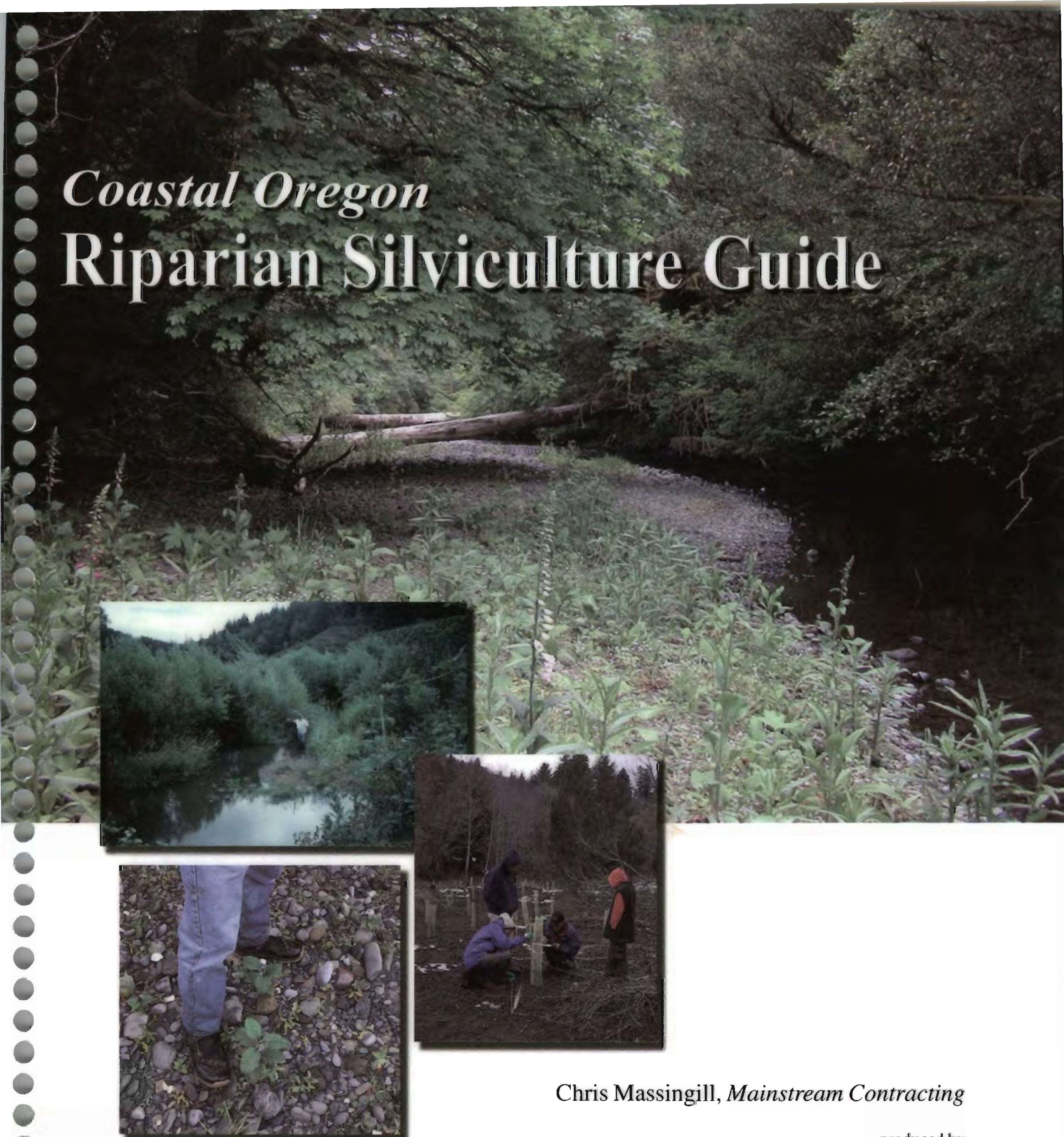
Coastal Oregon
Riparian Silviculture Guide



Chris Massingill, *Mainstream Contracting*

produced by
Coos Watershed Association

December 2003

Oregon Plan for
Salmon & Watersheds

Coastal Oregon Riparian Silviculture Guide

Chris Massingill, *Mainstream Contracting*; Monroe, Oregon

December 2003

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the Coos Watershed Association...

...is a 501(c)(3) non-profit organization whose mission is "to provide a framework to coordinate and implement proven management practices, and test promising new management practices, designed to support environmental integrity and economic stability for communities of the Coos watershed." The Association, founded in 1994, works through a unanimous consensus process to support the goals of the Oregon Plan for Salmon and Watersheds. Our 20 member Executive Council includes representatives from agricultural, small woodland, waterfront industries, fisheries, aquaculture, local government, environmental industrial timberland, and state and Federal land managers.

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Introduction

The amount of intact or functional riparian vegetation found along streams and rivers is a **key indicator** of the health of Oregon's riparian areas (SOER 2000). Restoration of these riparian areas, to improve both structure and function, is a common activity for watershed councils throughout the state, and is a primary goal of the Oregon Plan for Salmon and Watersheds.

Protection and restoration of riparian vegetation and stream processes is vital to recovering salmon stocks, providing cool and clean water for all uses, and dissipating stream energy in a safe and natural manner.

How to best recover or restore vegetation in degraded areas?

Many professionals recommend a passive approach from the start, especially when the cause of the degradation is otherwise addressed. However, active restoration may be needed where exotic species have been introduced or where seed sources or hydrologic functions have been altered. In these cases, and others, establishing desirable riparian species may require riparian planting.

> ***"A primary goal of riparian forest restoration efforts is to establish a sufficient number of trees to create forest conditions along a stream as quickly, efficiently and economically as possible. Managed restoration, including proactive site preparation and tree planting, as opposed to natural regeneration, is desirable and/or necessary at many locations because of a high local incidence of herbivores and/or invasive plant competitors, an insufficient quantity or poor diversity of local seeds for desirable plant species and a need to quickly restore habitat and water quality of the local stream." (Sweeney et al. 2002)***

Healthy riparian corridors:

- **provide shade**
- **filter sediments and toxic substances**
- **capture excessive nutrients**
- **maintain streambank stability**
- **stabilize floodplain soils**
- **provide energy inputs to food webs**
- **preserve floodplain complexity**
- **produce large wood for habitat structure**
- **provide riparian plant and wildlife habitat**

(SOER 2000; Riparian Management Work Group 2000)
(For more details, see pages 63-65.)

How to Use This Guide

This document is designed to provide guidance for active restoration by riparian planting, from determining where and when it is needed to assessing the planting project. It is not a "cook book" approach with prescribed recipes, but more describes options and considerations for a variety of situations.

Information presented in this guide was collected from local restoration groups (watershed councils, conservation districts, and landowners), planting professionals (contractors, agency personnel, industry groups), researchers (in published and unpublished literature), and monitoring data collected on actual projects.

The major concepts presented in this guide are:

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Setting Planting Objectives	***Why?***
Site Selection	***Where?***
Planting and Establishment	***What? When? How?***
Maintenance	***When? How Much?***
Monitoring and Assessment	***What Happened?***

Information Needed for Successful Planting Projects

In order to get the best match between site potential and objectives, and to have clear expectations for the restoration site, it is important to know:

- historic vegetation patterns
- historic and present land use
- historic and present channel conditions
- soil type and condition
- flood and low-flow information
- species suited to the site and to the zones within the site
- species available as wildling stock, cuttings, or from nurseries
- competing vegetation present, with locations and intensities
- wildlife, livestock, diseases, and insects on site

Skills Needed for Successful Planting Projects

In order to get the best performance from purchased or harvested stock, the following skills or resources are recommended:

- ability and facilities to properly transport, store, and plant stock
- ability to monitor planted stock for survival, vigor, damage, and competition
- ability to maintain sites in terms of competing vegetation and browse protection
- ability to map and/or document planted stock, planting efforts, and maintenance

Costs Associated with Successful Planting Projects

Costs associated with planting projects typically include:

- functional assessment
- site plan
- site preparation
- planted stock
- planting efforts and recordkeeping
- stock protection
- monitoring
- maintenance

It is important to have clear and realistic expectations of when and how a project will achieve its objectives. The survival of planted stock, as well as their growth rates, is dependent on site conditions, planting method, protection, and maintenance. The time needed for canopy closure, free-to-grow status, and increased shade are all dependent on the level of care provided, especially in the first few years following planting.

Notes

Setting Project Objectives

Determine Project Goals

Each landowner or watershed council must decide their fundamental goals for each site. Ultimately, project goals are determined by site characteristics, the condition of similar sites within the watershed (or the region), the overall condition of the entire watershed, the needs or constraints of noteworthy or special species, significant political or social situations, and the personal inclinations of the landowner or watershed council.

The most common priorities today are:

1. **protect** intact habitat
2. **reconnect** isolated habitat
3. **then restore** degraded habitat, beginning with hydrologic functions

While these goals are often pursued simultaneously, they may not be pursued equally.

> ***"Key elements to a landscape approach to salmonid recovery include:***
> ***(1) considering landscape scale biological processes such as metapopulation structure,***
> ***(2) landscape scale research, modeling and planning,***
> ***(3) inventory and assessment,***
> ***(4) prioritization,***
> ***(5) monitoring and adaptive management, and***
> ***(6) selecting projects that maintain and restore landscape scale processes."***
> ***(IMST 2002)***

Landowner-Specific Objectives

Riparian management objectives for individual landowners are typically at a smaller scale and use a more locally-oriented approach than watershed-wide functional assessments usually undertaken by watershed councils. Landowner objectives are often directly tied to legal compliance issues with state and federal agencies, such as with Senate Bill 1010 and the EPA 303(d) list of streams with water quality limitations. Landowners are increasingly expected to manage their properties in such a way as to not have a negative impact on water quality and fish habitat through the addition of sediment, increases in water temperature, or alteration of channels and floodplains. In many situations, landowners rely on watershed councils for expertise or labor in implementing restoration projects, especially in planting.

Some of the other more common objectives specific to landowners include:

- economic benefit through conservation easements from foundations and the Federal government (Conservation Reserve Enhancement Program)

> ***Noteworthy Considerations for Organic Farms and Special Forests***
>
> ***Objectives are much the same in the special case of organic farms, dairies, or ranches, though such settings require more care in implementation. For example, according to the Organic Alliance (www.organic.org), operators are not allowed to use a wide variety of inorganic fertilizers, pesticides, growth agents, or antibiotics, and must consider carefully the origin of seedlings, nature of mulches, and certain nitrogen sources.***
>
> ***In some situations, riparian activities might be subject to requirements of the Forest Practices Act. Local Service Foresters with the Oregon Department of Forestry can determine if projects are subject to regulations, and how they may be met.***

- reducing management difficulties with animals in riparian areas, such as stock falling in or getting stuck in mud, trespassing stock, parasites, etc.
- adding riparian trees and/or shrubs to act as shelter from sun and wind, providing cover in strong winter storms for livestock and prolonging periods of green forage under tree canopies during dry summers
- adding riparian vegetation to filter debris carried by flood waters, keeping flows within the channel rather than on farmed pastures and keeping debris out of fences
- tax benefits, such as those offered by ODFW and DEQ for riparian restoration/ protection projects
- planting species with commercial value such as alder or medicinal/edible "cash crops" (Bishaw et al. 2001)
- taking advantage of niche marketing for environment-friendly food production, i.e., the Salmon-Safe label
- planting in conjunction with soft engineering for bank erosion control
- garnering environmental benefits, such as better fish habitat, clean and cool water, erosion resistant banks, etc.
- social recognition as good land stewards
- aesthetics
- increased property value

Once site goals are set, the proper function of the riparian area needs to be assessed so that specific needs can be identified. Incorporating broad spatial scales is crucial in setting appropriate, attainable goals, as well as in properly understanding riparian functions and assessing specific site needs.

