

a guide to RIPARIAN TREE PLANTING in Southwest Oregon

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Figure 1.—A newly installed riparian planting along Bear Creek, Jackson County.

Planting trees in riparian areas is increasingly common in Oregon as part of efforts to improve fish habitat, water quality, and other riparian functions. Yet tree survival and growth are poor in many projects, and some fail outright (see “Survey shows variable success with riparian tree planting,” page 4).

Establishing trees in riparian areas poses significant challenges. There are often high levels of competing vegetation and animal damage. Despite proximity to water, riparian soils are often droughty. Potential planting sites either may be subject to frequent flooding or on dry terraces far from the water table. There may be limits on use of tools and techniques near water,

such as herbicides or heavy equipment. And, landowners may face difficulties integrating the riparian area’s needs with management goals for adjacent lands. Despite these challenges, riparian tree planting projects can be successfully designed and implemented.

This publication is a step-by-step guide to riparian tree planting in interior southwest Oregon, including Jackson and Josephine counties and the noncoastal portions of Douglas County (Figure 2, page 2). Compared to other parts of western Oregon, this area experiences hotter, drier summers, and lower annual precipitation, which poses unique challenges for the survival and growth of riparian plantings.

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While some details apply mainly to this region, the principles discussed are broadly applicable to tree-planting projects in riparian areas throughout the Pacific Northwest.

We outline six steps to developing successful riparian projects:

- Design your project
- Select and obtain plant materials
- Prepare the site
- Plant your trees right
- Take care of the planting
- Monitor and learn from the results

Why focus on trees? Shrubs and herbaceous vegetation are important components of riparian areas, too. However, trees are the key to enhancing impor-

tant riparian functions such as shade over the stream and large woody debris in the stream. Once trees are established, conditions for other vegetation are often favorable.

Tree establishment costs vs. benefits

Riparian restoration is often a noncommercial and community-oriented endeavor, in which cost-benefit criteria vary greatly depending on perspective. Well-established methods effective in commercial forestry and agriculture have been adapted to some riparian situations at costs of \$0.70 to \$1.50 per established tree. On the other hand, some riparian planting efforts successfully establish trees without

herbicides using intensive manual labor (often volunteer) equivalent to \$5 to \$10 per tree. Both cases can be considered successful, depending on your perspective. Regardless of methods employed, establishing healthy, vigorous trees or shrubs that will persist in the long term (that is, be “free to grow”) is the objective measure of success.

In this publication, we present information on methods, effectiveness, and costs to help you decide on the best approach in your situation. We also emphasize the major challenges in riparian planting and the need to diligently apply effective methods in order to ensure success.

Caution: A minimalist approach to riparian planting often leads to failure.

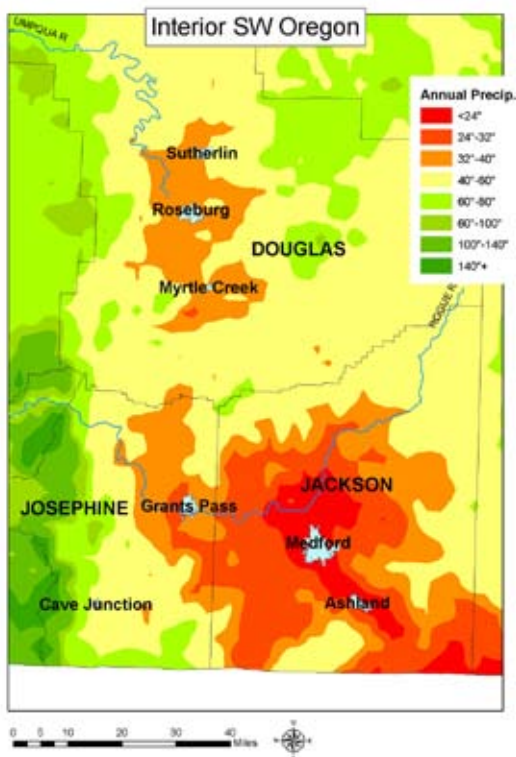


Figure 2.—The approximate area discussed in this publication. Interior southwest Oregon experiences hot, dry summers. Moisture stress is often the the most important factor influencing the survival and growth of riparian plantings in this region.

STEP 1. DESIGN YOUR PROJECT

Assess watershed needs

Base your project goals and design on a careful assessment of current riparian functions at both the local and watershed levels. To determine your priorities, identify what is missing or most in need of enhancement. For example, the assessment may show that warm water temperature is the limiting factor along certain streams in your watershed; your enhancement efforts would then be directed at increasing shade to moderate stream temperatures (Figure 3).

Look first to any watershed assessments prepared by the local watershed council or the larger public or private landowners in your watershed.

Then make your own assessment of local needs and opportunities on sites available for your project. Contact your local Extension office for more information on watershed councils and major landowners in your watershed.

Develop objectives to enhance key riparian functions

Develop objectives for your riparian tree planting project that are aimed at restoring or enhancing important riparian *functions* (Figure 4, page 4), not just vegetation *conditions*. While your actions will most directly affect vegetation conditions, choose target conditions in order to support desirable functions (see Appendix 1, “Key riparian functions, supporting vegetative conditions, and riparian buffer design considerations,” page 25).

Conditions before European settlement often are used as a guide for desirable riparian conditions, so consult references on historical conditions, if available. Restoration to presettlement conditions, however, often is impossible or inappropriate. Due to the natural complexity and changeable nature of riparian systems, there is no absolute “natural” condition for a given riparian area.

Riparian areas are naturally dynamic, changing in response to processes such as fire, flood, and landslides. These processes themselves have changed under the persistent influence of humans’ land uses (farm, forest, residential, commercial) and structures (roads, buildings, parking lots, dams). In order to restore riparian functions, set objectives for vegetation conditions within a realistic range of possibilities determined by the environmental processes expected to predominate from now on.

What would happen if you took no action on your prospective project site? Given the dynamic nature of riparian areas, perhaps the system could move in the right direction with no human intervention. Or, perhaps the only action needed is to remove certain influences, such as livestock grazing or intensive cultivation right next to the stream bank.

Along with objectives for enhancing riparian function, consider your overall land management objectives as well as time and financial constraints.

- Realistically, how much money, time, and energy are available to install and maintain the project, and will this be adequate to achieve its ecological objectives?

Checklist for Step 1: Design your project

Attention and thought at this stage, though time consuming, will lead to a better and more cost-effective project in the long run.

- ❑ Assess needs for riparian enhancement based on local site conditions and overall watershed priorities. What is missing or most in need of enhancement?
- ❑ Target key riparian *functions* such as streambank stability, large woody debris, and shade. Don’t focus just on trying to restore vegetative conditions thought to have prevailed in the past.
- ❑ Select your project sites after evaluating stream size, channel type, flood potential, competing vegetation, animal damage potential, and soil moisture and fertility. What sites offer the highest potential for success and the biggest “bang for the buck”?
- ❑ Think about possible obstacles to success, such as conflicting management goals (e.g., the landowner doesn’t want to establish a buffer because it will take land out of production), lack of time and money for maintenance treatments, access to the site, and landowner commitment. Is there still a good chance of success?
- ❑ Develop site-specific designs, taking into account desired buffer width, location and directional orientation of the buffer, access, fencing needs, species composition, and tree spacing and arrangement.

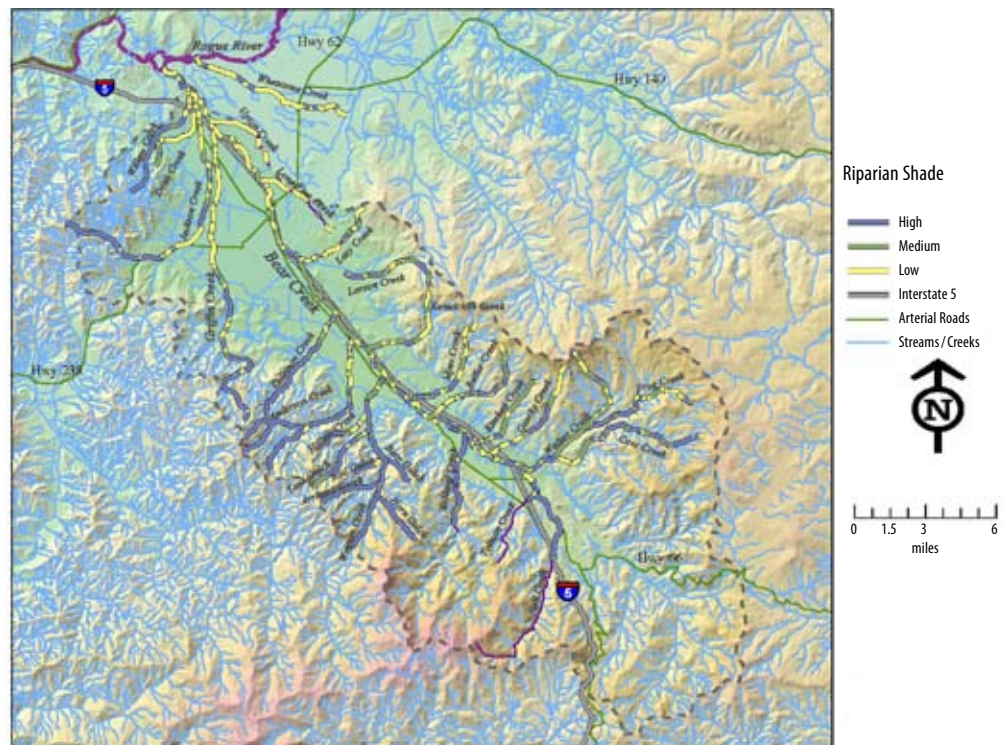


Figure 3.—Example of a watershed-level assessment of riparian conditions. This map was used to identify stream reaches for potential riparian planting projects to enhance stream shading. (Map courtesy of Bear Creek Watershed Council.)

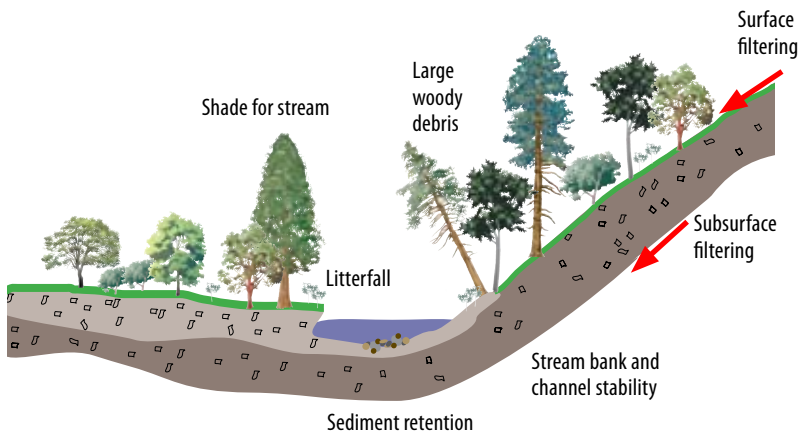


Figure 4.—Important functions of a riparian area include shade for the stream, stream bank stability, woody debris for the stream, sediment retention, litter for aquatic organisms in the stream, water filtering, aquatic habitat, and riparian wildlife habitat. (Adapted from Sacramento Area Flood Control Agency.)

