actively growing in spring or fall. For some shrubs, results are best when glyphosate is sprayed in spring on actively growing plants. Late summer or early fall also can be excellent times to control shrubs such as ninebark and oceanspray. At that time of year, target plants are storing carbohydrates in their roots, and the absorbed herbicide "catches a ride" into the root system, more effectively controlling the plants. Late summer and early fall also are good times for a release spray because conifers have set their winter resting buds and are more resistant to herbicide damage. Spring release applications are trickier because some conifers are quite sensitive even when they appear dormant.

Application considerations

Apply as a sprinkle (adjust the nozzle for larger drops) on dry foliage. Use a sprinkler effect where you cannot reach or where brush is too tall. Spray when air is calm and temperature is cool to avoid drift and contact with green bark or non-woody surface roots.

Foliage of glyphosate-treated shrubs shows a normal yellowing and little evidence of control in the autumn after application. However, the following spring when growth begins, treated plants grow slowly or show distorted growth, called "littleleaf " because small bunches of distorted leaves form where shoots grow. Treated plants may display littleleaf for up to one season before finally dying.

Glyphosate is absorbed through foliage and translocates throughout the plant. Only sprayed plants are killed; new plants can reinvade by seed. Once the chemical comes in contact with soil, it is inactivated quickly. There are no long-lasting effects on the site.

In late summer and fall, glyphosate can be sprayed over Douglas-fir, grand fir, western redcedar, spruce, and pines; however, do not intentionally soak tree seedlings. Some conifers are more tolerant than others. Use lower rates for release applications over more sensitive species. Western redcedar, western hemlock, lodgepole pine, ponderosa pine, and western white pine are sensitive. Larch is also sensitive, and little information is available on its response to glyphosate. Therefore, use caution with release applications around larch, using directed sprays and applying only when trees are dormant. Douglas-fir has intermediate sensitivity, and true firs and spruce are the most tolerant.

Calibrate the sprayer carefully; a moderate overdose will injure trees. Mix glyphosate only with clean water. (Soil particles in dirty creek water deactivate the chemical.) Place the herbicide in the sprayer first, and then add the correct amount of water. This assures proper mixing.

Glyphosate can be used as a spot spray to control competing grasses and herbaceous plants. Cover seedlings with PVC or stovepipe to prevent spray contact. The normal treatment rate is a 2 percent solution: 2.5 ounces of herbicide per gallon of water. Standing on stumps and "raining" the chemical mix down works well, as does standing on the uphill side of the tree. Whatever the approach, it is still important to keep the pattern uniform over the area.

Remember: Low-volume coverage with moderately large drops is all that is necessary with glyphosate. If your application runs or drips off the foliage, you have applied more than enough for effective control. Five gallons of spray material per acre is adequate coverage.

Sulfometuron

This selective herbicide, sold under the trade or product name Oust XP, is a pre-emergent dispersible granule that mixes with water. It is very concentrated, allowing very low rates of application. Oust can be used for site preparation or release for Douglas-fir, ponderosa pine, grand fir, lodgepole pine, western white pine, spruce, and western larch. Observations in the Blue Mountains of Oregon indicate that newly planted Douglas-fir and ponderosa pine seedlings appear to exhibit slow growth for a few years when treated with sulfometuron. Western redcedar is also sensitive and may sustain minor to moderate injury.

Sulfometuron controls bluegrass, brome, crabgrass, fescue, dog fennel, ryegrass, fireweed, foxtail, goldenrod, horseweed, nutsedge, and witchgrass. Local observations are that at low rates this herbicide is not very effective on pinegrass and elk sedge. Fall applications for site preparation seem safest for trees. Adding hexazinone, 2,4-D, or clopyralid will help prevent thistles, which Oust does not control. Westar contains sulfometuron and hexazinone for more thorough control of competing grasses and forbs.

Rates

For site preparation:

- Apply 2 to 4 ounces per acre for Douglas-fir, grand fir, lodgepole pine, ponderosa pine, western larch, western white pine, and western redcedar.
- Add glyphosate, 2,4-D, Escort XP (Oust Extra has Oust and Escort), or Transline, as label directs, to Oust for added competition control.

For release:

- Apply 1.5 to 2.5 ounces per acre (label allows up to 4 ounces) over established dormant Douglas-fir, grand fir, lodgepole pine, western larch, western white pine, ponderosa pine, and western redcedar.

Carrier

- For ground applications, use 5 to 20 gallons of water per acre.
- For aerial applications (helicopter only, no fixed-wing aircraft), use 5 gallons of water per acre.

Timing

To prevent injuring or killing trees, avoid applications after budbreak in the spring and before the final resting bud has hardened in the fall. This product seems to be safest when applied in the fall. Both roots and foliage absorb sulfometuron. After 4 to 6 weeks, treated plants begin to die.