Incorporating Broad Spatial Scales

Taking a broad, systemic view of the watershed and its processes is critical to the overall success of restoration planting and the ultimate success of the project. A key part of that systemic view is identifying the cause of the initial degradation. Without taking a larger perspective of watershed processes, there is a risk of spending much time and money without addressing the *real* problem. For example, planting riparian conifers next to an incised channel does very little for improving salmon habitat or water quality when the fundamental problem is highly altered flow patterns and a disconnected stream and floodplain.

Objectives for riparian planting related to environmental concerns, such as shade, production of large wood, filtering of runoff, and noxious weed control, need to take a larger view of the watershed and processes that create and maintain healthy riparian areas in order to best address limiting factors (Benthrup and Hoag 1998; Borman 1996; Carlson et al. 1992). In any riparian restoration project, the causes of degradation have to be identified and addressed before initiating any intervention activities (Borman 1996; Briggs et al. 1994; Kauffman et al. 1997; Case and Kauffman 1997; Rickard and Cushing 1982). Several leading scientists in riparian ecology recommend addressing the causes of damage and then waiting a number

of years to observe natural healing processes before initiating restoration projects (Borman 1996; Briggs et al. 1994; Elmore and Beschta 1989; Kauffman et al. 1997; Platts et al. 1987).

The success or failure of a particular planting may be only part of the success of the entire project. Briggs et al. (1994) reviewed 27 riparian re-vegetation projects in Arizona over the previous ten years to evaluate the correlation between planting success and project success. They judged the projects against their own objectives, stated at the onset of the projects. The authors found that of the 27 projects, 19 successfully met their objectives; 8 did not. Of the 19 successful projects, 8 had greater than 20 percent planting survival and 5 had less than 20 percent planting survival. In 11 of the projects, natural regeneration was rated strong to prolific. Objectives in some projects were stated in such a way that survival of planted vegetation had little bearing on the success of the project. One riparian planting project, for example, was designed to improve habitat for resident fish by narrowing the channel and creating more diverse in-stream characteristics. **Although in many cases the plantings had virtually no survival, damaging land uses were stopped, natural regeneration occurred, and project objectives were met.**

Control of noxious weeds in our watersheds also benefits from taking a larger view of processes. Naiman et al. (2000) states that "...improvement of riparian ecosystem functions—including flooding, restoring surface and groundwater exchanges, and removal of anthropogenic disturbances such as grazing, timber harvesting, and roads—often reduces the need for frequent, expensive exotic species control measures or habitat substitution projects." One application of this concept related to riparian planting and control of noxious weeds is to aggressively plant sites with few or no noxious weeds, gradually move to moderately infested sites where control is feasible, and finally address more heavily infested sites once previous plantings are stable and free-to-grow.

Many Northwest streams have been stripped of large wood over the decades and have very few sources for gaining more wood (IMST 2002). Lowland streams are at least as likely as near-stream areas to have wood sources originating in uplands; landscape approaches to lowland restoration of instream wood must consider the entire watershed. Functional assessments help identify where large wood and long-term recruitment is most critical and which stream reaches are most likely to respond to enhancement.

Assess Current Riparian Condition

Assessments are extremely helpful in determining what activities to plan first to get the best value for the effort.

In any planting project, it is important to assess early in the course of action how well the physical processes of the stream are currently working. The movement of soil and water over the landscape follow predictable patterns and are controlled to varying degrees by streamside vegetation. In lowland systems, vegetation typically plays a very large role in determining and stabilizing stream functions. It is important to question, before the project begins, if stream processes are stable enough to allow planted stock to remain and flourish—or if planting is needed at all. In many cases, regeneration occurs naturally after disrupted stream processes are restored. Such natural regeneration often results in populations that are more dense and robust than could have been planted.

Defining "Proper Function"

According to the recently adopted *Oregon's Statewide Riparian Restoration and Management Policy* presented to the Legislature's SR2 committee in May of 2002, "Ensuring the integrity and continuity of riparian functions where possible will be central to developing a landscape approach to riparian restoration and management. The policy emphasizes the need to sustain the functions of riparian areas across the landscape." In this policy, the definition of proper functioning condition from the Bureau of Land Management is used (emphasis added):

*"**A riparian area is considered to be in properly functioning condition** when adequate vegetation, landform, or large woody debris is present to:*

- *dissipate stream energy associated with high water flow, thereby reducing erosion and improving water quality;*
- *filter sediment, capture bedload, and aid floodplain development;*
- *improve water retention and ground-water recharge;*
- *develop root masses that stabilize streambanks against cutting action;*
- *develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses;*
- *support greater biodiversity.*

The components of this definition are in order relative to how processes work on the ground." (Prichard et al. 1998)

Establish Reference Points

In order to understand how well a stream and riparian area are performing these functions, it is critical to understand how they functioned in a less-altered state, called the potential condition, or reference condition. Reference-based methods for assessing riparian functions are discussed by the National Research Council Report *Riparian Areas: Functions and Strategies for Management*, released by the National Academy Press in 2002 (emphasis added):

*"Three referenced-based methods may be particularly useful—Proper Functioning Condition (PFC), the Hydrogeomorphic Approach (HGM) and the Index of Biological Integrity (IBI). All are oriented toward **evaluating the condition of ecosystems** by comparing the project site with conditions expected in the absence of human activities or in least-disturbed sites. Once methods are developed in the form of guidebooks (for HGM) or indices (in the case of IBI), their application is relatively straightforward. PFC is the most rapid assessment in that it is conducted in the field and the results are 'immediately' known. While PFC is qualitative and dependent on the knowledge and judgment of a team of experts, HGM and IBI are based on quantitative data gathered and analyzed from unaltered to degraded sites prior to the assessor involvement (although the collection and analysis of such data require considerable expertise). Unlike PFC, neither HGM nor IBI was developed primarily for riparian areas, and both would require modification in their approaches to data collection and analysis."* (National Research Council 2002)

Using Reference Points To Set Objectives

In a PFC assessment the potential condition of the stream is **discussed** and **described** and used as a reference point for determining present condition. Potential functioning is explored *via* historical photographs, documentation of species present, remnant vegetation (or evidence of it), examination of soils, historic landforms, and knowledge from individuals with long-term history of a site (Prichard et al. 1998). HGM **measures** habitat features from reference sites within the area and then compares measurements of similar features from degraded sites. In both methods, the level of function is determined by the amount of departure from the reference sites.

Quantifiable project objectives can be easily drawn using any of these three assessments (by targeting "no" answers on a PFC checklist or low scores on HGM or IBI assessments). According to Lisa Lewis, Soil Scientist with the National Riparian Service Team, the best approach for restoration is to **"observe and mimic in order to accelerate."** Her favored sites for restoration, whether in uplands or in riparian areas, are those where natural recovery processes have already begun and ecological "momentum" can be utilized (Lewis personal communication 2002). One example of this approach would be observing willow establishment in sand substrate behind instream wood, then using that observation to guide your placement of additional cuttings or seedling of similar species in similar microsites.

> ***The assessment of current watershed processes and functional conditions is critically important when prioritizing protection and restoration activities. Assessments highlight processes that are working well and focus attention on the processes that need help.***
>
> ***Water quality and quantity can be limited in a variety of ways, from a variety of sources. For example, bank stability may fail because of changes in stream-bed level lower in the system, from disturbance to bank-holding vegetation, from imbalanced water/ sediment delivery due to upland land uses or events, or a combination of all these. Each scenario has a different approach for restoration and different implications for planting projects.***

Use Historic Pre-settlement Conditions to Guide Restoration

"Remnants of intact riparian systems and stream habitats are extremely important and should be conserved." (IMST 2002)

Although it can be daunting, understanding the potential functioning condition of any stream reach or watershed is necessary for matching desired conditions to current conditions. For example, it is very important to know what communities were present before intensive agriculture and mechanization altered the watershed while deciding which species to plant at what densities (Borman 1996; Hoag and Benthrup 1998; Carlson et al. 1992). Species chosen for planting might be ill-adapted for current conditions, or might simply represent an intermediate stage of what could be supported under current conditions. Investigations into potential functioning or historical conditions can provide insight into the amount of floodplain needed to provide critical habitat, especially when combined with watershed size, stream size, and hydrologic alterations.

Remnant riparian communities and pre-settlement records are critical to understanding and creating riparian plant associations that most closely mimic historic conditions. Formal detailed plant associations are often available for upland forest and grassland communities, but few exist for riparian areas. Our best information can come from walking through local intact areas, making notes of species, amounts and types of wood present, and what seedlings are prevalent in which microhabitats.

In the South Fork Coos Watershed Analysis, notes from General Land Office (cadastral) surveys of the late 1800s were interpreted and combined with soils information to produce maps of probable historic community types. Though somewhat general, such information can be very useful in identifying species or types of plants that were in a given site, "should" be there, or could exist there now. Historic community types have been similarly identified for most of Oregon and have been mapped for coastal areas (Christy et al. 2003).

In watershed council situations, the planting patterns used are generally a blend of historical information, present conditions, reference sites, and opportunities that simply arise. Historic photographs are also often employed, as well as accounts from long-term landowners. In some cases, however, planting sites and species selections have been much more opportunistic—sometimes based solely on what plants were available (or donated) and on which landowners were willing to participate.

Determine Project Timelines (Rates of Recovery)

When planting is part of the riparian restoration plan, decision-makers will need to:

- ***select sites for planting***
- ***plant appropriate species and ensure their establishment***
- ***maintain plantings***
- ***monitor planted sites and assess project success***

Adequate planning will require familiarization with each of these important aspects of riparian restoration before embarking on the project.

Clearly articulated project objectives are also key to accurately determining project timelines. The rate of recovery is governed in passive restoration projects by the plants available on site and by the function of regeneration processes. In active restoration/ planting projects, rates of recovery are more closely tied to:

- site preparation
- care of the seedlings in the initial years
- condition of the soils
- control of competition
- herbivory
- the appropriate match of species to sites

Plant growth, not just survival, must be considered in time-line projections for shade production and large wood, as exemplified in the following case study:

In a study of deciduous tree reforestation in Maryland, data on survival and growth suggests that tree shelters and herbicides (Roundup®) are the most effective tools for rapidly achieving forest canopy closure over small streams (in less than 15 years) in areas with high vegetation competition and heavy deer predation.