SURVEY SHOWS VARIABLE SUCCESS WITH RIPARIAN TREE PLANTING

Slightly fewer than half of 105 riparian tree planting projects in western Oregon achieved tree survival rates of 75 percent or more, according to a study by the Oregon Watershed Enhancement Board in 2002.

In 40 percent of the projects in the study, fewer than half the trees survived.

Projects installed under the Conservation Reserve Enhancement Program (CREP) were more successful than projects funded by grants. The study's authors attributed this difference to the greater use of

site preparation, postplanting maintenance, and tree protection under the CREP program.

Data for southern Oregon (in the Rogue, Umpqua, and Klamath basins) show that “over 50 percent of projects have some mortality related to desiccation and soil conditions, over 30 percent have suffered from plant competition, and 50 percent from animal predation.”

Statewide Survey of OWEB Riparian and Stream Enhancement Projects. 2002. Anderson, M., and G. Graziano. Oregon Watershed Enhancement Board, Salem, OR.

- What conflicts might arise with adjacent land uses (e.g., farming or grazing), and how can these be resolved?
- Is there good access to the planting site, and can you move in any needed equipment or supplies?
- Is the planting site in a remote location, which will be visited only occasionally, or in a place where it can be monitored frequently?

The scale of the project is also an important consideration. Small projects (e.g., dozens to a few hundred trees) allow use of a wider range of techniques, such as hand-cutting competing vegetation, that would be prohibitively expensive on larger projects. As the project's size and complexity increase, so does the need for cost-effective methods of site preparation, planting, and vegetation control (also called *release*).

Select sites

Base site selection on key site factors and the degree to which the project will benefit riparian functions or achieve other goals.

Site factors to consider include stream size, stream channel characteristics, soil moisture and fertility, animal damage potential, and competing vegetation (see Appendix 2, “Factors to consider in site selection,” page 26). Assess these factors to determine feasibility for individual sites as well as to choose among prospective sites.

Once a site is selected, consider soils, climate (macro and micro), and hydrology to guide project design and species selection.

Many riparian planting projects are initiated by watershed councils and public agencies but are on private lands. Thus, landowner objectives and commitment are critical in both site selection and project success.

Sites that are less than ideal from an ecological standpoint still may be the most favorable in the watershed because participating landowners are enthusiastic, capable, and willing to follow through with postplanting maintenance. Site selection then becomes a matter of finding willing owners of sites where riparian plantings will, over time, significantly enhance watershed function, even if they are not ideally located. The potential educational value of a site (e.g., for watershed tours) also may be an important factor in site selection.

Design the project

Once you have selected potential sites, consider the extent to which tree establishment goals can be met by encouraging or “releasing” natural regeneration (see Appendix 4, “Promoting natural regeneration,” page 30).

Then design the planting project, detailing features such as location of plantings, space between plants, fencing, access for people and equipment, in-stream structures, future maintenance, and monitoring. Practical considerations for access, site preparation, planting, protection, and

maintenance are particularly important. See Appendix 3, “Project design features and considerations” (page 28), to help you choose features that fit your situation.

STEP 2. SELECT AND OBTAIN PLANT MATERIALS

What species should I plant?

Choose species that are well adapted to conditions on your site. Key factors to consider include planting zone and tolerance to drought, flood, and shade.

Riparian planting zones

Riparian planting zones (Figure 5, at right, and Table 1, page 6) reflect the availability of soil moisture during the dry summer months and the potential for flooding

Drought tolerance

Moisture stress is often the limiting factor in seedling survival in southwest Oregon due to the hot, dry climate. Even sites close to streams may have sandy or rocky soils with low moisture-holding capacity, and those dry out in summer. Choose a species that is drought tolerant, or plant deeply enough that roots can access the midsummer moisture level.

Checklist for Step 2: Select and obtain plant materials

Species and stock type selection are critical aspects of your riparian project.

- Select species that are well adapted to the site. Is the site droughty, flood-prone, or shady? Take into account the species’ tolerances to these factors.
- Choose species and stock types that are appropriate for individual riparian planting zones, which reflect the availability of soil moisture during the dry summer months and the potential for flooding.
- Consider also availability, cost, planting difficulty, handling sensitivity, and the skills and experience of the planting crew in selecting species and stock types.
- Choose high-quality seedlings with a root system in balance with the shoot (aboveground portion of the plant). Bigger stock often has better survival and growth rates, but it is harder and more expensive to plant.
- Select plant materials that have been collected locally or grown from seed collected from locally adapted sources; use appropriate seed transfer guidelines.
- Plan ahead. Order seedlings well in advance.

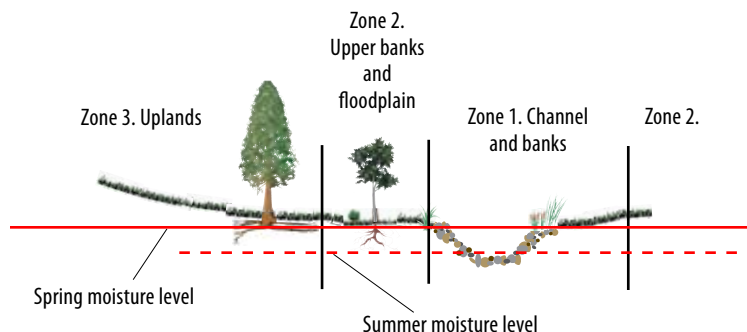


Figure 5.—Riparian planting zones (adapted from Crowder and Edelen 1996). The availability of soil moisture during the dry summer months is a key factor in selecting species to plant.

Flood tolerance

If planted in Zone 1 (stream channel and banks), the species must have high flood tolerance; if planted in Zone 2 (upper banks and floodplain), medium flood tolerance. Be aware of areas with poor soil drainage, which species such as Douglas-fir and incense-cedar cannot tolerate.

Shade tolerance

Many riparian tree species are intolerant of shade and thus are not suitable for planting in the understory of other trees. Examples are willow, cottonwood, and alder.

Table 2 (page 7) lists riparian tree species for interior southwest Oregon and each species' riparian planting zone and tolerances to drought, flooding, and shade. A variety of shrubs and small trees may be suitable for riparian plantings (Table 3, page 8), although less is known about their environmental tolerances and field performance.

Coniferous species often are a priority for riparian plantings due to their high value for functions of shade and large woody debris. Most species will contribute, to some degree, to important riparian functions.

Native species usually are the best choice, simply because their adaptability to local sites is proven. However, non-natives may be appropriate, too, when they help meet goals for riparian function.

While your assessment of site conditions should cover all major environmental factors, moisture is often the single most important factor in southwest Oregon. It is important to select species based on their moisture needs and drought tolerance in relation to local climate, soils, and topographic riparian moisture zones (Figure 5, page 5, and Table 1). A variety of shrubs and small trees may be suitable

for riparian plantings (see Table 3, page 8), although less is known about their environmental tolerances and field performance. Table 2 lists riparian tree species for interior southwest Oregon, their growth rates, suitability for various objectives, and tolerances to drought, flooding, and shade.

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Table 1.—Riparian planting zones.

Zones	Description	Planting
Zone 1 includes the stream channel and banks.	The zone is flooded at least part of every winter and supports largely hydrophytic (water-loving) vegetation. Often, soils are rocky and difficult to plant.	Cuttings (whips and poles) of hydrophytic species planted deeply enough to access midsummer moisture. Large plugs (see page 9) or bare-root stock may be feasible, but consider the risk that they will be washed away by strong storm flows.
Zone 2 includes the upper banks and floodplain.	This may be a very narrow zone in a channelized or confined stream, or a wide zone in an unconfined stream. Moisture usually decreases from the boundary of Zone 1 to the boundary of Zone 3. Shrub and weed competition may be intense. Often, soils are sandy and/or rocky and droughty.	Plantings of hydrophytic species may be successful if seedlings or cuttings are able to access midsummer moisture. Most stock types are suitable for this zone. Larger stock, either bare root or container, usually will survive and grow better. Cuttings must be longer and planted more deeply than in Zone 1.
Zone 3 includes the upper terrace and the uplands adjacent to the stream bank.	This zone supports primarily upland vegetation, although some Zone 1 and Zone 2 species may be at the boundary with Zone 2.	Appropriate species are upland conifers and hardwoods. Drought tolerance is a key consideration. Stock types are usually bare-root or plug seedlings.

Table 2. Characteristics of riparian and bottomland tree species in southwest Oregon.

Species	Riparian planting zone	Tolerance to			Comments
		Flooding	Drought	Shade	
Bigleaf maple <i>Acer macrophyllum</i>	2–3	Medium	Medium	High	Lives longer than cottonwood and alder. A soil builder.
Black cottonwood <i>Populus trichocarpa</i>	1–2	High	Low	Low	Prefers moist but well-drained soils. Well-suited for shade and bank stabilization. Roots well from cuttings.
Douglas-fir <i>Pseudotsuga menziesii</i>	3	Low	Medium	Medium	Does not tolerate even short periods of flooding. Poorly suited to riparian plantings in areas with less than 30 inches of annual rainfall.
Grand fir <i>Abies grandis</i>	2–3	Medium	Low	High	Fast growth. Source of woody debris. Higher precipitation zones.
Hybrid cottonwood <i>Populus trichocarpa</i> x other <i>Populus</i> species	1–2	High	Low	Low	A hybrid of native black cottonwood and non-native species; various clones are used. Excellent growth; similar requirements to those of native species.
Incense-cedar <i>Calocedrus decurrens</i>	2	Low	High	Medium	Slow growth. Source of woody debris.
Oregon ash <i>Fraxinus latifolia</i>	2–3	High	Medium	Medium	Tolerates poorly drained, heavy clay soils that dry out in summer.
Oregon white oak <i>Quercus garryana</i>	2–3	Medium	High	Low	Very slow growing. Important habitat values. Adds diversity.
Ponderosa pine <i>Pinus ponderosa</i>	2–3	Medium	High	Low	Large, long lived; moderate growth rate on average sites if weed control is good. Source of large woody debris over the long term. Better than Douglas-fir for droughty sites in southwest Oregon.
Red alder <i>Alnus rubra</i>	1–2	High	Low	Low	Grows in higher precipitation zones than white alder. A nitrogen fixer.
Western redcedar <i>Thuja plicata</i>	2–3	High	Low	High	Only on the wetter sites in southwest Oregon; not found in Jackson or Josephine counties.
White alder <i>Alnus rhombifolia</i>	1	High	Low to medium	Low	Common riparian tree in interior valleys. A nitrogen fixer.