Application considerations

- Rain must fall after application to activate the herbicide in the soil.
- For best results, apply before or shortly after target vegetation emerges.
- Do not apply to frozen ground.
- Apply only after rain has settled the soil around the roots after transplanting.
- Take extreme care to prevent drift.
- Use extreme care when applying near water.
- After sulfometuron applications, use the spray tank only for non-crop applications.
- Use caution when applying over newly planted plug seedlings.

Calibrating herbicide applications

It is essential that herbicides be applied at the correct rates as well as at the right time. For information on how to calibrate a backpack sprayer, watch the *Calibrating and Using Backpack Sprayers* video (EM 9039), available through Oregon State University Extension Service publications at https://catalog.extension.oregonstate.edu/.

Controlling competing hardwood trees and shrubs using cutting, tree injection, and basal bark treatment

(Adapted from "Winter Weed Work," Ahrens, 2014)

Cutting, tree injection, and basal bark treatment are control methods used primarily on hardwood trees

(such as willow, black hawthorn, maple, and a variety of other hardwoods, depending on location) or on large shrubs (such as ninebark, ceanothus, and oceanspray).

Cutting only

Remove aboveground competing vegetation by cutting all the competing trees and brush down to the ground with chainsaws or brushcutters. Many landowners rely on repeated cutting as their primary brush control method. It is labor intensive but can succeed with diligence and repetition. Unfortunately, most competing trees and brush resprout vigorously, and cutting does little to reduce sprout vigor since many plants store energy reserves in their root systems. Cutting is often most effective in reducing sprout vigor when it is done in early summer, after plants have expended energy in spring shoot growth. To release conifers from brush competition and allow them to reach free-to-grow status, multiple cuttings repeated over several years may be needed.

Cutting plus treating stumps with herbicide

Treating cut stumps with appropriate water-based herbicides (amine formulations) is effective for killing root systems on most competing tree and brush species. This is not a good alternative for small-diameter shrubs or hardwoods because of the difficulty in finding and effectively treating small stems. The optimal season to do this work is usually summer or fall, but may vary depending on the herbicide and plant species. Imazapyr, triclopyr-amine, 2, 4-D amine (amine is the water-carrier formulation), and glyphosate are some of the more effective herbicides for treating cut stumps. Apply herbicide to the cambium/sapwood area of the stump.

All methods involving cutting have the drawback of accumulating slash on the ground, which may require treatment (such as lop-and-scatter or creating small

Chemical use on forestland in Oregon, Washington, and Idaho

Chemical use on forestland is highly regulated due to potential hazards to human health, fish, and wildlife; contamination of soil, domestic water sources, ponds, lakes, streams, wetlands; and damage to crops adjacent to forestland. Chemicals here refer to herbicides, insecticides, rodenticides, fungicides, fertilizers, and petroleum products. These regulations oversee the proper handling, storage, and application of chemicals.

Before you apply chemicals on your property, you may be required to notify your state's forestry agency. Below is a synopsis of the notification requirements for Oregon, Washington, and Idaho. For current regulations related to reforestation on forest lands, contact the agency listed for each state.

Oregon

- Chemical applications require a notification of at least 15 days to the Oregon Department of Forestry before conducting a chemical application on forestland.
- The notification must include common name of chemical(s) being used; the product name(s); application method; and for fertilizers, the intended rate per acre.
- Operators must maintain chemical-handling equipment in a leak-proof condition.
- A written plan is needed for any chemical operation within 100 feet of a type F (fish) or D (domestic water source) stream, or within 300 feet of a specified resource site, such as significant wetlands or an eagle's nest.
- Operators must follow guidelines specified on the chemical's label, which is a legal document.
- Operators must keep records of chemical applications for three years after the application.
- Application of chemicals near streams used by community water systems requires notification to community water system managers.
- Chemical spills must be immediately reported to the Oregon Department of Forestry.

Oregon Department of Forestry
Forest Practices Section
2600 State Street
Salem, OR 97310
Tel. 503-945-7470
http://www.oregon.gov/odf/privateforests/Pages/index.aspx

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(continued)

Washington

Washington State Department of Natural Resources
Forest Practices Division
P.O. Box 47012
Olympia, WA 98804-7012
Tel. 360-902-1400
http://www.dnr.wa.gov

- In "Class I" areas where operations have no direct potential for damaging public resources and outside the Columbia River Gorge National Scenic Area (CRGNSA), ground-based chemical applications and aerial applications (except insecticides) less than 40 acres do not require forest practice review and notification, where the application does not take place within 100 feet of lands used for farming or within 200 feet of a residence.
- Pesticide treatments within the core or inner zones of the Riparian Management Zone (RMZ), Type Np RMZs, sensitive sites, or wetland management zone shall be applied by hand unless the Department of Natural Resources (DNR) has approved a site-specific plan with another method of treatment.
- Aerial application of chemicals near streams, wetlands, and other water sources requires no-spray buffers on all Type S and F waters, Type Np and Ns surface waters, and Type A and B wetlands.
- On all aerial chemical applicators, the operator is required to maintain for 7 years daily records of spray operations.
- Chemical spills must be immediately reported to the DNR.