Combinations of bareroot stock and container stock, and of mowing, weed mats, herbicides, and tree shelters, were investigated in a carefully designed four-year project. Three species of oak were used, as well as river birch and red maple. Survival was substantially lower in the unsheltered trees, both in the first and fourth years into the study. Seedlings planted with shelters and treated with herbicides had growth rates 2.1 times higher than the seedlings with no weed abatement, and 18 times higher than seedlings with no shelters in herbicide plots. Sheltered trees with weed mats had survival of over 50 percent after four years, but growth was considerably slowed; crown closure was estimated at about 25 years, rather than the 15 years projected for trees with shelters and herbicides. Survival for sheltered trees with mowing treatment at four years had survival less than 30 percent, and sheltered trees with no weed abatement had less than 20 percent survival. All plots were plowed and disked before planting (Sweeney et al. 2002).

According to Dr. David Hibbs, Oregon State University Forestry Department, the answer to all risks to riparian silviculture, with the exception of beaver, is vigorous and rapid growth (personal communication 2001). With the proper site selection, preparation, stock care, protection and release from competition, a Douglas-fir can double in height each year, producing a six-foot-tall free-to-grow individual in as little as two years. Good quality alder seedlings, planted in well-prepared sites, are expected to have 1-2 meters of height at the end of the first growing season (Peterson et al. 1996).

Define Project Success

How will you know when you've succeeded?

Specific, measurable objectives should be drawn from the consideration of the elements presented in this chapter: site characteristics; the conditions, needs, and constraints of the site and of noteworthy species; the realities of political, social, and fiscal situations; and the inclinations of the landowner or watershed council.

Such objectives are often required by granting or permitting agencies, and should be noted in the planting project summary (see Appendix B).

Those objectives should be recorded for reference for the duration of the project, for it is by comparing the differences between the pre-project condition and the post-project condition with your initial objectives, tempered with observations of outside and unforeseen affects, that will indicate the project's success.

Examples of short- or mid-term objectives that are specific and measurable include:

- 80% of the initial blackberry population replaced by native shrubs
- 30% increase on the amount of shade over waterway
- 50% reduction of active stream bank erosion

Notes

Site Selection

Determine Suitable Areas for Revegetation or Supplementation

Once a particular stream reach or tributary has been identified as a good candidate for planting, the next task is to identify areas within that reach that are "plantable." Factors to consider include legal or economic issues (such as CREP or OWEB guidelines), microsites within the reach that are favored for particular species, and risks to planted stock such as predators, competition, and distance to water.

> ***"Disturbance frequency and moisture gradients play key roles in determining the vegetative composition of riparian areas, and are associated with riparian landform. Distinctive communities occupy floodplain, low terrace, and high-terrace landforms along smaller channels...However, no physical factors can explain the vegetative differences between these landforms and adjacent hill slopes, suggesting that biological factors (e.g. competition, herbivory, disease) become increasingly important with small increases in elevation (and decreases in disturbance frequency) from the channel."***
> ***(Naiman et al. 2000)***

Establish Width of Planting Area—Available/Desirable/Required

The boundaries of the planting area are determined by the water's edge and, generally, by fencing or other barriers that exclude livestock from the area. The width of the planting area ("setback") is the distance between the water's edge and the boundary upslope from it.

Riparian planting width is a concept that has caused considerable debate in many arenas. Determining how far from the stream is adequate to reestablish riparian vegetation is a complex issue involving many factors. The central question is: ***How wide does the planting area need to be to achieve the desired riparian function and to allow natural community development?***

Some funding sources, such as the Oregon Watershed Enhancement Board (OWEB) and the Conservation Reserve Enhancement Program (CREP), have standard formulas to determine minimum widths. The OWEB *Habitat Restoration Guide* links riparian planting with fencing and strongly suggests considering long-term channel migrations in "fence and plant" projects. For some channels that are confined by bedrock or other naturally resistant material, fencing can be placed very near the high water mark. In more alluvial situations, fences and newly planted stock should be placed far enough away to allow for natural regeneration and avoid damage from floodwaters. In incised channels, OWEB suggests placing fences at a minimum of two times the bank height plus ten feet. Suggestions made in the *Habitat Restoration Guide* become requirements for projects funded through OWEB.

The CREP program requires an average setback width of 35 feet as a minimum and allows up to 180 feet, encouraging restoration of stream hydraulic and geomorphic processes. In very wide alluvial valleys, riparian setbacks may be set at a percentage of the entire valley bottom. The Independent Multidisciplinary Science Team (IMST 2002) recommends varying riparian buffer width, considering the width of the flood-prone area, stream size, and/or watershed function. Buffer widths should accommodate the desired processes identified by the functional assessments.

Zone D is well within the active channel, with exposed mineral soils. Contact with the water table is typically very good, even during dry seasons. Competition for light is very low, as is soil compaction. Floodwaters cover this area frequently, and with considerable power.
Typical species – shrub-form willow, alder, and possibly ash in slower water areas.

Zone E is often a steeply sloped or vertical surface that is subjected to the strongest stream forces; includes outside meanders and bends. When fully vegetated, light competition can be intense. Natural regeneration may be limited on the most steeply sloped sites.
Typical species – willow, alder.

Zone F is typically beyond the bankfull width, although it will be impacted by storm energies during high flows. Though competition for light is high, plant roots have access to sub-soil water from hill slopes. Soil quality is good, with low compaction.
Typical species – often more upland species such as elderberry, salmonberry, maple, twinberry, as well as conifers such as cedar, hemlock, spruce, or fir.

Identify and Resolve Potential Hazards and Risks

The best, least expensive, and most effective time to manage hazards and risks is before planting, notably, during project planning, site selection, and site preparation. At the very least, being alert to potential problems will make their detection—and subsequent resolution—more likely. Successfully resolving those hazards and risks during the duration of the project will be key to the project's success. **Many hazards and risks can be avoided or lessened by critically selecting sites with lower potential risk, followed by conscientious planning.**

Potential hazards arising from planting projects include increased overland runoff from areas cleared for planting and increased overbank flooding as vegetation recovers and captures sediment. Platts et al. (1987) states strongly that new seedlings and transplants cannot be established amid an existing competitive stand of plants (including grasses), but that complete elimination of the existing stand could be an unnecessary effort and pose excessive risk for increased erosion. These hazards must be considered when planning restoration projects, when making species selections, and in discussions with landowners.

Risks to the vigor and survival of planted stock, even in the best sites, come in a variety of forms, including competition from existing and potential vegetation, herbivores (of all kinds), insects, and diseases.

Again, according to Dr. David Hibbs, OSU Forestry Department, the answer to all risks, with the exception of beaver, is vigorous and rapid growth (personal communication 2001).

Possible risks to riparian plantings include:

- amount of competition from existing vegetation and planting stock tolerance for shade and drought (Emmingham et al. 2000; Platts et al. 1987; Svejcar et al. 1992)
- expected rates of growth from planted stock, relative to competing vegetation (Tu et al. 2001)
- small mammals girdling trees, especially in areas with thick vegetation surrounding seedlings
- beaver damaging or removing trees; beaver ponds drowning trees
- deer and elk browse, especially in exposed trees
- human traffic patterns (vehicles, maintenance activities, trespass/vandalism)

- trespass grazing and fence integrity
- insects
- diseases, both existing on site and those from nursery stock
- location of trees relative to eroding banks (outside bends of channels)

Identifying the cause of mortality and loss of vigor is often clouded with multiple possibilities and interactions; for example, risks of disease and insect damage increase with lowered tree vigor. Vigor can be challenged by soils, wind, competition, browse, handling of seedlings, mechanical/ herbicide damage, disease, and insects.

Watershed council members recommend talking to landowners to determine what planting-threatening animals are present, where and when overbank flooding occurs, and what human traffic patterns are involved (mowers, equipment, trespass/vandalism). Some landowners are actively planting their own riparian areas, often without the help of the watershed councils, and can provide very specific and local information.

The willingness and participation of the landowner is a factor that must be considered. Frequent monitoring of fence conditions and animal access takes commitment that some landowners are not willing to make or are unable to fulfill.

Wildlife

Predation on small seedlings and cuttings is a very large concern with nearly all riparian planting projects, most often involving beaver, elk, deer, cattle, and/or small mammals. Bishaw et al. (2001) reported that beaver damage was considerable on their Central Oregon Coast project, requiring that a majority of the stock be replanted. Harkelroad (2000) had similar comments in his status report for the Umpqua National Forest. Newton and Cole (1998) reported that their riparian planting projects suffered significant losses due to beaver, boomers (mountain beavers), elk, and deer.

Animals are active, natural modifiers that can and do alter landscapes, biochemistry, and succession, with long term effects (Naiman et al. 2000). For example, deer that selectively browse on hardwoods and more palatable conifers will promote site dominance by species that are less palatable or are more browse-tolerant; i.e., deer may favor alder, willow, and western red cedar for browse, allowing Sitka spruce to dominate, effectively altering most of the major processes of that site for decades—or even centuries. In another case, alteration of water level in small streams by beaver may exclude less flood-tolerant species and favor more opportunistic and wetland species.

Beaver can impact planted stock in a variety of ways. Beavers' primary threat is to bite and remove newly planted stock, but they will also girdle or fell established stock. Beaver ponds may drown mature trees and seedlings. Some councils densely plant willow cuttings next to the channel as "sacrificial plants" in order to deter beaver predation on more expensive rooted stock.

Deer and elk typically favor Douglas fir and cedar, and avoid spruce trees. One council member remarked that Vexar tubes were like "diner open" signs for deer and elk. Hyatt et al. (1991) observed that for planted western hemlock seedlings, damage due to small mammals increased as cover increased. As cover was reduced, damage from deer increased.

Small mammals, typically voles in heavy grass cover, are a very real risk to a seedling during the first few years, often completely girdling tree stems. Duddles and DeCalesta (1992) describe evidence of vole predation as small scratch-like marks on the outer bark of young trees, typically very low on the stem. Voles are highly dependent on cover for protection from predators and can be effectively excluded by clearing vegetation from around seedlings or wrapping stems with foil.


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Vole damage on young tree stems can be reminiscent of scaring made by line or blade trimmers.

Livestock

Few watershed councils will plant trees in grazed areas without a functional fence to protect planted stock. Recovery of streams through natural processes after exclusion from heavy cattle grazing is well documented (Kauffman and Kruegar 1984; Case and Kauffman 1997; Rickard and Cushing 1982). The literature on the role of livestock grazing in riparian *planting* projects is much more limited. In most planting projects, it is assumed that planting stock is protected from browse and trampling—at least until the plants are above competition and browse and are free-to-grow.

Conroy and Svejcar (1991) documented that the proximity of planted willow cuttings to the stream channel had more impact on planting growth and survival than did the amount or timing of use by cattle. In a project on Beaver Creek, on the central coast south of Newport, Oregon, exclosure was one of the many treatments used to establish free-to-grow alder stands. Riparian setbacks as well as "clump" fences were tried on that project with variable success (Rogers personal communication 2002).