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Figure 6.—Black cottonwood is well suited for giving shade and for stabilizing stream banks.

Table 3. Characteristics of riparian and bottomland small tree and shrub species in southwest Oregon.

Species	Riparian planting zone	Tolerance to			Comments
		Flooding	Drought	Shade	
Chokeberry <i>Prunus virginiana</i>	2–3	Medium	Medium	Low	Large shrub or small tree. Good wildlife species.
Klamath plum <i>Prunus subcordata</i>	2–3	Medium	Medium	Low	Large shrub or small tree. Confined to southern part of our region.
Mock orange <i>Philadelphus lewisii</i>	2–3	Medium	Medium	Medium	Tall understory shrub.
Oregon crabapple <i>Malus fusca</i>	3	High	Medium	Medium	Large, thicket-forming shrub or small tree.
Pacific ninebark <i>Physocarpus capitatus</i>	2	Medium	Low	Medium	Tall understory shrub. Roots from cuttings.
Red-osier dogwood <i>Cornus stolonifera</i>	1–2	High	Low	Medium	Medium to tall understory shrub. Roots well from cuttings.
Serviceberry <i>Amelanchier alnifolia</i>	2–3	Medium	Medium	Medium	Large, thicket forming shrub.
Snowberry <i>Symphoricarpos albus</i>	2–3	Medium	Medium	High	Low shrub. Roots from cuttings.
Willows <i>Salix</i> spp.	1	High	Low	Low	Some willows are tree size; others are large shrubs. Root very well from cuttings. Well suited to bank stabilization and bioengineering projects.

What type of seedling should I plant?

Several types of seedling or stock types are used in riparian plantings (Table 4, page 9). Important considerations in selecting a stock type are:

- Availability
- Handling sensitivity
- Cost
- Ease of transport and planting
- Survival and growth potential

As a general rule, regardless of stock type, bigger is better. Bigger stock is less likely to be overtopped by competing vegetation, handles browse better, and is often more heat and drought

tolerant. However, bigger stock is also more expensive to buy and plant. It is important to ensure that bigger stock has an adequate root system to support the large shoot system.

Bare-root seedlings (Figure 7, page 9) are grown in nursery beds, usually for 2 years. Common designations are “2-0” which is a 2-year-old tree that has grown only in a nursery bed, and “1-1” which is a tree grown 1 year in a nursery bed and 1 year in a lower density transplant bed.

The 1-1s tend to be larger than the 2-0s and have denser, more fibrous root systems. They also cost more. Bare-root trees are

planted during the winter dormant season. Advantages of bare-root seedlings are relatively low cost, ease of transport, and wide availability of many species, especially conifers. Disadvantages are a smaller planting time “window” compared to container (plug) seedlings, more skill needed in planting, and the trees’ greater sensitivity to root drying and other damage prior to or during planting.

Wildings are trees uprooted from the wild, usually where small seedlings are abundant, and replanted in the desired location. Advantages are the cost—they’re free—and greater assurance that the stock is adapted to local conditions. However, digging

wildlings is labor intensive, and it can be difficult to find a good source. Landowner permission is required. Take care to avoid damaging wildlings' root systems during transplanting. Severe transplant shock has been common with wildlings due to damaged or diminished root systems that were unable to support the trees' large shoots.

Container seedlings are grown in containers and planted with the soil intact around the roots. Small container seedlings commonly are referred to as plugs. They come in a wide range of sizes, from "Styro-10s" (10 cubic inches of soil in the plug) to 1-gallon pots to large, specialized plugs grown in PVC pipes that are 24 inches long (Figure 8, page 10). Advantages include a larger planting time window (fall through early spring), less skill needed in planting, and less potential for handling and planting damage. Compared to bare-root seedlings, small plugs are easier to plant on rocky and other difficult sites, and large plugs show better survival on droughty sites. A major disadvantage of container stock is higher cost.

Plug-1 seedlings (Figure 7) are container seedlings that have been transplanted to an outdoor nursery bed and grown there for 1 year. They have characteristics of both container and bare-root seedlings and have well-developed fibrous root systems. They are more expensive than bare-root seedlings.

Cuttings are leafless stem cuttings from dormant hardwood trees and shrubs (Figure 9, page 10).



Figure 7.—Examples of different stock types. From left: Douglas-fir container (plug), 2-0, and 1-1; and ponderosa pine P-1. From Robin Rose and Diane Haase, 2006, *Guide to Reforestation in Oregon*, Oregon State University.

Table 4.—Characteristics of seedling stock types for riparian planting.

Stock type	Size (stem caliper and height)	Unit cost range	Comments
Bare-root	0.1–0.5 caliper, 8–24 inches	15¢–65¢	Wide availability; winter planting; extra care in handling.
Wildlings	0.1–0.5 caliper, 8–24 inches	Labor and transport	Need landowner permission; extra care in handling; transplant shock is common.
Container plugs	0.05–0.3 caliper, 6–20 inches	25¢–80¢	Fall to spring planting window; less skill in handling; easier for rocky sites.
Container: 1- to 5-gal pots, or 3- to 4-inch by 18- to 24-inch PVC pipe	0.2–2.0 caliper, 12–60 inches	\$1.00–\$10.00	Fall to spring planting window; less skill in handling; survival on droughty sites; expensive to plant.
Cutting: cane or whip	0.25–1.0 caliper, 12–72 inches	20¢–30¢ per foot; or, labor and transport	Presoaking advised; can U-cut from local sites; must plant so roots are within reach of summer water table; tolerate flooding; grow rapidly.
Cutting: pole	1.0–4.0 caliper, 48–96 inches		
Ball and burlap (B&B)	1.5–5.0 caliper, 36–240 inches	\$25.00–\$250.00	Expensive, instant landscape for park, yard, or green space.



Figure 8.—Large container stock at Stone Nursery, Central Point, OR. Increasingly, riparian plantings in southwest Oregon are made with large (1 gal or larger) container stock.



Figure 9.—Cottonwood and willow cuttings, ready for planting. Note that the two cuttings in the foreground have begun to root.

When conditions are right, cuttings will root after planting, though some species such as cottonwood and willow root much better than others (See Table 3, page 8). *Canes* or *whips* are flexible cuttings, 1 to 4 feet long and up to about 1 inch in diameter at the large end. *Poles* are rigid cuttings, larger in diameter and usually longer than whips. Any cutting **must** be planted deeply enough to access midsummer soil moisture. Cuttings of some species are available at nurseries or can be U-cut at cooperating landowners'. Most cuttings in riparian projects are cottonwood and willows. Soaking cuttings before planting and selecting

newer (current-year or 1-year-old) wood generally increase survival and growth rates. Advantages of cuttings are relatively low cost, ease of planting (for whips), tolerance of flooding, and rapid establishment since the cuttings are often large to begin with and grow well once they have rooted.

Ball and burlap (B&B) stock has a large ball of soil around the root system held in place with a burlap wrap. These tend to be much larger, much more expensive trees and are seldom used in remote locations. However, ball and burlap stock is used commonly in stream plantings in park settings and other greenspace located in or near urban areas. Advantages include good survival and growth. Disadvantages include the cost and the difficulty of planting.

Obtaining high-quality planting stock

Many commercial forest nurseries in the Pacific Northwest grow plants for riparian and other restoration projects. The popularity of these projects, and the demand for planting stock, has grown enormously in the past decade. Most nurseries grow some stock on “speculation,” based on expected demand, which they sell on a first-come, first served basis.

Generally, you also can contract with nurseries to grow plants to your specifications, using seed you’ve collected or have acquired from another source. A minimum number of seedlings (e.g., 2,000) is required for such contracts.

Lists of nurseries are available from the OSU Extension forester who serves your county and from Oregon Department of Forestry Stewardship foresters; or, see the website for the Oregon Association of Nurseries—<http://www.nurseryguide.com/>—which has a searchable database of Oregon nurseries.

Characteristics of high-quality seedlings

Seedlings should be vigorous and free from damage and disease and should have a root system large enough to support the aboveground portion (the shoot) of the plant. A well-developed root system is particularly important in southwest Oregon, with its long summer drought.

For bare-root trees, a shoot-to-root ratio of 1.5 (or less) to 1 is desirable. The root system should be dense and fibrous (see Figure 7, page 9). Shoot systems also should be dense and well branched; tall, thin stock is often less vigorous and less resilient to damage. Seedlings should be fully dormant for winter planting.

For container seedlings, the root mass should be well developed and visible throughout the soil medium. Within a batch of seedlings, buyer and seller should agree on a minimum stem diameter (caliper) and height to cull out undersize stock.

SEED SOURCES AND GENETIC ISSUES

To ensure that plants are adapted to the local environment, they should be grown from a local seed source. How local is “local?”

Because climate varies so much over short distances in southwest Oregon, there is no rule of thumb (e.g., “50 miles”) for how far trees and shrubs can be moved safely from their source. Instead, *seed zones* have been established to minimize the risk.

Seed zones are geographic areas within which temperature, rainfall, and other climatic factors are fairly uniform. If the area includes major elevation changes, *elevation bands* within each zone further define areas with important similarities in conditions.

Trees can be planted safely within their zone of origin based on both the geographic seed zone and the elevation band. Planting in a higher or lower elevation band from the zone of origin increases the risk that the plant will adapt poorly to its new environment.

The seed zone and elevation (to the nearest 500 or 1,000 feet) normally should be specified when ordering seedlings.

Seed zones have been established for most conifer species and for red alder and black cottonwood. Relatively little is known about genetic variability among other native riparian hardwoods and shrubs. In the absence of specific zones for a species, Randall (1996) recommends using basic westside zones to guide seed transfer in other hardwood and shrubs species (Figure 10). Most of interior southwest Oregon is in Zones 5, 7, and 10. Seed transfer should be relatively safe within these zones.

In practice, planting stock is not always available from the desired seed zone and elevation. In this case, how can risks of seed transfer be minimized?

- Moving between two adjacent seed zones, especially close to their boundaries, may pose little risk, as long as there is relatively little difference in temperature and precipitation.
- Avoid moving seed across major environmental divides, such as from the interior valleys to the coast and vice versa.
- Moving up in elevation (more than 1,000 feet) increases the risk of frost damage. Moving down in elevation poses less risk, although growth may be slower.
- Regardless of zone boundaries, moving seed from areas of high precipitation (i.e., above 60 inches) to areas of low precipitation (below 30 inches) poses risks that plants will be vulnerable to drought stress.