Idaho

Idaho Department of Lands
Forest Practices Section
3780 Industrial Avenue South
Coeur d'Alene, ID 83815
Tel. 208-769-1525
http://www.idl.idaho.gov/forestry/fpa/index.html

- The aerial, mechanized, or hand application of chemicals requires a notification to the Idaho Department of Lands (IDL). All notifications must be officially accepted by the IDL before any chemical application may begin.
- Any person applying, mixing, or loading pesticides shall comply with Idaho's licensing requirements.
- Equipment used for transportation, storage, or application of chemicals shall be maintained in a leak-proof condition.
- Buffers of varying widths are required for aerial, ground application with power equipment, and hand applications of pesticides:
  - Aerial pesticide applications require leaving at least 100 feet untreated on each side of all Class I streams, flowing Class II streams, and other areas of open water. Aerial applications of pelletized fertilizer require leaving a minimum of 50 feet untreated on each side of all Class I streams, flowing Class II streams, and other areas of open water.
  - Pesticide applications by ground application with power equipment require 25 feet untreated on each side of all Class I streams, flowing Class II streams, and areas of open water. When applying fertilizer, leave at least 10 feet untreated on each side of all streams and areas of open water.
  - For hand application of pesticides, apply to specific targets, such as a stump, burrow, bait, or trap. Keep chemicals out of all water sources or streams.
- Chemicals shall be applied in accordance to instructions and limitations printed on the product label.
- When chemicals are applied on forestland, the operator shall maintain a daily record of spray operations and retain these records for three years.
- Chemical spills shall be reported and appropriate cleanup action taken.

slash piles) to improve access and reduce fire hazard. Working with a chainsaw poses a safety hazard due to the rotating, toothed chain and exposure to exhaust fumes. To protect yourself from injury when operating chainsaws, you should wear appropriate safety gear, including chaps, boots, gloves, hard hat, and eye and ear protection.

Two options that do not require cutting are herbicide injection and basal bark treatment.

Herbicide injection or hack-and-squirt

This option is most useful for larger diameter hardwood species (more than 2 inches in diameter at breast height, or DBH) and involves using appropriate water-based herbicides that can effectively translocate herbicide from the injection sites (at intervals around the stem) to the root system, resulting in tree death. By leaving the trees standing, slash is not an immediate problem, and standing dead trees provide partial shelter from excessive sun exposure of overtopped conifers. Small-stemmed brush species are not easily treated this way.

Basal bark treatment with herbicide in oil

For basal treatments, apply to the lower 15 inches of a tree trunk or brush stem using a backpack sprayer or other ground-application technique, soaking the trunk liberally to the ground line and making sure the entire circumference is treated. This is an effective treatment on most of the target hardwood trees and shrubs mentioned above. It can be used at almost any time of year, except during mid-winter, when cold temperatures limit effectiveness and make application difficult or impossible. A preferred herbicide is triclopyr-ester, an oil-soluble herbicide that is mixed with oil (either diesel or one of the crop oils now available) as a carrier. The oil helps the herbicide absorb through the bark and translocate to the roots. Some advantages of the basal bark method are that one herbicide solution can be used on both trees and shrubs, there is no immediate slash problem, and it kills the roots effectively. Basal treatments usually control even larger hardwood trees with thick bark.

Resources

OSU Extension publications

Oregon State University Extension Service publications available online at https://catalog.extension.oregonstate.edu/

- *Calibrating and Using Backpack Sprayers* video (EM 9039)
  https://catalog.extension.oregonstate.edu/em9039
- *A Guide to Riparian Tree Planting in Southwest Oregon* (EM 8893)
  https://catalog.extension.oregonstate.edu/em8893
- *Introduction to Conifer Release* (EC 1388)
  https://catalog.extension.oregonstate.edu/ec1388
- *Shrubs to Know in Pacific Northwest Forests* (EC 1640)
  https://catalog.extension.oregonstate.edu/ec1640
- *Trees to Know in Oregon* (EC 1450)
  https://catalog.extension.oregonstate.edu/ec1450
- *Oregon Pesticide Safety Education Manual: A Guide to the Safe Use and Handling of Pesticides* (EM 8850).
  https://catalog.extension.oregonstate.edu/em8850
- *Selecting and Buying Quality Seedlings* (EC 1196)
  https://catalog.extension.oregonstate.edu/ec1196
- *Pacific Northwest Weed Management Handbook*
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