Damage by cattle has been and will continue to be a large problem in planting success. Riparian areas, especially on larger streams and rivers, are difficult to fence effectively from either resident or neighboring animals, and fences in riparian areas take a greater amount of maintenance than fencing in upland areas. Blackberries and other brush cause "shorting-out" in electric fences, and the more permanent sheep fences or woven-wire fences are prone to catching flotsam during floods and washing out. Sheep and goats are notoriously difficult to keep confined, and they can do great damage in a very short amount of time. Even one animal trapped on the wrong side of the fence for a few days at the wrong time of the year can remove huge amounts of biomass, damage leaders, trample stems, and even pull entire plants out of the ground. Planters and landowners alike must take fence integrity very seriously, carefully considering stream flooding, flow of debris, animal type and behavior, as well as the level of commitment from the owners for the time and resources needed for repairs.

Competing Vegetation

In some cases, depending on the level of participation of the landowner, temporary fences can be very effective in giving young plants the protection they need until they become free-to-grow. Electric fences have been problematic enough that some watershed councils will not use them. However, on other projects with committed, involved, and active landowners, electric fences have been highly effective. Planting projects on larger rivers may be more challenging, if not impossible, to protect when neighboring cattle use the riverbed as a highway.

Fencing is not the entire story, however. In coastal watersheds, especially on

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the south coast, it is common to find fencing and planting projects only a few years old where newly planted trees—and sometimes even the fence—are completely overtaken by blackberry canes. Livestock grazing is a very effective control of blackberry expansion; ceasing grazing without weed control may greatly hamper restoration efforts. In a monitoring report for the South Coast Coordinating Council (Ricks Myers 2002), competition from blackberry stands was mentioned in 25% of planting failures; damage due to livestock was listed for 24% of planting failures. Increased planning, site preparation, maintenance, and costs are required when dealing with all noxious weeds, but particularly with blackberry and reed canarygrass in riparian zones. Poor maintenance and follow-through in riparian fencing and planting projects with noxious weeds can sometimes result in problems for restoring native species that are larger than those caused by uncontrolled grazing.

Insects and Diseases

Insects and diseases in forests and planted stock are common problems in Oregon, though they are more likely to decrease growth rates than to increase mortality. Trees often succumb to insects and disease due to increased stress of some kind, such as drought, competition for resources, or injury (Filip 1999; Filip et al. 1998). Infection and infestation problems are usually best approached by encouraging strong vigor in planted stock, so that the tree can better survive—or even ward off—such invaders. However, planting susceptible stock in areas known to harbor Port Orford cedar root rot and sudden oak death should be avoided. (See table 2, following page.)

Insects and diseases have been a minor concern for planting success for watershed councils, especially when compared to competition and predation. However, watershed councils should be aware of which diseases are present in certain areas, such as organisms attacking Port Orford cedar on the south coast, and causing Swiss needle cast in the north coast. One creative solution to the problem of deer browse on the north coast was to plant a western red cedar and a Sitka spruce in the same hole. The spruce offers protection from browse while both are young. Spruce budworm activities eventually keep the spruce leaders short and bushy while neighboring cedar grows tall.

Table 2. Examples of common diseases and pests in coastal Oregon.

forest pest	stock affected	management/control
laminated root rot [1]	All conifers, worst in Douglas fir, grand fir, and mountain hemlock.	Prevention—favor resistant trees at planting or thinning.
Port Orford cedar root rot [2]	Port Orford cedar	Avoid planting near streams.
sudden oak death [3]	A wide variety can be infected including bigleaf maple and Oregon myrtle. Known to be fatal to several species of oaks and evergreen huckleberry.	On south coast only. Avoid planting susceptible stock in areas of known infestations.
western tent caterpillar [4]	Most deciduous species	Generally none since population typically moderates after 2-3 years. Mortality is rare.
Sitka spruce weevil [5]	Sitka spruce	Prevention—favor resistant trees at planting or thinning, encourage new leader by trimming all but best top lateral branch. Plant trees close together to stimulate height growth.
spruce aphid [5]	Sitka spruce	Prevention—thin host trees in dense stands, encourage non-host species in mixed stands.
Swiss needle cast [6]	Douglas fir only	Avoid planting Douglas fir in "Spruce Zone" near coast or in areas with known infestations.

[1] **(Filip 1999)**
[2] **(www.fs.fed.us/r6/nr/fid/mgmtnote/pocrr.pdf)**
[3] **(www.oda.state.or.us)**
[4] **(www.odf.state.or.us/fa/FH/fhn.htm)**
[5] **(Filip et al. 1998)**
[6] **(www.odf.state.or.us/fa/fh/snc98/snctxt.htm)**

For more extensive information, refer to Filip (1999) for descriptions of root diseases and Filip et al. (1998) for forest insects. These publications are available from your local OSU Extension office. The Oregon Department Forestry, Forest Health Program web site, and the Forest Disease Management Notes (FDMN) are available through the US Forest Service, Pacific NW Region web site **(www.fs.fed.us/r6/nr/fid/widweb/wid-rots.shtml)*****; and the Department of Agriculture, Plant Division web site, have detailed information on sudden oak death.***

Planting and Establishment

Planting stock selected will depend on the project objectives, the site's expected "natural" populations, the site's current conditions, the stocks available, as well as the budget for purchasing, planting, and maintaining the stock. Planting success will be determined by the quality of site preparation, the density of the plantings, the care taken in handling the stock before planting, the actual planting techniques used, and the protection measures taken to protect the newly planted stock as they become established.

> ***In designing our planting projects, we should strive for the natural plant composition found on similar landforms in nearby intact riparian areas, knowing that it may take many years and several phases to achieve. In areas with no reference sites or intact communities, historical reconstructions combined with soils information can provide some guidance.***

Select Model

Choosing the model or pathway that best fits the natural processes of the project site will help determine which species are most appropriate for re-vegetation efforts. The two different models of riparian development presented here show different ends of the disturbance spectrum.

Disturbance Recovery Pathways

In the disturbance recovery (or developmental) pathway model, Naiman, Bilby, and Bisson (2000) describe how lowland streams and rivers in the Pacific Northwest recover after a "system resetting" event. Such an event may be a large flood following an intense upland forest fire, the breaching of a landslide dam, or multiple simultaneous landslides. In this scenario, entire reaches may be scoured of vegetation, with large volumes of sediment deposited with a multitude of large wood pieces. Stream channels are very exposed, braided, and loaded with a wide variety of sediment sizes. Some of the very large wood pieces deposited within the channel borders will "stick" and begin altering local stream flow. Areas of coarse sediment will develop upstream of the wood, and smaller sediments are deposited within and parallel to the wood, creating nicely protected microsites for vegetation. Riparian plants quickly claim the site and begin stabilizing sediments captured from the channel. The original wood pieces are sometimes buried or obscured by the developing island. Vegetative development will radiate from these new islands, effectively narrowing the channel, covering the stream banks, and shading the water surface. What appears to be a large riparian forest patch may be the result of many islands or smaller patches of vegetation that merged together after the large disturbance. Forest islands may grow at more than 500 square meters per year (Naiman et al. 2000). Diversity within the riparian patches may be due to many factors, including the founder effect (what got there first), level of protection from selective browse by predators, various needs for shade or nurse logs, or specific substrate requirements of the different species.

Successional Pathways

The second developmental model is more typical of lowland streams and rivers between large events. As channels migrate across floodplains, they erode outside bends and deposit on interior bends. These new deposits are actively colonized by riparian vegetation. As riparian vegetation matures, it plays a more active role in slowing water, capturing sediments, and developing a floodplain. As the channel moves farther away, terraces or interior floodplains get

In our managed coastal landscapes, the presence of noxious weeds or livestock grazing often obscures the "window of opportunity" for natural regeneration in hydrologically intact streams. In streams that are out of balance in regards to stream energy, sediment and/or large wood, and in channels that are disconnected from their floodplain, there may be no "window" at all.

"higher and drier" and are more removed from the intense scouring energies immediately adjacent to the channel. The vegetation continues to capture organic materials and finer sediments from floodwaters even as it contributes to soil productivity with leaf drop, root growth, and nitrogen production. Although colonization with new riparian plants is more difficult here due to the lack of open sites for seeds and the distance from sub-surface water, upland or facultative species may begin to colonize and become established. As short-lived riparian plants begin to die out, more areas become available for upland plants. Longer-lived riparian species may remain for many years, sometimes persisting until the channel migrates back.

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Winward (2000) describes riparian areas as under nearly constant change. Streams move across floodplains, cutting banks and depositing new sediments, forcing riparian communities to continually readjust. Unlike upland ecosystems, long-term, self-perpetuating plant communities occupying a specific area are rare in riparian areas. This rapid and constant change has created species that are uniquely adapted to development on sand and gravel bars and newly broken banks. The author points out that seedlings of typical riparian species (such as cottonwood, alder, and willow) are often very poor competitors in dense grass or heavily sodded areas. **This natural migration and movement of stream channels over the years must be considered carefully for every project, especially when planting slow-growing trees that will require decades before providing the desired function.**

Natural processes of riparian development may be essentially stopped where invasive noxious weeds (such as gorse or reed canarygrass) are strong dominants; such sites may warrant revegetation on that basis alone (Borman 1996). When gorse or Scotch broom are the overwhelming invaders, it may be necessary to plant fast growing stock such as willow and alder into recently cleared areas to gain control of the site, and then interplant the desired conifer species in later years. Slower-growing conifers have more dense shade that persists throughout the year, and may be required to control sites occupied by less shade-tolerant weeds.

In areas where soil and site conditions are favorable, noxious weeds are minimal, and objectives are tied to large wood rather than shade production, it may be advisable to plant only conifers. This strategy is more likely to succeed as a supplement to an already functioning system, as opposed to depending solely on conifers to recover the site.

In recently exclosed pasture situations, existing weeds such as blackberry will often quickly claim dominance over the fenced area if not discouraged by control measures or rapidly growing riparian plants. In terrace pastures with considerable broken banks and exposed soils, the risk of domination by noxious weeds is even higher.

Watershed council members in the windy "blow zone" of the south coast have discussed the possibility of first planting hardy shrubs, such as willows, slightly upwind of areas where they want conifers. Once the willows are established, they can act as a windbreak for young and not-quite-established conifers.

Soil conditions are another concern when considering successional pathways. In highly disturbed areas with mostly mineral soils, opportunistic species such as willow, alder, cottonwood, and some grass, sedge, and forb species will usually colonize the site. These species will serve to build up the organic matter and nutrient level within soils by root growth, litter fall, capture of fine sediments, and capture of plant materials arriving from upstream. This building of soil quality will enable more sensitive species to successfully occupy the site in later years. Alders are very adept at this, as they are able to fix atmospheric nitrogen and convert it to a form useful for other plants; alder also contributes a considerable amount of leaf litter and readily-degraded wood (Peterson et al. 1996).

Prepare Site

Site preparation takes time and effort, but is crucial for the success of riparian plantings. Clearing competing vegetation—thatch, canes, and boles—is the first step, followed by a means of killing or removing rootstock. (The control of re-sprouts and new seedlings is an ongoing process that can take years; that process is covered in the maintenance section of this document.)