For more information, see “Selecting Native Plant Materials for Restoration Projects,” EM 8885-E (see page 32)



Figure 10.—Basic seed zone map for western Oregon. Use for hardwoods and other species that do not have their own designated seed zones. Zones for conifers vary by species.

STEP 3. PREPARE THE SITE

Research has amply demonstrated that good site preparation can greatly increase both survival and growth rates of planted stock. Inadequate site preparation reduces survival and increases the risk of project failure. Competing vegetation is usually easier to control before planting than after. Good survival rates and rapid initial growth of planted stock produce early dominance of planted trees, which greatly reduces the need for maintenance weeding.

In evaluating tools and methods, consider the vegetation on the site, what may invade after planting, the species and stock type(s) to be planted, site access, and terrain. Smaller seedling stock generally require more thorough site preparation merely to ensure survival and growth. Larger stock may be more competitive with weeds, but their performance still will be improved greatly by increasing weed control.

Table 5 (page 13) describes and compares a range of preparation methods for major types of competing vegetation. The most effective methods kill both the shoot and root of competitors. Herbicides are the least costly method for this. Removing only the above-ground portion of competing vegetation provides good access and temporarily reduces competition. However, if root systems of perennial herbs and shrubs are not killed or removed, they usually resprout quickly and compete vigorously with the planted stock. This can be controlled with repeated cutting, mowing, or slashing, which of course entails greater effort and/or cost. There is a clear

Checklist for Step 3: Site preparation

Competing vegetation often is easier to control before planting than after. Lack of adequate site preparation is a major factor in the failure of riparian projects.

- ❑ Plan ahead for site preparation: reduce the amount of vegetation that will compete with planted trees for moisture, nutrients, and sunlight.
- ❑ Ideally, choose site preparation methods that remove or kill the root system of competing vegetation, so that it doesn't resprout. Mowing or cutting provides only a temporary reprieve from competition unless it is repeated frequently, which is labor intensive and expensive.
- ❑ Consider effectiveness, duration, and cost in choosing site preparation methods. Herbicides are often the most effective and least costly method for controlling competing vegetation. Tilling, cutting, mowing, pulling, grubbing, and mulching can also be effective.
- ❑ Plan ahead to minimize potential erosion problems. Aggressive site preparation may remove competing weeds, but also will expose bare soil, leading to erosion and the possibility that new weeds will invade the site.

tradeoff between less effective site preparation and increased need for maintenance.

It's important to consider the effects of site preparation on potential future weed communities.

Intensive mechanical site preparation that includes tilling or removing roots can control established weeds effectively. However, these mechanical methods also expose mineral soil, which is invaded quickly by weed seed blown in from surrounding areas as well as by sprouting, previously dormant seed already in the soil. After herbicide use, dead thatch, leaves, or stems often can be left in place as a mulch, although weeds eventually seed in again. Repeated herbicide application also can result in bare soil that weeds will colonize after treatments cease. The result is replacing one weed problem with another.

USE PESTICIDES 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.

Table 5.—Site preparation methods for vegetation types.

Method	Effectiveness and duration*	Cost per acre per application	Comments
Grasses and herbaceous vegetation			
Herbicides: applied with vehicle and boom spray or hose, or with backpack or hand sprayer	High 1–2 years	\$50–\$150	Can apply to strips or planting spots – minimum area 3 x 3 feet, centered on seedling. Dead plant material temporarily protects soil, delays weed reinvasion from seed.
Mechanical: tilling	High 2–4 months	\$80–\$160	Exposed soil is rapidly invaded by weeds sprouting from seed.
Mechanical: mowing	Low 1–4 weeks	\$40–\$120	Mowing does not stop moisture competition but may reduce rodent problems. Must be repeated often.
Manual: scalping, hoeing	Medium 3–6 weeks	\$100–\$300	Exposed soil is rapidly invaded by weeds sprouting from seed.
Mulch mats	Medium 1–2 years	\$150–\$400	Must be well secured and lie flat on ground. Mulch mats can harbor rodents and might wash away in high water.
Woody shrubs			
Herbicides: applied with vehicle and boom spray or hose, or with backpack or hand sprayer	High 1–3 years	\$50–\$200	Complete spray coverage is most effective. Dead plant material provides temporary soil protection, delays weed reinvasion from seed.
Herbicides: cut-stem or basal-bark treatment	High 1–3 years	\$40–\$100	Water-soluble formulations applied to cut stem surfaces. Oil-soluble formulations applied to penetrate bark. Standing dead material provides dead shade; debris and leaf litter cover soil.
Mechanical: grubbing roots, raking	High 1–2 years	\$500–\$800	Exposed soil is rapidly invaded by weeds sprouting from seed.
Mechanical: mowing	Low 1–4 weeks	\$80–\$160	Doesn't kill roots, which rapidly resprout. Must be repeated often.
Manual: slashing	Low 1–6 weeks	\$300–\$500	Doesn't kill roots, which rapidly resprout. Must be repeated often.
Manual: grubbing roots	High 1–2 years	\$1,000–\$2,000	Exposed soil is rapidly invaded by weeds sprouting from seed.

*Effectiveness at reducing competition for site resources; duration is the period that competition is significantly reduced.

Grasses and herbaceous vegetation

Many plantings, both upland and riparian, fail for lack of adequate grass control. Grasses are tough competitors for newly planted trees and shrubs, for several reasons:

- Grass has a dense, fibrous root system that rapidly absorbs soil moisture.
- Grass can green up in the fall, start growing early in the season compared to woody vegetation, and set seed by early summer, at which point much of the available moisture in the upper soil profile may be exhausted.
- Grass can spread rapidly via underground runners (rhizomes) and can resprout from root fragments.
- Dense grass cover is good habitat for voles (meadow mice), which often girdle the bases of and kill seedlings. Pocket gophers also may be a problem in grass.

Most grasses and herbaceous vegetation are killed easily with herbicides before planting tree or shrub seedlings. Vegetation is treated in spots or strips at least 36 inches wide (Figure 11, page 14). Retaining the dead grass/herb thatch around planting spots helps suppress germination of new weeds. Mechanical tilling in strips effectively controls weeds temporarily. Adding mulch mats or mulch materials after tilling will delay recolonization of weeds from seed. Mowing grass and herbs alone is



Figure 11.—Using herbicide spray to create a grass-free strip in a pasture lessens moisture competition for newly planted tree seedlings, and Vexar tubing protects seedlings from browsing animals.



Figure 12.—Scalping provides only a temporary “leg up” on weed competition.



Figure 13.—Reed canarygrass.

not effective at reducing moisture competition but may reduce vole problems if mowing is close to the ground and frequent.

A simple site preparation method for grasses and herbs is to scalp them down to bare mineral soil—using a planting hoe or other tool—to create a planting spot at least 3 feet square (Figure 12). This is very labor intensive and provides only a temporary reprieve from competition. Larger scalps are even more effective, but time and expense increase accordingly.

At least one re-treatment usually is needed during the first growing season. Treatments also will be needed in subsequent years until the seedlings are free to grow, but the first year is most critical. Using mulch mats or other mulch materials after scalping can prolong the relief from competition; see Step 5 (page 19).

Reed canarygrass

Canarygrass is an exotic (non-native) invasive species that often grows in dense stands up to 6 feet high, forming a dense sod layer that excludes other plants (Figure 13). It is common in riparian zones and wetlands throughout western Oregon. Canarygrass is readily controlled with herbicides; higher volumes or concentrations of chemical may be needed compared to other grasses. Spraying fully developed canarygrass in fall may be most effective at killing the entire root system. Mowing in summer followed by a fall herbicide application can facilitate access and coverage while giving good control.

Small patches of canarygrass can be eliminated through hand-pulling, using a shovel or other digging tool. Work when soils are moist. The entire root mass must be removed, as new plants can sprout from small root fragments. For this reason, tillage is not effective unless followed by prolonged flooding. Cutting or mowing five times per season for at least 5 years reportedly is effective, but two mowings per season are not. Mowing can be with weed trimmers, machetes, or—where access and

slopes permit—tractor-mounted mowers. Mulches such as black plastic and weed cloth can be effective if the edges are well secured and the material is left in place for a year. Sheet mulching (e.g., several layers of cardboard topped by wood chips) also can work. Grazing is not effective.

Himalayan blackberry

This invasive species is very abundant in riparian areas throughout western Oregon. Himalayan blackberry (HBB) rapidly occupies disturbed areas, and mature patches may reach 6 to 8 feet high, with canes climbing even higher into trees. HBB thickets form virtual monocultures, displacing native vegetation and preventing new tree and shrub seedlings from becoming established. HBB propagates both from seed and vegetatively, from rhizomes and tip rooting. When cut, it resprouts rapidly, growing up to 48 inches in 1 year on good sites in southwest Oregon.

HBB is a good case for illustrating site preparation methods for competitive woody shrubs. Applying herbicide to uncut HBB foliage in late summer or in fall probably is the most effective one-time application. If HBB patches are large enough to impede access for herbicide application equipment, mowing plus herbicides may best facilitate access across the entire HBB-occupied area. It is effective to cut or mow in early to midsummer, then apply herbicides in fall once canes have regrown to approximately boot height. However, a single herbicide treatment won't control all plants (Figures 14a–c).

Several formulations of both glyphosate and triclopyr can control HBB. Late-season applications, especially of glyphosate, are more effective. Take extreme care whenever spraying, especially near riparian zones. See Step 5, page 19, for more about herbicide use.

Other methods for HBB control include the following. With all of them, a challenge is that even when HBB has been controlled effectively in a given area, the area later may be rapidly invaded from surrounding HBB patches—the so-called “edge effect.”

Manually uprooting blackberry roots and rhizomes is extremely labor intensive but effective if done thoroughly. Considerable soil may be displaced due to the depths of the roots, increasing the risk of erosion and invasion by other weeds on the bare mineral soil.

Mechanical removal with a brush-blade-equipped tractor or other specialized equipment can be effective if most or all the roots can be removed. Soil compaction, erosion, and weed invasion are concerns.

Grazing is ineffective for site preparation but may be suitable in a few cases for release treatments.

Mowing or slashing HBB once or twice per season, to stubble

height, is unlikely to reduce HBB cover significantly. However, multiple annual mowings repeated over several years may substantially reduce HBB cover. In a southwest Oregon trial, nine slashings done by hand over a single season provided levels of control comparable to herbicides. Where access and slopes permit, HBB can be mowed with a Brush Hog-type machine. More typically, crews use machetes, loppers, brush cutters, or chainsaws. A chainsaw with a hedge trimmer attachment also is effective.

Existing natural regeneration of native riparian trees and shrubs (especially regeneration from stump sprouts or root suckers) can be released with even temporary reductions in blackberry



Figures 15a–b.—Poison-hemlock, above left, and English hawthorn, above right, are common invasive species in southwest Oregon riparian areas.

cover. This is particularly true where soil moisture is not limited; for example, close to the active stream channel.

Himalayan blackberry is considered shade intolerant. In practice, most narrow riparian buffers with deciduous trees have adequate sunlight, from above and from the side, to sustain vigorous HBB growth. Establishing wider buffers with a heavy conifer component may provide enough shading to achieve HBB control in the long term.

Besides HBB, other invasive species common in southwest Oregon riparian zones include English hawthorn and poison-hemlock (Figures 15a–b), purple loosestrife, and various non-native grasses.

Minimizing erosion

“Light touch” site preparation may reduce the risk of erosion but poorly control competing vegetation. More aggressive site preparation may provide excellent competition control but also expose bare soil, thus increasing the risk of erosion. This is of particular concern on or near stream banks that are washed by storm flows.



Figures 14a–c.—Example of Himalayan blackberry control in a riparian terrace next to a farm field. Site preparation included two mowings followed by a fall application of glyphosate. Postplanting treatments included spot spraying with glyphosate and hand weeding. Clockwise from top left: the site just prior to mowing with a Brush Hog-type machine; in the middle of its first growing season; and after 4 years of growth.



Figure 16.—Erosion-control matting was used on this section of Thompson Creek, in Jackson County, after a steep, eroding bank was graded back to a more desirable angle, exposing bare soil. The site was revegetated with willow cuttings (visible as stakes in the fabric) and grass. Photo courtesy of Applegate River Watershed Council.

Strategies for minimizing erosion include:

- Prior to site preparation on stream banks and terraces, plant and establish willow cuttings near the channel, to dissipate stream energy.
- Remove competing vegetation only in small patches along a stream reach rather than in a continuous section.
- Use erosion-control cloth and other bioengineering approaches (Figure 16).
- Use herbicides and retain dead material to protect soil.
- Maintain untreated strips of vegetation along contours between treated areas.
- Maintain a heavy organic mulch on the soil surface, and place logs and other large woody debris perpendicular to the slope to capture any eroding sediment.

STEP 4. PLANT YOUR TREES RIGHT

Well-established guidelines for tree planting in forestry and horticulture generally are applicable for riparian plantings (see resources listed in “For more information,” page 32). However, special circumstances in riparian areas sometimes call for extra attention.

When to plant

- Plant bare-root seedlings during the winter dormant season, preferably when soils are above 40°F. Avoid planting during warm, dry, or windy weather or in dry or frozen soil or snow.
- Digging, lifting, and transplanting can be successful during more active growth periods (spring or fall), though little is known about suitability for this practice in southwest Oregon. This

Checklist for Step 4: Plant your trees right

Many problems with seedling survival can be traced back to improper care and handling of the seedlings, from nursery to the planting hole.

- Avoid problems by making sure seedlings stay cool and moist and by minimizing physical damage to them. This is critical from the time the seedlings leave the nursery, through transport, short-term storage, storage on site, and planting.
- Plant at the right time of year—during the winter dormant season for bare-root trees, and during fall through early spring for container seedlings.
- When planting, make sure the hole is deep enough and free of debris. Plant the seedling at the appropriate depth, with the roots in their natural position. Select suitable microsites for seedlings, such as the shade of logs or on well-drained hummocks.

usually requires retaining large soil and root volumes and/or immediate transplanting (“hot” planting). Planting during more active growth periods also is possible if irrigation is available.

- Container seedlings ranging from small plugs to ball-and-burlap stock can be planted fall through early spring. If soils are moist and warm

(above 40°F), fall planting may be advantageous since the seedlings’ roots may experience a significant pulse of fall root growth.

- Plant hardwood cuttings in the dormant season. Planting in late winter helps minimize the risk of loss to flooding.

Seedling care and handling

After trees are lifted or pulled at the nursery, they are vulnerable to damage throughout packing, transporting, storing, and planting. Many problems with seedling survival can be traced back to improper care and handling. Key concerns include:

- Roots dry out rapidly when exposed to the sun or wind. If roots appear dry, fine roots and root tips are likely damaged or dead already.
- When seedling temperatures exceed 42°F (and especially above 50°F for more than a few hours), they begin “growing in the bag”; i.e., respiring. This draws down their energy reserves, making less available for survival and growth after planting.
- Physical damage from crushing, dropping, or excess vibration, and from tearing roots when unpacking seedlings from bags or boxes.

Table 6 lists recommendations for seedling care and handling, focusing on bare-root stock.

Planting tools

Use the tool that is best suited to the seedling’s root system and to soil and site conditions.

For bare-root and plug plantings, a heavy-duty, reinforced shovel with a blade size matching the seedling root system works well. Other hand tools include the dibble and planting bar (suited for small plugs) and the hoedad (best suited for work on steeper slopes).

Table 6.—Checklist of seedling care and handling.

Stage	Recommended practice
Long-term storage (more than 3 days)	Store in a cooler at 33° to 36°F. Use packaging that prevents moisture loss. Most nurseries store and ship seedlings in waxed bags or boxes that “breathe” but prevent water loss.
Transporting from nursery	Use a refrigerated or insulated truck or reflective tarp (white exterior, silver-foil interior) over seedlings in an open-bed truck. Do not expose seedling containers to direct sunlight. Avoid using dark-color tarps, which build up heat. Travel during cool times of day if possible.
Short-term storage (a few hours to 3 days)	Store below 42°F (ideal temperature range is 34° to 36°F).
Transport to planting site	Use proper packaging for seedlings and reflective tarp. Do not transport seedlings in the open. Do not stack more than two bags or boxes high. When arriving at the site, store seedlings in shade. Do not take more seedlings than can be planted in 1 day.
At the planting site	The greatest risk of damage from moisture, temperature, and physical handling is at this stage. Handle seedling boxes or bags gently; do not throw or drop. Repair any tears with duct tape. Avoid rubbing or tearing roots when taking seedlings out of the storage bag and putting them in the planting bag. Do not cram too many in the bag. Seedlings may be dipped in water (for 1 minute at most) before placing in a planting bag, but do not store in water or the roots will die. Do not leave seedlings laying out on the ground, unprotected, and make sure the roots stay moist.



Figure 17.—Auger planting can be helpful for large stock types.

Tractor-mounted or hand-held power augers can work if the soil is not too heavy (clay) or rocky (Figure 17). Auger planting is especially helpful with large container stock. To plant very large stock or to open holes in especially rocky or gravelly soil, specialized equipment may be needed (Figure 18, page 18).

Contact the OSU Extension Service office that serves your county to find out about options for and availability of such equipment.

Planting techniques

A variety of tools and techniques are appropriate for planting tree seedlings as long as you accomplish the basic goals of:

- Opening a hole large enough to position the seedling roots naturally
- Positioning the tree straight and at the proper depth. Planting too shallowly is a common problem; the root collar (the point where highest root joins the tree stem) should not be exposed.
- Preparing soil of adequate quantity and quality to fill back around roots without debris or air pockets
- Refilling the hole and packing soil around roots, so that tree is held firmly but without compressing roots

Planting bare-root stock Figure 19 illustrates the standard technique for planting bare-root seedlings with a shovel or hoedad.



Figure 18.—The Stinger, an excavator with a boom-mounted dibble, is used to open planting holes and insert pole cuttings or large container stock. It is especially useful in rocky soils.

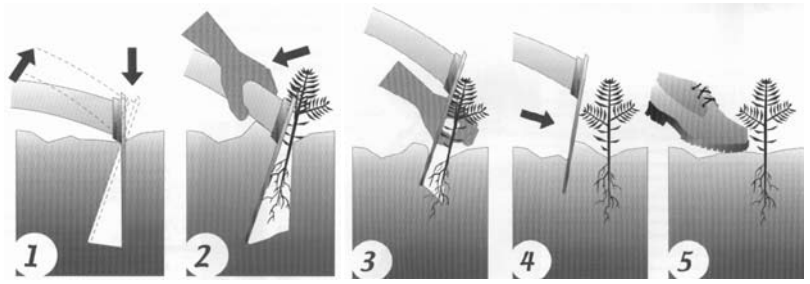


Figure 19.— Planting technique with a hoedad. From Rose, R., and P. Morgan, "Guide to Reforestation in Western Oregon," Oregon State University, 1992.

Planting plugs or container stock

Take care to keep the soil-and-root mass intact and ensure that it is well watered before planting. Prepare soil and open holes large enough to provide some free soil around the soil-root mass for unimpeded root growth. For larger plugs, augers may be needed to create sufficiently large planting holes.

Planting poles and other cuttings

Cuttings may be pushed into moist soil or planted in holes excavated with either hand tools or machinery, depending on the depth of planting and size of cuttings.

- General rules about care in handling, storage, moisture, and temperatures apply.
- Soaking in water for 1 to 10 days before planting is recommended for willow and cottonwood.
- Plant cuttings right end up (i.e., the buds point up).
- If possible, plant deeply enough that the bottom of the cutting is in the summer water table, or plan to do supplemental watering.
- Trimming some buds in spring may reduce transpiration and thus the plant's need for water.

Selecting the planting spot

Even within relatively narrow riparian areas, selecting specific planting spots can be important to minimize hazards. Whenever possible:

- On exposed south- and west-facing sites, plant in shade of debris, stumps, or logs.
- Avoid depressions that are subject to high water table or persistent ponding.
- In high-water areas, plant on hummocks and where soil is built up around rocks or debris.
- Where larger trees are to be retained, avoid overstory shade, or seek spots with more side light.
- Plant away from other shrubs or clumps of vegetation that are not going to be controlled effectively as weeds.
- Avoid planting on active wildlife trails, or plan for extra protection on seedlings in such locations.

AVOID THESE COMMON MISTAKES IN SEEDLING CARE, HANDLING, AND PLANTING

- Seedlings exposed to high or low temperatures during transport and temporary storage (leaving bags of bare-root trees in the garage for several days prior to planting is not a good strategy!)
- Seedlings not protected from drying out.
- Seedlings physically damaged by handling.
- Roots stripped when plants are pulled out of bundles.
- Branches or roots broken; trees hit or shaken during handling.
- Trees planted in unfavorable spot; e.g., on the south side of debris, in a wet depression, downhill from movable debris.
- Planting depth is too shallow (if the seedling root collar is exposed, the roots are not protected from drying out).

Other planting problems are illustrated in Figure 20.