Clearing top growth often involves mechanical or manual means of some sort. Mowers, trimmers, chainsaws, machetes, weed-pulling tools such as the Weed Wrench®, and heavy equipment, have been used effectively. Recently exclosed pastures are often already "cleared" of competing top growth. Manual and mechanical methods are best suited to small projects, or to projects with a large pool of volunteer (or nearly free) labor available (Tu et al. 2001). These methods are often most successful when combined with other techniques, such as cutting/pulling shrubs and treating re-sprouts with herbicide. Chemical methods are effective for clearing pasture grasses and some shrubs, but still require that canes, boles, and heavy thatch be removed by other means.

With any chemical, it is vitally important to carefully read the label and have all the training necessary to apply the chemical. Such training and subsequent licensing is available from Oregon Department of Agriculture.

At the writing of this document, glyphosate is the chemical most often mentioned as least mobile, least active in the soil, and, in the Rodeo®, Accord®, or Aquamaster® forms, has low toxicity to fish and animals.

Triclopyr is mentioned also, though it is highly mobile in the less fish-toxic salt (amine); the oil-soluble ester form is much less mobile, but is highly toxic to fish.

The Nature Conservancy Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas (2001) provides a template for policy and planning for herbicide use, as well as a detailed description of herbicides relatively safe to use in wildlands. **Most of those listed are not appropriate for use very near streams,** but depending on mobility, may be useful at greater distances from open water.

One suggested sequence for blackberry removal/control:

Initial control (July – August): mechanical removal of top growth (when plants have the most resources tied up in foliage and fruit).

Follow-up control (September – October): herbicide spot treatment (when plants are translocating resources to roots preparing for winter) *or* wait until re-growth reveals locations of roots when winter rains begin, then pull or dig rootstock.

Plant species (December – January): replace blackberry by planting desirable species.

Follow-up control—maintenance: repeat herbicide spot treatments or root grubbing as necessary until planted stock is free-to-grow.

Eliminating weed rootstock is critical to regaining control of the site, since planted stock is rarely able to out-grow re-sprouts from intact rootstock. Manually pulling roots, grubbing or prying roots, or wiping/spraying with herbicide are all effective means of rootstock removal. Roots of pasture grasses and herbaceous species can be fierce competitors for water and must not be overlooked. Mulching, tilling, and soil solarization (placing a cover over the soil surface) have been effective in killing existing rootstock and preventing germination. Seedlings of weeds must also be controlled by preventing soil disturbance that give weeds an opportunity and by spraying, wiping, or pulling those that do grow. Encouraging thick and vigorous herbaceous species between planted stock will greatly enhance weed prevention by shading out weed seeds and seedlings. Take care to protect planted stock from the same competition that inhibits weeds.

One of the most effective strategies for recently exclosed pastures is to "pre-treat" individual tree sites with 30-36 inch circles of herbicide or mats in the days, weeks, or even months before actual planting. This preserves the herbaceous cover for weed prevention but clears roots that would compete with the seedling. Recent monitoring by OWEB has shown no difference in planting survival between mechanical and chemical site preparation (Anderson and Graziano 2002).

Lessons learned:

- Some species are stimulated to vigorously rootsprout after top growth is removed.
- Some species with strong vegetative reproduction (e.g., blackberry and knotweed) can sprout from fragments left on the surface of the soil or in the stream channel.
- Avoid providing additional seeding sites for weeds.
- Avoid moving weeds from one site to another via equipment, boots, etc.
- Grazing is best used for controlling re-growth. Care must be taken to not spread weed seeds to new sites on fur and in manure and to avoid damage to desirable/ planted stock.
- The best time for manual control for most plants is in summer when they have the highest level of resources allocated to top growth and fruit production and before they translocate resources to roots in fall.
- Planting short-lived or native grasses can be effective at preventing some germination on highly disturbed sites such as those altered by channel relocation or pulled-back banks.

Common Species of Concern in Site Preparation

Pasture Grass

Bishaw et al. (2001) used a chemical site preparation with herbicide application in strips and with a non-sprayed section between the planting site and the creek, although some follow-up spraying was required after planting. Platts et al. (1987) recommends herbicide spot treatments shortly before planting. Deep scalping (below root crowns) and solarization are also likely to be effective at killing rootstock.

Reed Canarygrass, *Phalaris arundinacea L.*

Lyons (2000) summarizes a variety of control methods that have been tried successfully, including integrated management approaches. Herbicide treatment (Rodeo+LI-700®) early in the growing season, plus disking, suppressed reed canarygrass and promoted more desirable species. Applying herbicides such as Fluazifop® (Fusilade®, Horizon®) early and late in the season was also effective, providing 99% control the first year. Hand-pulling reed canarygrass is effective if done 2-3 times per year for five years. Covering with black plastic or other material has had mixed results. To be at all effective in controlling reed canarygrass, shade must be less than 40% of full sun and shoots must not extend beyond the edges of the cover. Cutting is effective if done repeatedly during the growing season; five times per season was effective, two times per season was not. Grazing is a poor option, as reed canarygrass is unpalatable (and may even be mildly toxic). From year-1 results of a reed canarygrass management study, best control was achieved by either: spraying twice—summer and fall; August mow followed by fall spray; or June mow and August mow followed by fall spray (Tu and Salzer 2002).

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Himalaya Blackberry, *Rubus discolor (= R. armeniacus, R. procerus)*

Hoshovsky (1989b), emphasizes that integrated management techniques are the most effective means of controlling blackberry and that all reproductive tactics must be addressed. Different approaches may be required to adequately control seed germination, rooting at cane apices, suckering from lateral roots, and sprouting from pieces of roots and canes. Burning slash and removing canes before seed set are suggestions for controlling seed germination; minimizing soil disturbance will also greatly discourage seed germination. Seedlings, rooting at cane apices, and sprouts from roots and canes can be effectively controlled by grazing, provided the animals are not damaging desirable plants or creating seed microsites. Goats, sheep, and cattle have been effectively used to inhibit spread of blackberry. The author states that cultivation (digging or pulling roots) or herbicides may be the only way to remove root systems and prevent root sprouting. If only a single cut for the year can be made, the best time is when plants begin to flower, as root reserves are low and seeds are not yet set. Canes may re-sprout from root crowns in greater density if not treated with herbicide (Hoshovsky 1989b).

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Gorse, *Ulex europaeus*

Gorse, like blackberry, has several reproduction techniques that must each be considered, as summarized by Hoshovsky (1989a). Root sprouting is common and vigorous after removal of top growth by

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physical means or by fire. Goat grazing has been shown effective in controlling gorse plants, typically those 2-4 inches high. Goats will browse mature brush, but will only defoliate lower branches and strip off bark. Prolific seeds can persist in the soil for more than 30 years. Since chickens are known to digest and destroy all seeds passing through their crops, they may be an effective means of reducing seed banks after removal of mature plants. Herbicide treatments should be made in the first season after cutting, in spring, when regrowth is the most sensitive and tallest shoots are less than 20 inches in length. Spot treatments of stumps, sprouts, and seedlings are recommended. Biological control methods have been successful for gorse in California, but appear to be less-well adapted for Oregon's climate.

Scotch Broom, *Cytisus scoparius*

Hoshovsky (1986c) recommends removing at least the above ground portion of the plant by machine, fire, or by hand. Resprouting from roots and cuttings should be controlled by removal of the root by hand or with chemical treatments; chemicals are most effective when the plant is in full leaf. Seeds are heavy and have a hard seed coat, and can persist in the soil for many decades. Germination is greatly reduced by good ground cover, and goat grazing shows

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promise for removing seedlings and resprouts. The twig-mining moth was introduced as a biological control agent in the 1960s and has become established from California to Washington, with limited impacts to Scotch broom populations.

Japanese Knotweed, *Polygonum cuspidatum*

Seiger (1992) states that while knotweed has very low rates of seed germina-tion, it is extremely difficult to remove once established. Knotweed primarily reproduces through rhizome expansion under the soil and

© John M. Randall/The Nature Conservancy dispersal of rhizome fragments by stream currents or fill-dirt removal. It is very important to initiate treatment at the upstream-most areas first. Digging out rhizomes is not recommended as fragments are easily spread. Cutting is probably not effective and may cause spreading. Testing for control by competition is currently underway. Foliar spray can be effective if done during key translocation periods; otherwise, spraying twice yearly for 2 to 3 years may be needed. Stem injection is an effective, one-time treatment, best applied in June/July when stems are large enough to inject.

Field Bindweed/Morning Glory,
Convolvulus arvensis L.


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Biology and management of field bindweed or morning glory is summarized by Lyons (1999). Field bindweed is common in formerly cultivated fields and is considered a pest because it twines around crops or other desirable vegetation and can topple them. It is also common in riparian areas and may aggressively compete for light, water, and nutrients. Reproductive strategies include sprouting from prolific roots and rhizomes, as well as from the long-lived seeds. Herbicides are effective when combined with disking or pulling and is guided by monitoring. 2,4-D (highly toxic to salmonids) is listed as most effective, though glyphosate can provide some control. Several years of consistent attention are needed for effective control. Shading field bindweed may be effective if the density of shade is increased by at least 50% for three years. Mowing is not recommended. Control through grazing is unlikely, as field bindweed is mildly toxic. Spraying with herbicide is recommended at first bloom, when root reserves are lowest. Fully vigorous late-season growth can effectively translocate herbicides to roots. Some populations may be resistant to herbicides, however, due to previous historical applications.

Fertilization

Opinions on the use of fertilizer are widely mixed. Forage samples in the Coquille basin showed deficiencies in nitrogen, phosphorus, and potassium, and some soils are known to be poor. Several councils are currently trying slow-release fertilizer tablets, though results are not yet in. Anecdotal evidence suggests that herbivory may be higher in fertilized trees; another anecdotal source suggests substantially increased vigor in fertilized trees. In all cases, care should be taken to avoid providing fertilizer to competing plants.

Platts et al. (1987) recommends using a fertilizer pellet in the planting hole, if needed, and only if competing vegetation is controlled. Vigor can be increase for 2-3 years after planting. Spraying or fertilizer application to the surface layer was not recommended, as grass species are quick to respond. Lewis (2000), recommends using a low-dose, slow-release fertilizer with wildling stock, but discourages the use of fertilizers for bareroot and container stock in the first year.

Mycorrhizal Inoculation

Certain species of conifers are known to have higher survival and vigor with the presence of root fungus symbionts called mycorrhizae. Bareroot trees will have mycorrhizae on their roots from the nursery, but there is speculation that the type of mycorrhizae found on nursery stock may be poorly adapted to riparian and/or coastal environments, and may therefore be contributing to transplant shock and/or low vigor. Fungus packs of mycorrhizal species are readily available and are being used in some planting projects. Horse manure is used as a fertilizer/soil conditioner by one northern group. Adding a handful of adjacent forest soil into the planting hole has also been proposed for obtaining local mycorrhizal species.