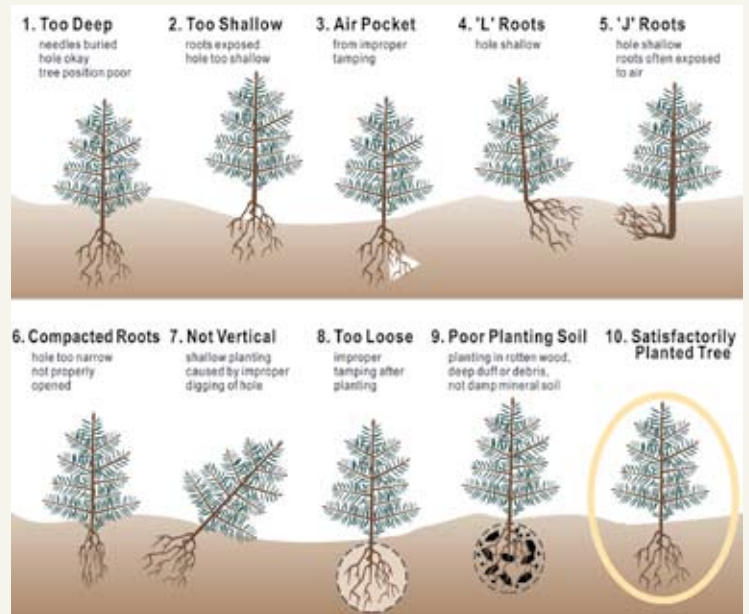


Figure 20.—Common tree planting problems. From Rose, R., and P. Morgan, "Guide to Reforestation in Western Oregon," Oregon State University, 1992.

STEP 5. TAKE CARE OF THE PLANTING

Maintenance weed management

Chemical Many people are reluctant to use chemicals or will use them only as a last resort. For many weed species and situations, however, judicious herbicide use is safe and extremely cost effective compared to other controls. Precautions are required to protect desirable plants and water in riparian areas.

Some herbicides are nonselective, meaning they will damage or kill any plants they contact. Various chemicals are available, however, with different selectivity and effectiveness on certain species or species groups.

Checklist for Step 5: Take care of the planting

Postplanting maintenance often makes the difference between success and failure of riparian plantings. Often, the single most important postplanting task is weed control, because sites can be rapidly occupied by competing vegetation, either from seed germinating on newly disturbed soil or from underground plant parts that resprout.

- Control competing vegetation using herbicides, manual or mechanical methods, mulching, or combinations of these methods. Good control of competing vegetation leaves more soil moisture and other site resources for seedlings.
- Minimize animal damage problems—whether from deer, elk, beaver, or other pests—by using seedling protective devices, fencing, or repellents. Plan ahead for this, based on the initial site assessment.
- Irrigate seedlings if needed to help them establish, especially water-loving species and on especially droughty soils. Consider the labor and expense involved, however, and whether the species can survive on the site over the long term without irrigation. Good weed control conserves soil moisture.
- Periodically visit the site to monitor seedling survival and growth and to assess maintenance needs. The first season after planting is the most critical, but maintenance may be needed for several years before seedlings are free to grow.

Some herbicides and/or their surfactants are toxic to aquatic organisms, and their use may have some restrictions.

Ask professional pesticide applicators or your OSU Extension office for current information on chemicals appropriate for your intended use.

Herbicide applications on forest land are regulated by the Oregon Department of Forestry, and on agricultural land by the Oregon Department of Agriculture. Land in other land-use categories may have different regulations. Contact the appropriate agencies for current information about buffer zones and restrictions on herbicide use near streams.

Here are some important points about using herbicides.

- Read the herbicide label and follow the instructions. The label is the law!
- Whenever possible, use formulations that are labeled for aquatic use. Note that toxicity of both the herbicide **and** the surfactant must be considered.
- Mix herbicides well away from riparian zones.
- Wear protective clothing and safety devices as the manufacturer's label instructs.
- Avoid spraying on windy or hot days (above 75°F) to minimize herbicide spray drift and risk

of volatilization (turning into a vapor). The risk varies with the herbicide.

- For herbaceous vegetation, spot-spraying or wipe-on techniques are suitable. Broadcast applications will seldom be appropriate due to the risk of drift.
- For woody vegetation, injection or cut-surface treatments can be appropriate. The Nature Conservancy's PVC applicator works well. A description and instructions for this are online at <http://tncweeds.ucdavis.edu/products/handbook/22.PVCapplicator.pdf>

See "For more information," page 32, for sources of more details on herbicide application and regulation.

Manual

Blackberries and other woody species can be cut back using chainsaws, brushcutters, and other tools. Grasses and forbs

can be removed (scalped) using a hoe. An area of at least 3 square feet around each tree is recommended (Figure 12, page 14); a larger area is better. Usually at least two treatments per season are needed because weeds regrow from root crowns or rhizomes. Manual treatments are labor intensive and therefore expensive unless labor is volunteer.

Mechanical

Riparian plantings can be designed for periodic mechanical maintenance including mowing and tilling. Adequate space between rows or planting spots is needed to prevent damage. It is essential that equipment operators know the locations of desirable plants. Accidental damage to planted trees during mechanical maintenance is very common, however. If planted trees are getting "lost in the weeds," that indicates maintenance is inadequate.



Figure 21.—Mulch mats underlie ponderosa pine seedlings on a dry site in southwest Oregon. Note the watering containers and tubing. Photo courtesy of Applegate River Watershed Council.

Mulching

Mulches commonly are used to suppress weeds around planted seedlings and to retain moisture into the summer. Various mulch materials have been used, including the following.

Weed mats Commercial products include Vispore, Pak, Brush Blanket, etc. Mats are made of woven synthetics, paper, or other materials (Figure 21). Longevity varies from one season to several seasons. Mats come in various sizes—e.g., 3 square feet—and larger is better. Mats are placed over scalped ground and fastened with landscape pins or with rocks and soil.

Mats are effective against grass and forbs but not sprouting woody vegetation. Their chief disadvantage is cost (75¢ or more per mat) and labor of installation. Newspapers, cardboard, and other low-cost alternatives also have been used as mats.

Organic materials Examples include straw and wood chips. These materials often are cheap and readily available (Figure 22). However, they are not as effective at suppressing weeds as mulch mats or fabric.

Animal damage control

In a recent survey,* animal damage was the second leading cause of plant mortality in riparian projects in the Umpqua, Rogue, and Klamath basins. Direct methods of damage prevention often are useful, but they also are expensive, and so the need for

**Statewide Survey of OWEB Riparian and Stream Enhancement Projects*. 2002. Anderson, M., and G. Graziano. Oregon Watershed Enhancement Board, Salem, OR.



Figure 22.—Organic material such as bark or wood chips is often used as an inexpensive form of mulch and weed protection.

protection should be carefully assessed. Note that all physical protection measures (fencing, cages, tubing, etc.) require periodic inspection and maintenance.

Using large planting stock and taking steps, such as good weed control, to promote rapid seedling growth will help minimize many animal damage problems.

Livestock

Young seedlings are palatable to most livestock (cows, horses, sheep, llamas) and can be heavily damaged if not protected. The best solution is standard woven wire or electric fencing to keep livestock out of planted areas.

Beaver

Where beaver are present, damage can be extensive, and prevention is a must. Protection measures include:

- Individual tree protectors such as 2- or 4-inch mesh wire cages
- Chickenwire or sheet metal loosely wrapped around larger tree trunks
- Fencing the area between the plantings and the stream

Removing the beaver may be an option; however, it is very likely that the site will be repopulated by beaver from adjacent areas.

Deer and elk

Young seedlings typically are browsed early in the growing season, when new shoots are tender. Browse heights range up to 3.5 feet for deer and 4.5 feet for elk, so the main tree stem will need protection until trees reach these heights. Area fencing must be at least 8 feet high to keep out deer and perhaps as high as 12 feet for elk.

Tree shelters (Figure 23) and plastic mesh tubing, supported with a bamboo or wooden stake, often are effective but expensive and labor intensive to install (\$3 to \$6 per tree installed). Big-game repellants (e.g., Deer-Away, BGR), applied about every 2 weeks in spring and early summer, are effective against lighter browse levels.

Bud-caps, made of Rite in the Rain paper, flexible netting, or other materials, are cheaper than tree shelters and sometimes prevent deer browse. Hardwoods and cedars are browsed heavily but pines less frequently.



Figure 23.—Tree shelters protect seedlings from several forms of animal damage but are expensive. Note: this tree needs better grass control.

Mice and voles

Most damage occurs during winter. Protections include:

- Good weed control, eliminating the heavy grass and herbs around seedlings that provide hiding cover
- Tree shelters
- Aluminum foil wrapped around the base of the seedling

Rabbits

Rabbits nip and clip seedlings. Protections include:

- Eliminating brush, heavy grass, and debris piles that provide hiding cover
- Using wire or plastic mesh tubes or tree shelters

Pocket gophers

Gophers can be a localized problem in pastures and meadows. Protections include:

- Good control of grass and herbaceous weeds across the planting area
- Gopher control with traps or poison

Irrigation

Irrigation can help planted seedlings survive southern Oregon's long summer drought as well as improve their vigor and growth. However, the need for irrigation should be carefully evaluated since it is time-consuming and expensive. In most cases, limit riparian plantings to species that will survive without irrigation beyond the establishment period.

While all plants can benefit to some degree from watering, good survival and growth can be achieved in many riparian projects *without* irrigation. This is particularly true for plantings of

upland species, which are adapted to southern Oregon summers. Species suitable for Zones 1 and 2 (see pages 7–8) will benefit most from watering.

In many cases, good weed control, proper planting technique, and planting high-quality stock of the appropriate species are just as critical to project success as supplemental watering.

Irrigation is most appropriate:

- When planting water-loving species such as alder, willow, and cottonwood, and the stock cannot be planted deeply enough to access mid-summer moisture
- For most species on very coarse soils (e.g., sandy or rocky) with minimal water-holding capacity
- If weeds are adequately controlled, or absent, and supplemental watering is needed to ensure survival or meet growth objectives
- During the first one or two growing seasons, to help seedlings establish. If irrigation is needed beyond this point, the plant materials' suitability for the site is questionable.



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August 2005

Figures 24a–b.—This project on Sterling Creek in Jackson County, used milk jugs in an intensive hand-watering system for the tree seedlings. Photos courtesy of Applegate River Watershed Council.

Irrigation methods

Hand watering Seedlings can be watered with buckets, 1-gallon milk jugs, etc (Figures 24a–b). This is labor intensive and most suited to small numbers of plants. Larger projects may employ a tank truck and pressurized hose, but this still is very labor intensive if there are more than a few dozen plants.

Drip systems Advantages of drip systems are the ease of watering once the system is set up. The chief disadvantage is the expense and labor of the initial installation.

Gravity-fed drip irrigation is seldom feasible on a large scale, due to the elevation drop needed. For example, to generate 20 pounds of pressure (a good target for a drip system), a 50-foot drop is needed. However, a 55-gallon drum or other storage container in an elevated position can water a few plants.