Determine Target Density and Spacing

The goal when planning density is to establish an adequate number of stocked plants at the time that benefits are needed, with mortality accounted for until then. For instance, while a minimum stocking of 200 trees per acre may be desired for providing adequate shade for weeds and stream temperatures, more than 400 trees per acre may need to be planted to compensate for losses to predators, diseases, floods, etc. One concept presented is to mimic the spacing of natural communities, such as planting willows in an extremely dense pattern and planting spruce seedlings only near stumps.

Density and spacing is dependant on objectives, soil conditions, condition of planting stock, and the mix of species to be used. Understanding the objectives of the planting is also crucial in density/spacing questions, since the canopy structure, crown shape, and crown depth for each tree species are all determined by stand density (Ahrens personal communication 2002). High density plantings are better at excluding understory vegetation such as blackberries, gorse, and grass, and can be thinned at a later date to allow more light and other potential species.

In a *Science Update* from the Pacific Northwest Research Station, the authors describe three 25-30 year old, second-growth conifer stands in the Oregon Coast Range. Two of the three stands had been pre-commercially thinned to different densities. The un-thinned stand had 491 trees per acre, no understory, and average diameters of 8 inches. The moderate density stand had 185 trees per acre, limited understory, and average diameters of 13 inches. The more heavily thinned stand had only 105 trees per acre, a well-developed understory and more diverse tree diameters, averaging 15 inches. This report suggests that planting designs should carefully consider anticipated mortality rates, and prepare to actively manage tree densities to achieve the desired habitat functions. For example, in areas with heavy noxious weed infestations, a tightly packed stand may be desirable; in projects designed for large wood recruitment, biological values, and diversity, lower densities may be called for.

Planting density can be very high for willows, with one restoration contractor planting as thickly as one willow stem per few inches, depending on the need, and letting time and nature sort them out. One-foot by one-foot density is common. Dense plantings of willow, cottonwood, and (possibly) Oregon ash are well within the goal of mimicking nature. Hoag (1993) recommends spacing hardwood cuttings at 1-3 feet apart for shrubby species and 6-12 feet for tree types. In areas with higher erosion risk, 1-1.5 foot spacing is recommended.

In harsh sites, bigger trees, with more space between trees, are recommended. However, some councils have taken the opposite approach, planting higher densities in harsh sites, knowing that a higher percentage will be lost. Spacing for trees in that case can range from 3 to 4 feet for a harsh site, to 12-

15 feet on better sites, depending on the objectives of the planting. Wider spacing allows for a fuller development of the crown on most species on all sites, and allows for easier access for maintenance equipment and crews. With densely planted trees, mortality rates can be considerably higher due to accidental mowing, weed eating, and herbicide drift, which can raise the risks of insect and disease problems due to resource competition and lower vigor.

Select Species

Carefully matching site characteristics with species tolerances and availability can be difficult, but it is critical to planting success. Whenever possible, consult with locally knowledgeable people when developing planting plans. Using intact riparian communities as a model can be a powerful tool, especially when noting what species are present, in what portion of the community, and in what abundance. Keep in mind the desired balance between hardwood and conifer trees, trees and shrubs, and woody and herbaceous plants. Historical reconstructions are available for many of our coastal basins, and can reveal at least a rudimentary list of species to consider.

A table in Appendix A lists the more commonly found tree and shrub species, their relative tolerance to flooding and shade, and lists potential sources for planting materials-seeds, cuttings, root cuttings. Dr. Bruce Follansbee, restoration ecologist, has provided two lists of common riparian species for this planting guide—one for the south coast (Appendix A-2), and one for the north coast (Appendix A-3). The lists are divided into two planting zones: the estuary/Sitka spruce zone and the river mainstem/low-gradient stream zone. These lists represent commonly available stock for planting on the west side of the Coast Range.

Rose et al. (1998) provides detailed guidance on seed collection and germination, cutting preparation, and general propagation methods for a great number of our Pacific Northwest plants. Such details are beyond the scope of this planting guide, but would be very useful to councils or restoration groups looking to expand their "planting palette." Most nurseries will send a list of available stock with prices, and many are willing to grow on contract species collected locally.

In projects where high success rates are needed within a short time frame (such as CREP or bioengineering projects), it is advisable to start with a small number of species that are known, tried, and true. The species mix can be diversified with greater success once basic functions are restored and robust.

Schedule Planting

Timing of planting varies considerably by species. Borman (1996) reports that planting should be timed according to the plants' ability to grow roots and the availability of water. In addition, watershed councils have found, even here on the coast, that dormant cutting stock has much higher survival rates than do cuttings with activated bud or leaf growth. Container stock, though more expensive, can be planted at any time of the year when soil moisture conditions are favorable.

Primary planting season for bareroot and wildling conifers in northwestern Oregon starts in December and ends mid-March. In Southern Oregon and more droughty sites, planting season is from December to late February (Rose and Morgan 2000). Nursery conifers are generally available to councils and landowners in early January. Alder have been successfully planted as late as March and April.

For some species, the best time of the year for root growth is in the fall, before the onset of dormancy. However, in the past nurseries have been unable to provide stock at that time, and the trees are more susceptible to handling damage in the fall (Hoag 1997). Nevertheless, early fall planting is becoming much more common in forestry and is showing very promising results for increased vigor and survival. Stock is often container grown with locally collected seed in nurseries as far away as British Columbia. To prepare stock for handling, dormancy is induced by "blacking-out" light in the nursery, mimicking the decreasing day lengths found in fall and winter (Ahrens personal communication 2002).

Choose Good Stock

After choosing species that are well-matched and adapted to local conditions as well as to the project objectives and model selected, the next task is to identify the most appropriate means of establishing those species. Several appropriate types of planting stock may be appropriate, since site conditions and objectives vary; for example, cottonwood may be planted as cuttings (small diameter), poles (larger diameter), harvested wildling rooted stock, or as purchased nursery container stock. Many of our local shrub species can be grown from cuttings, and a variety of hardwood species are available as large container stock through commercial nurseries. Conifers are typically acquired as bareroot or small container "plug" stock. Bareroot stock is identified by the number of years grown in growth medium and the years grown in a natural soil nursery bed. For example, a 1+1 Sitka spruce plant has been grown for one year in growth medium and one year in a soil bed. Small container stock or "plugs" are identified by the volume of soil (typically cubic inches) within the container. Cuttings are portions of stems or sticks that are cut from live shrubs or trees and directly planted. Wildlings are plants harvested from sites where they have grown naturally and are transported with soil and roots intact to a new location.

In addition to the type of plant stock, it is important to consider and plan for the size and age of stock needed, the quality of stock, the genetic implications of various stock types, as well as transporting and handling the stock in ways that maintain its quality.

Genetics

Vigor and survival, preservation of local gene pools, and species keyed to seed zones must all be considered when ordering, growing, or harvesting plants. Important considerations include:

- Stock that both originates and is propagated locally is ideal for preserving vigor and genetics (Linhart 1995). Some coastal watershed councils, especially in the north, have extensively used wildlings, citing both cost and genetics as major reasons for the choice.
- Seed zones should incorporate latitude/longitude as well as elevation in their coding system, recording seed harvest areas within 500-foot zones. Lewis (2000) suggests using watershed boundaries as collections zones for wildlings or cuttings and planting harvested stock within 250 feet elevation above or below the elevation of the harvest site.
- Seedlings outside of their known seed zones can lead to planting failure, sometimes decades after planting, as seedlings may be more susceptible to insects, wind, temperature regimes, and diseases (Rose and Morgan 2000; Duddles and Landgren 1993).
- Use of exotic species in riparian revegetation should be approached with extreme caution. Many of our noxious weeds, including gorse, Scotch broom, and non-native blackberries, were released with such good intentions. Further, in

many cases the introduced species will be poorly adapted and will not thrive. In even the best case, non-natives will occupy space that could be maintained long term by locally adapted plants while not providing the valuable functions of the natives.

- Cultivars can be quite vigorous stock but have the potential of interbreeding and weakening local populations (Carlson 1991).

In general, genetics and seed zones have been considered in coastal lowland restoration efforts, especially by those groups who are actively ordering trees to be planted. Willow cuttings are typically taken from an adjacent site, as are cottonwoods on the south coast. Redwoods are an exception, and they are commonly planted outside their present range. Redwoods are attractive trees with good growth rates and are favored by many landowners, but may have a higher risk of failure as a result of freezing temperatures during their lifespan.

Stock Types

Once the potential plant species have been identified, stock type must be chosen with regards to planting objectives. Bareroot stock, container stock, rooted and un-rooted cuttings, wildlings, and direct seeding are all options—sometimes within the same species. Cottonwood available from a nursery, for example, may also be cultivated from cuttings harvested at an adjacent site.

Stock size is another consideration in plant selection. In some cases, larger rooted stock will be more likely to survive; in other cases, smaller stock may be warranted. For some purposes, such as bank stabilization, a high number of small willow cuttings may be appropriate; in other cases, larger diameter pole planting may have better odds for success and be more effective at immediate bank stabilization.

Hoag (1997) states that cuttings (usually hardwoods) are recommended for plantings at the water line to mid-bank. Long cuttings and poles (sometimes up to 12' long) are often the only means of reaching lower water tables from terraces. Hoag states that cuttings are often considerably less expensive to plant, are easier to plant, handle, and store, and the higher densities made possible by less cost can offset mortality. He recommends using plugs, bareroot, potted, and paper-sleeved stock when planted: 1) on mid- to upper-bank/floodplain where flooding and erosion are less likely; 2) where adequate moisture is available (natural or irrigation); 3) where competition is absent or well controlled within 30 inches of the plant; and 4) where plants have low risk of being pulled or eroded from the soil, especially during the first year in the ground, before their root system is fully developed.

Bareroot trees and willow cuttings are very common stock types for planting projects on both the north and south coast. Use of container stock, though considerably more expensive, is becoming more common. Sweeney et al. (2002) found that there were no significant differences between growth and survival of container stock and bareroot stock after four years of study. On the other hand, they state that container stock may be worth the higher cost, as container-grown plants are more resistant to handling damage and root desiccation. Also, with container stock, seedlings can be planted over a much broader time span than the narrow 6-8 week window for bareroot stock, and container stock may allow seedlings the benefit of fall root growth at the planting site.