Gasoline- and battery-powered pumps are available. Conventional drip lines can water dozens of plants at once (Figure 25). After one to two growing seasons of use, the drip lines can be lifted and moved to a different location. However, weed growth over the surface may make it difficult to take up the line.

Water can be from the stream or brought in from off-site. If you plan to draw from the stream, you will need a water right. Contact the Oregon Water Resources Department for more information.



Figure 25.—Drip irrigation was installed in this newly planted area along Lazy Creek in Jackson County. Photo courtesy of Rogue Valley Council of Governments.

Deep pipes A 1- to 3-inch-diameter pipe (PVC or bamboo) is inserted 12 to 24 inches (depending on plant size and root depth) into the soil alongside the seedling. The pipe is filled with water at the time of planting and is refilled when it's empty. If the seedling is small, holes may be drilled in the pipe. The pipe is capped to keep out rodents and to reduce evaporation. This technology has been used successfully to establish plants in arid environments.

Soil amendments Materials that store and release moisture can be used as a soil amendment. For example, the material DRi-WATER consists of 98 percent water and 2 percent organic products (cellulose and alum); it breaks down slowly and releases water through the activity of naturally occurring soil bacteria. It reportedly has been used successfully in very harsh desert conditions.

Other options are water-absorbent polymers (also known as root-watering crystals, planting gels, and water-retention granules) which can be added to

the backfill soil when planting. They absorb up to 400 times their own weight in water, then slowly release it over time to make it available to plant roots. One study (Fisher 2004) indicates that these amendments can improve survival and growth in arid environments, but data from local field trials are lacking.

When to irrigate? How much?

For maximum benefit, begin watering before the onset of summer drought and high levels of plant moisture stress. For much of southern Oregon, this will be in late spring.

Plan to water each plant every 10 to 14 days, tapering off as summer progresses. Upland species in particular use drought stress to induce dormancy, a necessary process for winter hardiness; so heavy irrigation in late summer may be risky.

For smaller container seedlings and bare-root seedlings, give each plant 1 to 2 gallons per watering. Larger planting stock will need more.

Aim for a deep watering that thoroughly wets the rooting zone. Light, frequent waterings promote undesirable, near-surface root development. A slow watering, allowing water to soak into the ground rather than run off, is best.

STEP 6. MONITOR AND LEARN FROM RESULTS

Monitoring the results of your riparian planting project is essential in order to:

- Identify any immediate needs for maintenance to ensure that trees survive and grow
- Determine whether tree survival and growth objectives are being met (implementation monitoring)
- Determine whether objectives for riparian functions such as shade, water quality, and erosion control, are being met (effectiveness monitoring)
- Learn what specific treatments or techniques worked, and what didn't work and why, in order to guide future riparian restoration efforts
- Document project implementation for agencies that funded the project

Planning and documentation

Before implementing the project, think about what you want to monitor (e.g., tree survival, shade, bank stability). How will these be measured or evaluated? When do key monitoring tasks need to be done? What is appropriate given your objectives, time, skills, and budget? Develop a monitoring plan that addresses these questions.

Good documentation is essential. Prepare an overall project description including location, site conditions, site preparation, and maps and descriptions of planted areas to be monitored. Compile planting records and note what was planted, where, and how. Record all project

Checklist for Step 6: Monitor and learn from results

Monitoring is an essential part of a successful project, but in practice it is often neglected.

- Build monitoring plans into your initial project design.
- Plan to inspect the planting early in the first growing season to assess weed and animal damage issues, while there is still time to address them. Plan for one or more follow-up inspections during the growing season and at least annual inspections thereafter until the trees are free to grow.
- Document the project. Maintain a log of project activities and monitoring observations.
- Consider establishing one or more photo points to document and communicate change in riparian conditions over time. Also consider more intensive monitoring such as establishing temporary or permanent plots.

activities, by date, in a project log. Also note results from periodic visual inspection of the project. This will be very helpful in evaluating the project down the road.

Consider marking the locations of planted trees with surveying ribbon or wire flags. Although time consuming, this will make it easier to locate trees for needed maintenance and monitoring, and make it easier to see that crews don't damage or cut trees accidentally during release treatments.

Periodic visual inspections

This is the simplest and most important type of monitoring. The main purpose is to see how the plantings are doing and to decide what, if any, corrective actions are needed to make sure the trees survive and grow adequately to meet project objectives.

Plan for a visual inspection of the planting site at least once per season.

- Are grasses or other weeds encroaching upon or threatening to overtop planted trees?
- Is there evidence of browsing, girdling, or clipping of stems?
- What steps need to be taken to correct the problems?
- Are the trees vigorous and healthy?
- Are trees of some species, or in certain areas, doing better? If so, why?

Note your observations briefly in the project log. The most critical time for inspections is the spring after planting, while there is still time to do something about emerging weed or animal damage problems.

Photo monitoring A series of photos over time is a powerful tool for documenting starting conditions and changes over time. Establish markers (e.g., steel pins or rebar) for reference points (photo points) so these can be found in the future. Prepare documentation about photo points, including directions for relocation, and indicate the direction (compass heading)

the photographer is facing from the photo point. See “For more information,” page 32, for sources of detailed information about photo monitoring.

Other monitoring techniques

Various techniques have been developed to monitor riparian projects; see sources in “For more information,” page 32, for details.

Most riparian monitoring will focus on project implementation:

did the planted trees survive, and are they healthy and vigorous? What problems require immediate attention?

These questions can be addressed largely through periodic visual inspections. More intensive monitoring techniques can be used to provide quantitative information that is objective, repeatable, and statistically valid. These approaches are important for evaluating project effectiveness

but are expensive and time consuming to implement.

Regardless of the technique used, it’s important to follow a consistent format for recording measurements and taking notes on project conditions.

Appendix 5 (page 31) gives examples of common monitoring questions, objectives, and techniques.

Appendix 1. Key riparian functions, supporting vegetative conditions, and riparian buffer design considerations

Riparian functions	Vegetation conditions and functions supported	Riparian buffer design considerations
Shade to keep water cool.	Shrubs and trees on the sunny side of the stream. <i>Provide foliage to block sunlight.</i>	South and west sides of streams are most critical for plantings. Buffer size depends on stream size, slope, and orientation.
Stabilize stream bank to prevent erosion.	Trees and shrubs on the stream bank and (on small streams) in the active channel. <i>Roots hold soil, and stems slow water to reduce erosive force.</i>	A stream bend’s inside bank requires a smaller buffer; its outside bank requires a larger buffer to account for channel migration. Most of a buffer’s stabilization effect comes from vegetation within 25 feet of stream channel.
Filter nutrients and sediments to maintain high-quality water.	Trees and shrubs at the upland edge of the riparian zone. <i>Vegetation cover slows and filters water flowing from adjacent uplands. Plant roots take up nutrients from the soil solution.</i>	Sediment filtration depends greatly on slope, soil type, and other factors. A 50-foot buffer can provide substantial filtration of sediment from overland flow. Larger buffers may be needed to take up soluble nutrients and pesticides.
Retain gravel in the stream bed for spawning and formation of pools for fish.	Large trees falling into stream. <i>Woody debris lodged in stream bed slows and diverts water, causing gravel to accumulate. Water plunging over and circulating around woody debris forms and maintains pools.</i>	Most debris comes from trees directly adjacent to the stream channel. Landslides and debris flows also can provide significant debris inputs, depending on landscape conditions beyond the riparian area.
Input nutrients to enrich aquatic system.	Vegetation overhanging the stream. <i>Deposits leaves and twigs. Insects fall from vegetation into the water.</i>	Most benefits come from vegetation hanging over or directly adjacent to the channel.
Habitat for nesting, roosting, foraging, and other wildlife activity.	Dense areas of shrubs for nesting and hiding cover. Large live trees and dead trees (snags) for cavity nesters. Closed-canopy forest. <i>Provides a corridor for wildlife passage.</i>	Buffer width needs depend on habitat and species of concern. Large buffers needed if they are to serve as corridors.

Appendix 2. Factors to consider in site selection

The key factors to consider in selecting a site are stream size, stream channel characteristics, soil moisture and fertility, competing vegetation, and potential for animal damage.



Figure 26.—Channel stability is important in site selection. Here, an overly steepened bank was cleared of dense blackberry cover, then planted. That winter, high stream flows washed away about 10 feet of bank along with most of the planted trees. Several years later, as seen here, parts of the bank were still eroding.

Stream size

The ability to significantly influence riparian functions diminishes as stream size increases. For example, riparian plantings offer little shade on a river. Techniques suitable for small streams (e.g., planting close to the water) may not be feasible on larger streams and rivers due to channel instability and the potential for flooding.

Stream channel characteristics

Very wide channels may be unstable and subject to frequent floods that either wash away plantings or bury them in sediment (Figure 26). Such sites are

often poor candidates for riparian planting. Many streams in southwest Oregon, as elsewhere, have been channelized (straightened out), which has caused them to entrench (Figure 27). Establishing trees often is difficult on these sites. Options frequently are limited to planting next to the stream, where seedlings easily can be uprooted by floods, or planting on top of the terrace high above the stream, where plantings must be irrigated or limited to drought-tolerant species.

Plantings on steep banks often do poorly because of bank erosion or unfavorable soil conditions. The ratio of slope length to height should be 2:1 or greater on sites selected for planting. Steep banks can be regraded to lower angles and natural meander patterns can be restored, but this is very costly. Bioengineering techniques such as placement of

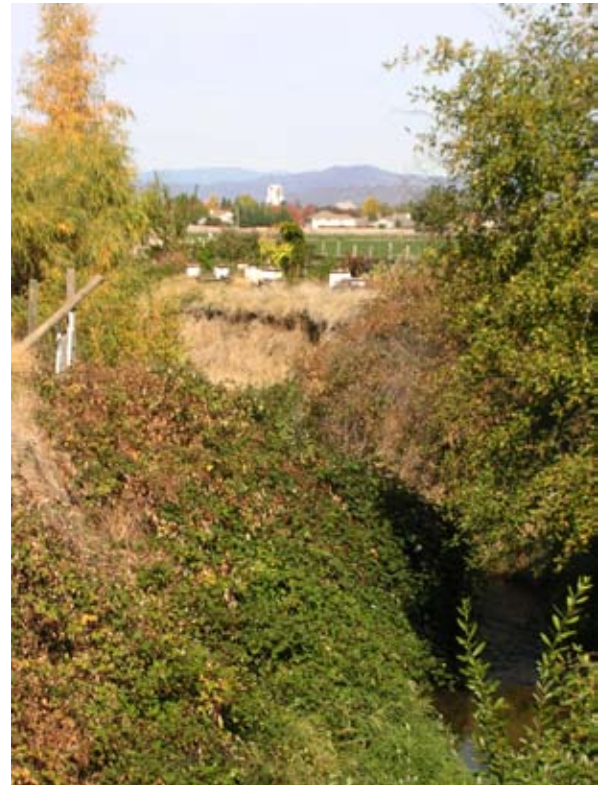


Figure 27.—An entrenched stream channel in an agricultural area on Jackson Creek, in Jackson County, dominated by Himalayan blackberry and reed canarygrass, with a lone alder at left. This is a tough site for a riparian planting because the top of terrace is very dry, the banks are too steep to plant, and plantings next to the stream are subject to frequent storm flows. Note the actively eroding cutbank.

brush or woody debris to deflect or slow water may also be appropriate on these sites.