Nursery Stock

Size and Age of Nursery Stock

Rose and Morgan (2000) state that three characteristics must be considered when choosing seedlings for a site:

1. **stem diameter** (caliper measurements), usually ranging from 2.5 mm for small seedlings to 6.5 mm for large
2. **shoot height**, ranging from 5 inches for small bareroot stock to 20 inches in larger volume container and older bareroot stock
3. **root volume**

> ***While diameters and heights have long been standards for evaluating nursery stock, it is critically important for a seedling to have a root system that can adequately anchor the plant and quickly access water in the soil.***

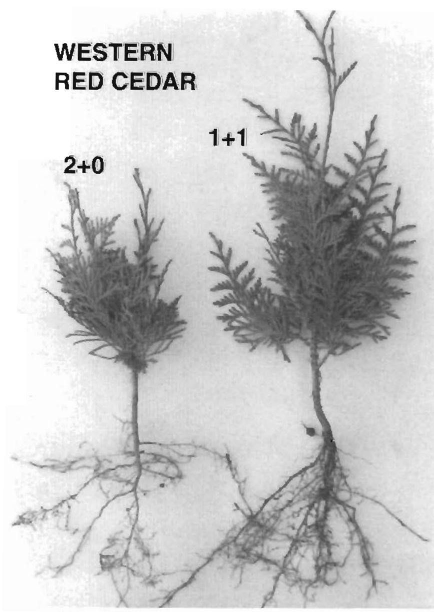
In general, larger stem diameter seedlings are better able to survive after browse, can better resist pests, often have large amounts of foliage and roots, and may be more resistant to heat stress or sunscald (Rose and Morgan 2000). Tall seedlings are better able to reach above competing vegetation (such as reed canarygrass and blackberry) and may better overcome browse by deer, but may also be more likely to topple in windy, droughty, or shallow soils. Seedlings with large root systems will help anchor the plant in windy sites and offer better growth, but can be difficult to plant in rocky sites (Rose and Morgan 2000). In general, look for seedlings with:

- large stem diameters
- large root systems (balanced with top growth 1:1)
- moderate shoot height (except in high light competition areas)
- seedlings with numerous, large, well-developed buds
- dark, healthy foliage color (not dry or moldy)
- well wetted roots

Small seedlings (1+0) require very careful handling and are generally suited to only very well-prepared sites where there is little potential for browsing. 2+0 plants often have smaller root volumes than plants that have been transplanted (1+1, 2+1). A 2+0 plant will usually be shorter, have a narrower stem, and have a less developed root system than a 1+1. 1+1 bareroot stock will usually have a large caliper size (diameter) and root mass, and will often be taller than 2+0 stock.

"Bigger is better" is the most commonly held opinion about nursery stock size and age in restoration groups. In general, the recommendation is to buy the largest and oldest stock that you can afford, while carefully considering the needs for the site.

Container stock, while demanding a higher price, is recommended for planting in rocky sites. Container stock can range from small plugs with small styroblock cavities filled with growth medium, to gallon-sized pots of soil holding 4-foot tall trees. Styro-8, for example, is a common outplanting stock with roots occupying 8 cubic inches of space. Container stock is easier to handle and transplant than other types of stock, with less risk to drying or damaging roots. However, large size container stock is more difficult to obtain without a contract (Rose and Morgan 2000).



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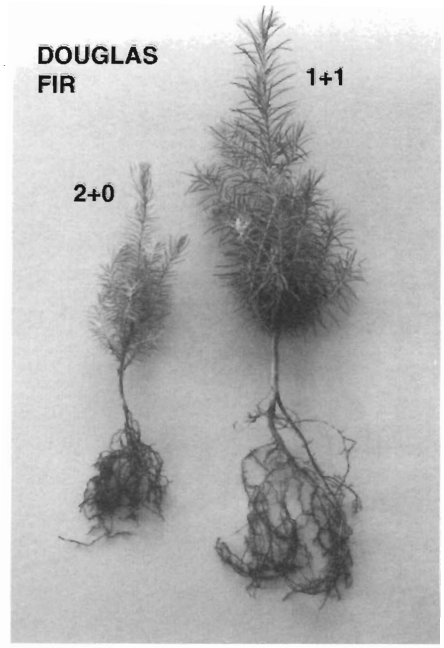
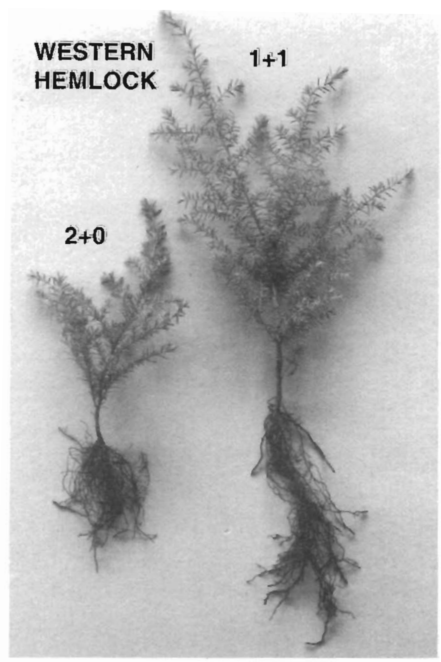
Inspecting Stock At The Nursery

Duddles and Landgren (1993) suggest visiting a nursery before ordering trees, and recommend August or September as an ideal time to see the quality of seedlings provided and the nursery's general condition. It is important to order trees many months before the planting season. The authors state that it is important to clearly communicate your expectations, minimum requirements (such as stem diameter and heights), and grading standards to the nursery staff. Keep in mind that nursery growing conditions change and stock in any year may look considerably different than in prior years.





Things to look for when inspecting bareroot stock (Ashdown personal communication 2002):

- Check to see that root volume is adequate for top growth. Root volumes that are larger than top growth are acceptable, and some nurseries strive for that.
- Look for signs of rot, chewing, and mold on roots.
- Check balance of coarse vs. fine roots (not all tap root with no fine roots, for example).
- Foliage should be fresh and firm, not wilted. Ask about time already spent in the cooler, as it will affect the storage time in your facilities before planting.
- Check for moisture in bags—trees are adversely affected by drying.
- Sizes of trees should be uniform; diameters should be "pencil size or larger."
- Trees should have good bud development, and not be all stem.
- Trees should smell fresh.
- Trees should be dormant. Reject trees with fresh "new" green growth.

For container stock, Hoag (1997) recommends removing a random sample of plants from their pots to check for kinked or girdled roots, and to check for roots that have been allowed to circle around the pot. Some roots in this case will need to be trimmed to increase the chances of survival. Some top growth may need to be trimmed also, in order to keep the root to shoot ratio balanced.

Caring For And Transporting Nursery Stock

Care of bareroot seedlings after being removed from the soil at the nursery is absolutely critical for successful planting efforts. Seedlings that are allowed to get too warm, too dry, or are handled too roughly may have reduced vigor for 2-3 years after planting—such mishandling may even kill seedlings before they're put in the ground. Care measures to minimize handling damage and stress placed on the seedlings include (Emmingham et al. 1996; Rose and Morgan 2000):

- **Keep roots wet** by dipping them in water for one minute before placing them in the planting bag. **Once roots dry out, they can never become functional again.**
- Temperature control is critically important for bareroot plants from the moment they are lifted from the soil until they are planted on site. (33° – 34° F is ideal.)
- Refrigerated vans are optimal for transporting stock from the nursery, though a truck with a canopy is acceptable.
- Plant stock as quickly and as soon as possible.
- Store remaining stock as close to 33° – 34° F as possible.
- Best planting temperatures are between 35° and 42° F. Damage is likely at temperatures above 42° F; expect mortality above 70° F.
- Planting on windy, dry, warm, or sunny days can dry roots within minutes and significantly increases risks to trees.
- Handle seedlings gently when pulling them from the bag, placing them in the ground, and when packing soil around the roots.
- Pull trees from the bag only after the hole has been dug.

Temperature and weather conditions are still very important at the time of planting plug and larger container stock, though there is considerably more room for error regarding the timing of planting, transporting the stock, and handling.

Cuttings

Restoration groups in coastal Oregon commonly use willow, dogwood, and cottonwood cuttings with variable success. Harvest of stock should be done in the dormant season with local stock. Many other species may yield cuttings, including red huckleberry, black twinberry, and alder (see Appendix A), but have not been tried to a great extent by restoration groups. Successful rooting of other species can be more complicated than with willows, sometimes requiring harvest during different times of year, treatment with rooting hormones, and/or scoring the bark to expose cambium tissues. Rose et al. (1998) provides excellent guidance on propagation details.

Size of cuttings typically ranges from 2-8 feet long, with diameters from ¾ inch to 4 inches in watershed settings, though pole plantings can extend to 20 feet in length in order to adequately reach summer water tables (Hoag 1993; Swenson and Mullins 1985). Whatever the size, it is critical to have a significant portion of the cutting (for willow and cottonwood) within the summer water table.

Considerations for the harvest of willow and cottonwood cuttings include:

- Take cuttings of willow and cottonwood in full dormancy for best survival.
- Larger diameter cuttings have better survival—no less than 3/8 inch (Hoag 1993; Zierke 1994).
- Consider the health of the "mother plant." Low water years, long periods of drought, insects, and disease can all decrease energy reserves of the mother plant and will impact the establishment of cuttings. (Hoag 1993)
- Take no more than 1/3 of the mother plant, and spread harvest evenly over the stand.
- Consider inspecting and marking stock to be harvested during the previous summer, since vigor is more easily judged in actively growing plants.
- Soaking cuttings before planting (10+ days for willow) can greatly increase survival, biomass, and growth, especially when planted in droughty soils (Schaff et al. 2002).

Wildlings

Wildlings are plants that are harvested from natural settings and transplanted in a new site. Hoag (1997) discusses wildlings as an excellent and inexpensive way to obtain adapted stock for revegetation projects, especially those using shrubby and/or herbaceous plants (willows, elderberry, sedges, and rushes). He recommends obtaining the proper permission/permits before collection, watching for weeds, looking for vigorous plants with little insect or disease damage, harvesting no more than 1/3 of the "mother" plant (shrubs and herbaceous plants) to avoid extensive damage, and being aware of the aesthetics of the harvest site. It is also important to check the sun/shade compatibility of harvested stock. Trees harvested from shade should be placed in shade; those harvested in full sun should be planted in full sun.

Lewis (2000) states that salvaging or harvesting seedlings from natural environments is an inexpensive source for revegetation projects, but that unless done carefully and in a timely manner, high mortality rates are likely. The author adds that moisture deficiencies and over-exposure to air and heat are critically important factors for wildling stock.

Lewis (2000) provides the following guidance for harvesting and planting wildling stock:

- Plants must be dormant and transplanting must be done carefully to avoid high mortality rates.
- Choose small, healthy plants that are growing by themselves.
- For small plants (<3 feet tall), dig a circle 8 inches from the mainstem and gently work the spade under the root ball. For 3-4 foot seedlings, a larger root ball is necessary.
- Place the root ball on a moistened burlap sack lined with leaves or mulch, then wrap.
- Carefully protect plants from air and heat exposure.
- Plant stock within two hours of harvesting.

Plant

Correctly planting stock is very important because poor technique can greatly decrease vigor and survival. In upland planting projects, seasoned, professional contract crews can plant as many as 1000 trees per day. With differences in soils and in existing vegetation, plus the tree protection required in riparian areas, 200-250 trees per day is a realistic goal. **How a plant is put into the ground (shovel, auger, hoedad) is often less important than the conditions it is planted into.** Planting methods that disturb competing root systems, stir up compacted soils, and allow tree roots to expand will likely have much better success.

Balled and Burlapped or Large Volume Container Stock

An illustrated example of how to plant balled and burlapped stock is provided in the Cowlitz County Soil and Water Conservation District (1993?). A similar technique is appropriate for container stock. Suggestions here are:

- Keep the soil ball intact while planting.
- Make sure that the plant is upright and at the correct depth (at the same depth as in the container).
- Avoid placing clods near the roots.
- Gently pack the soil around the tree.
- Create a small ridge of soil around the planting hole as a watering basin.
- If possible, water trees and shrubs after planting to settle the soil and to remove large air pockets that can damage roots.