On ideal planting sites, there will be enough time between heavy storm flows for vegetation to become established but still enough soil moisture and access to ground water to favor riparian species (Figure 4, page 4).

Soil moisture and fertility

Many riparian plantings in southwest Oregon are on extremely coarse soils that are droughty despite being close to water and are low in fertility (Figure 28). Planting in these soils may require using larger stock, summer irrigation, or both. Soil amendments, fertilization, or inoculation of planting stock with mycorrhizae (beneficial symbiotic root fungi) also may be appropriate.

Competing vegetation

Common weeds on southwest Oregon riparian sites include reed canarygrass and other grasses, forbs such as poison-hemlock and purple loosestrife, and Himalayan blackberry, a woody shrub. These and other weeds can overrun plantings easily if site preparation and/or maintenance is inadequate.

Potential for animal damage

Beaver and other rodents clip or girdle unprotected tree seedlings. Elk and deer browse unprotected seedlings. Sites with evidence of current animal use or a history of heavy use may not be good candidates for planting projects unless intensive protection measures are used.



Figure 28.—A low-gradient floodplain channel on Little Butte Creek in Jackson County. Challenges for riparian planting include coarse, droughty soils, channel instability, and low summer flows due to water withdrawals.

Appendix 3. Project design features and considerations

Buffer width – “Every little bit helps”

There is no one-size-fits-all buffer width. Wider buffers generally provide more benefits, but beyond a certain size there may be relatively little increase in benefit for a relatively large increase in buffer width.

Varying buffer widths are needed to support different riparian functions. For some functions, such as stream bank stability, relatively narrow buffers suffice. For others, such as uptake of soluble nutrients from farm land runoff, wide buffers may be required (Appendix 1, page 25).

Consider a variable-width buffer. Good places to have a wider buffer are on the outside bank of a stream bend, so that when the channel migrates the whole buffer isn't lost; and on low terraces and low-gradient reaches, to enhance bank stability and off-channel habitat where flooding is more frequent.

Buffer width on forest lands is dictated by the Oregon Forest Practice Act. On agricultural lands, there are no specific buffer-width requirements; owners must comply with local water-quality management plans established under Oregon Senate Bill 1010. Contact your local Soil and Water Conservation District to learn about local water-

quality management plans. City or county jurisdictions may have ordinances dictating buffer width.

Location

Providing shade on the south and west sides of the stream is particularly important for moderating water temperatures (Figures 29a–b). Trees on both sides of a stream are best for most other riparian objectives.

Access requirements

Provide access and adequate space between trees for any machinery to be used. Regular rows with adequate row spacing (6 to 10 feet) are needed for tractors and ATVs. Closer spacing and irregular tree distribution are OK if using smaller mowers, backpack sprayers, or hand tools.

Fencing and other livestock and wildlife controls

Both standard woven wire and electric fencing are adequate for domestic livestock, but they need to be maintained to prevent and repair breaches (Figure 30, page 29). Very carefully managed rotational livestock grazing can be compatible with riparian planting without fencing out the entire riparian area (but cross-fencing to establish multiple pastures is key).



Figures 29a–b.—Before (above left) and after (above right) installation of a riparian stream buffer on Beaver Creek, in Lincoln County. Trees were planted on the south side of the creek to maximize shading and to minimize loss of grazing land.

Deer and elk can jump easily over livestock fencing, so 8-foot or higher fencing is needed if you intend to protect plants from these animals. This can be prohibitively expensive; individual tree protectors often are used instead.

A chickenwire fence 18 inches high, placed between the stream and planted stock, keeps out most beaver and nutria.

***In-stream structures (rock, wood, other)
to direct water flow and prevent stream bank erosion***

Locate plantings in the specific areas that you expect will be protected by in-stream structures.

Species selection and mix

Plant trees and shrubs in the appropriate moisture zone (see Table 1, page 6). Normally, fast-growing hardwoods such as willows, cottonwoods, and alder will be planted close to the stream, and conifers and other upland species will be planted on higher terraces. The hardwoods will grow quickly to provide short- to medium-term shade, while the conifers will provide longer term shade and large woody debris.

Not much is known about the merits of planting clumps of each species versus uniform mixtures of species. However, if growth rates of two adjacent trees are greatly different, this may pose problems down the road as the slower growing species is shaded out. For this reasons, clumps of one species may be simpler logistically to install and manage. Plant conifers at least 15 feet from fast-growing hardwoods.

Spacing and distribution

Typical upland spacings of 10 x 10 feet and 12 x 12 feet probably are appropriate for riparian tree plantings. To account for possible mortality, more than one tree is sometimes planted in one spot. Closer spacings also are used to ensure more rapid dominance of planted trees over other vegetation, but this also will require early thinning. Shrubs can be planted much more closely than trees.



Figure 30.—Riparian buffer installed next to a farm field. A stream is at left, outside the photo frame. In this case, livestock fencing (at right in photo) is essential to the success of the buffer planting.

Appendix 4. Promoting natural regeneration

Promoting natural regeneration can help establish desired vegetation with less expense and effort than planting seedlings.

Other advantages of natural regeneration are that the species are genetically adapted to local conditions and, especially with vegetative reproduction, are set for rapid growth.

Greater reliance on natural regeneration also can increase the cover of desirable riparian plants without having to use intensive, soil-disturbing ways to control invasive species. However, conditions must be right for natural regeneration to occur. Natural regeneration alone generally cannot be relied upon to meet tree establishment goals for species composition or stocking.



Figures 31a–b.—Two seasons after cutting back Himalyan blackberry on this site (upper photo), sandbar willow (*Salix exigua*) has made a good recovery (lower photo).

Favorable conditions for regeneration of woody species include:

- Abundant soil moisture
- Freedom from excessive flooding
- Temporary freedom from vegetative competition
- Available sources of seed

Conditions for natural regeneration are most favorable after a major disturbance such as a flood. Floods can remove streamside vegetation and deposit fresh sands and gravels, which are ideal for germinating seeds of many riparian species.

Many riparian species also regenerate vegetatively, including resprouting from the root crown, root suckering, layering, and sprouting from stem fragments.

What can be done to enhance natural regeneration?

1. Protect plants from livestock or other animal damage by fencing or individual tree protection.
2. Release existing plants from competition. Killing or cutting back competing vegetation gives desirable plants more growing space, and they can respond rapidly. Often, more desired woody plants are in riparian zones than first meet the eye. These may need to be flagged before contract crews or volunteers begin cutting.
3. Stimulate root suckering, layering, and sprouting by cutting back competing vegetation twice per year. Black cottonwood (*Populus trichocarpa*) and sandbar willow (*Salix exigua*) both sprout vigorously from underground shoot buds on lateral roots. A temporary reprieve from competition can help these species move rapidly into previously unoccupied areas (Figures 31a–b).
4. Minimize cover of competing vegetation to stimulate germination and rapid early growth of seedlings of desirable species. A “rain” of seed often falls into riparian zones, but new plants can regenerate only under favorable conditions. Note that it isn’t important to eliminate invasives entirely, just to reduce their cover to low levels while desirable species get established.

Appendix 5. Sample monitoring questions, objectives, and techniques

Monitoring question	Objective	Technique
How many trees planted? Where?	Documentation for project funders, etc.	Include in project documentation and monitoring plan.
Are the planted trees threatened by weeds or animal damage?	Address any immediate threats to tree vigor and survival.	Visual inspection of planting area. Most critical time is spring after planting. Inspect at least once per season.
Are the planted trees vigorous?	Evaluate success of planting. Vigor is one criterion.	Visual inspection (qualitative) or intensive measurement (quantitative). Indicators of vigor include plant size, leaf size, bud size, needle length, leaf length, and foliage color. Timing: during the growing season.
Did the planted trees survive?	Implementation—determine overall success of planting.	Visual inspection (qualitative) or intensive measurement (quantitative). This can be simply walking the site to get a general sense of tree survival or can involve tallying every tree or a representative sample of trees to determine survival rate. Flagged tree locations can be very helpful at this stage. Timing: end of the growing season. The first growing season is often an important benchmark since most mortality is in the first year.
How fast are trees growing?	Implementation—determine overall success of planting. Also, determine how growth varies by planting site, species, treatment, and other variables.	Visual inspection (qualitative) or intensive measurement (quantitative) such as tree height and diameter. Height is less sensitive to effects of vegetative competition than is diameter. Thus, differences in diameter often are used to evaluate treatment effects, such as different site preparation methods.
Are the trees “free to grow”?	“Free to grow” is an important benchmark for project success. At this stage, trees can be expected to dominate the site without further intervention.	Free-to-grow trees are vigorous, not threatened by competing vegetation, and poised for further growth and site dominance without additional interventions. Determining whether a tree is free to grow is somewhat subjective in borderline cases. Timing: usually 3–5 years, or more, but is very site specific.
Are trees doing better in one area than another? Areas may differ ecologically (e.g., soils, drainage) or in treatments (e.g., site preparation).	Implementation—determine success of planting in each section. Also, learn about factors affecting plants on the site and what might be done differently next time.	Visual inspection or intensive measurement. Comparisons could be made on the basis of tree survival, vigor, and/or growth (height, diameter, stem volume).
What are the major reasons trees died?	Learn about factors affecting plants on site and what might be done differently next time.	Visual inspection or intensive measurements. Note any evidence of trees’ dying from overtopping/encroachment of competing vegetation, lack of water, lack of nutrients, animal damage, etc.
Is the riparian condition trend positive (e.g., is cover of desirable vegetation increasing)?	Effectiveness in meeting riparian objectives.	Photo monitoring or intensive measurement.
Did the project increase shade to the stream?	Effectiveness at meeting riparian objectives.	Photo monitoring may show increases in stream cover. Intensive measurements—e.g., with a solar pathfinder or fish-eye lens—are needed to quantify increases in shade.
Did the project reduce nitrate input to streams from adjacent farm lands?	Effectiveness at meeting riparian objectives.	Intensive measurements.

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To locate the watershed council in your area, visit http://www.oregon.gov/OWEB/WSHEDS/wsheds_groups.shtml

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