Bareroot Stock

Bareroot stock can be planted with a shovel, auger, and in some cases a hoedad. According to Rose and Morgan (2000), plants should be placed in a mineral soil and be free of weeds and debris. The planting hole should be large enough for the roots to hang down naturally and allow the tree to stand straight up and at the same depth as in the nursery. Roots must have good contact with the soil, with no air pockets, and not be compressed into a very narrow area.

Bareroot stock is very commonly used in watershed council projects, as well as most landowner projects. Shovel planting is typical, though some councils use augers, and in one case, an auger that creates a watering well at the same time. Hoedad planting, while very efficient in upland sites, poses some challenges in more compacted riparian soils and in soils that are fully occupied by grass or shrub roots. It is sometimes difficult to plant trees in a fully upright position. Root depth and plant height are critical for the establishment of new plants; both are compromised with a leaning tree. (In one monitoring exercise, cedar trees planted at an angle in 1998 [as documented by photographs] were found at the same angle in 2002.) Also, roots need to be able to spread laterally to some degree within the hole, and a single cut into compacted soils may not accomplish that as well as other means of planting.

Cuttings

Successful planting techniques for cuttings can range from tractor mounted posthole diggers, augers, planting bars, and shovels to planting by hand. The simplest and

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most common method is to push cuttings into the ground, made easier with a 45° angled cut on the bottom end (Hoag 1993). The author suggests a number of considerations for choosing the appropriate planting method,

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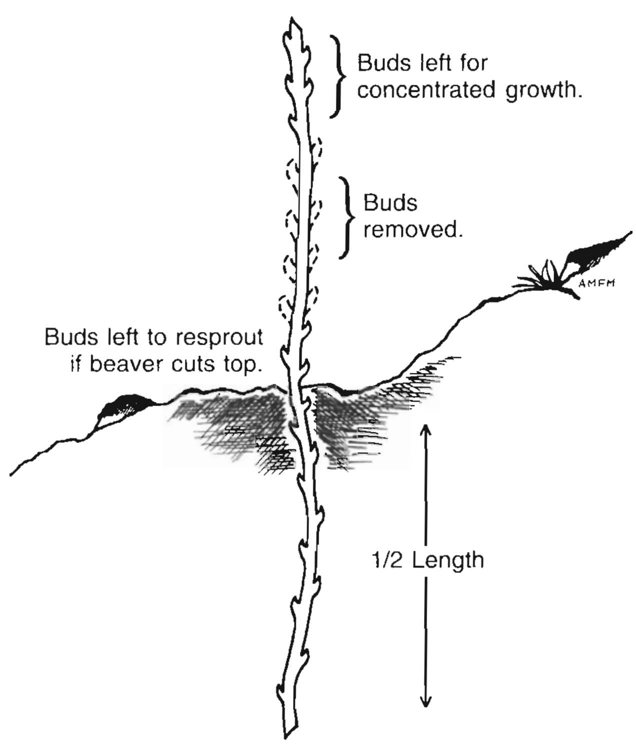
including the need for good contact with the soil along the length of the cutting, obtaining a depth necessary for water table contact, and avoiding damage to buds when the cutting is placed in the ground. Hoag et al. (2001) describes the water-jet stinger, a high pressure water drill designed to create an ideal rooting scenario for cuttings while creating low impact on planting crews. Hoag (1994) describes an attachment for a back-hoe which is designed to create planting holes for large diameter willow or cottonwood stock, as would be needed in some bioengineering and streambank stabilization projects. Hoag (1993) also describes clump planting, a process in which a back-hoe digs up an entire willow plant, moves it to the project site, and "pushes" a hole for it as it drops it from the bucket. The author notes that clump planting can be very useful in areas where heavy runoff occurs or where the water column directly impacts vertical banks.

In coastal lowland restoration projects, cuttings have been augered and/or pushed into the soil, some with less than half of the length left above ground. Some groups

Figure 2. Proper bud trimming for cuttings.



trim buds from the middle portions of the above ground stem, leaving buds at the top for reaching over competing vegetation (in some cases reed canarygrass) and leaving a few buds at the base in case of beaver browse. One group found that with auguring or planting bars and the soft nature of soils on site, angled cuts on the bottom end were not needed, and planting crews were experienced enough to identify top from bottom of the cutting by the orientation of the buds.

Considerations for planting willow and cottonwood cuttings include:

- Soaking cuttings before planting (10+ days for willow) can greatly increase survival, biomass, and growth, especially when planted in droughty soils (Schaff et al. 2002).
- Cuttings need to be kept cool and moist, but not wet, until they are ready to be planted. If kept in a large cooler at 24-32° F, cuttings can wait several months before planting. (Platts et al. 1987)
- Place no less than half of the total length of cutting into the ground, with a portion of the stem into the summer water table (Hoag 1993).
- The top of the cutting should extend above competing vegetation.
- Plant cuttings "right-side-up." Mark or blunt-cut top ends, sealing tops against water loss and disease, if needed.

Wildlings

Recall that it is important to check the sun/shade compatibility of harvested stock; trees harvested from shade should be placed in shade; those harvested in full sun should be planted in full sun. Recall, too, that unless wildlings are planted carefully and in a timely manner, high mortality rates are likely. Further, moisture deficiencies and over-exposure to air and heat are critically important factors for wildling stock.

Lewis (2000) provides the following guidance for planting wildling stock:

- Plant stock within two hours of harvesting.
- Carefully protect plants from air and heat exposure.
- Dig a hole at least two times the volume of the root ball, if possible, adding a low dose of time-release fertilizer to the planting hole.
- Spread roots carefully to avoid kinking or circling, taking great care to protect fine root hairs.
- Add water to the hole before and after planting to settle soil.
- Firmly (but not excessively) tamp soil around the plant and prune the top growth to balance root loss (1:1).

Herbaceous Plants

Constructed wetlands, wetland restoration, and many stream systems could potentially benefit from herbaceous revegetation techniques, especially in cases where increased streambank stability is needed quickly or where natural seed sources are lacking (Hoag 2000). One suggestion is to harvest whole, mature, wetland plants from a nearby, stable, and well-stocked site, transport harvested plugs in buckets, and plant at restoration sites. This strategy has worked best in conjunction with willow or other woody plant treatments.

In general, restoration groups on the coast have tried herbaceous planting on a very limited scale, and tried it mostly as ground cover on sites with considerable surface disturbance. At one site where banks were re-shaped with a backhoe, bare soils were seeded with a native rye grass. Grasses were also seeded into an estuary restoration project where many cubic yards of fill were removed, exposing considerable area of soil to erosion. Care must be taken to protect stock from competition from such plantings, however.

Protect Planted Stock

Once plants are in the ground, it is sometimes becomes a battle to keep them there, as a variety of animals, large to small, eat seedlings. A range of protection strategies have been tried, some very successfully, to prevent high mortality from predation. Each strategy has strengths and weaknesses, and some strategies are more appropriate in certain sites than in others. The following section describes various protection methods for restoration projects, including when they are most used, what they offer protection from, and other positive and negative aspects of each. **As in all protective treatments, it is better to identify predation risks before the time of planting and plan for them, than it is to react after predation has occurred.**

Fences

A variety of fence styles are available; fence suitability depends on the type of animal to be contained, the land owner's capacity for maintenance, and risks of water-born debris. Harry Hoogesteger of the South Coast Watershed Council provided the following review of fence types (personal communication 2002):

Woven wire fences (sheep fence) consist of 4x4 inch square woven panels, often with two strands of barbed wire at the top and an additional wire at the bottom. This type of fence is very effective for excluding nearly all livestock types, but does not allow wildlife passage. Further, in flood prone areas, this type of fence is extremely difficult to maintain due to flotsam that collects on the panels.

Three or four strand *barbed wire fences* are common, with wood or metal posts and with strands set approximately one foot apart. This style of fence is much more wildlife friendly, and is effective for controlling access from cows or horses. Restricting sheep and/ or goats with this type of fence is considerably more difficult, however.

Electric wire fences are typically one, two, or three strands on permanent poles. Power sources can be solar collectors, household outlets, and, in some cases, generators. Electric fences allow fairly easy access for wildlife and are very inexpensive to operate. Although this style of fence takes a high amount of maintenance, it is very effective for excluding livestock when "on."

A variation of the electric fence is the *New Zealand style fence*, a generally temporary set-up with small lightweight posts that are easily moved. A ribbon or strap-like strand is strung between posts and is often electrified. These temporary fences have been highly effective in flood-prone areas such as lower flood plains and estuaries, as they can be removed during the winter and replaced the following spring. As with standard electric fences, New Zealand fences are inexpensive, but require considerable management and maintenance.

Tree Tubes

Tree tubes come in a variety of shapes, sizes, and colors, but are generally made of hard plastic and designed to enclose the stem and crown of the young tree until it emerges from the top of the tube. Common heights range from 3 to 5 feet, with an average diameter of 4 inches. Some are perforated, hinged, or tabbed in order to split when the tree stem has filled the tube. Tree tubes offer protection from beaver, voles, deer, and elk. (For the latter two, protection only lasts until the tree emerges from the tube.) Tree tubes are widely used by watershed councils on both the coast and east of the coast range, with differing levels of success.

Benefits:

- Tree tubes offer effective protection from deer, elk, beaver, and voles.
- Tree tubes offer protection from mechanical damage during competition release treatments.
- Tree tubes offer some protection from herbicide treatment overspray.
- Tube protected trees are easy to find.

Lessons learned:

- Tubes require a substantial stake (1"x2" wood stake, ¾" bamboo, or fiberglass rod).
- Tubes impact stem diameter and strength, to some degree, both from lack of wind pressure and from the tree "stretching" within the tube for access to light. Trees may be more susceptible to falling over once tubes are removed. (If tubes are left on for several years after emerging from the top, the stem will thicken and adequately support the tree.)
- Tubes have to be more than 3 feet tall to protect from beaver, and possibly taller in areas that are deeply flooded in winter.
- Tubes may cause temperature problems for the plant. In hot sites, the tree may over-heat, and if the tube is not seated carefully into the soil, the tree can be considerably dried out. Some conifers in the south coast showed "burnt tips" on branches after tubes were removed.
- Excess moisture problems have been noted in north coast projects, with some corresponding increase in leaf diseases—especially with conifers.
- Tubes take more maintenance in the "blow-zone," as well as on frequently flooded sites, and have to be periodically cleared of grass, forbs, and/or silt.
- Monitoring tree vigor and survival are more difficult than with other techniques.
- Tubes offer protection from beaver predation even in free-to-grow trees; however, if tubes are not removed when full or if they fail to give way as designed, they can constrict tree growth.

Vexar Tubes

Vexar tubes in a variety of lengths have long been used in upland forestry as protection from deer and elk browsing. Vexar tubes are made of large-pore netting that can stand upright on its own, are commonly 2-4 feet tall, and have an average diameter of several inches. Protection value is vastly improved when the tube is stapled or attached to a substantial stake. Tubes can be moved up the stem as the tree grows, to extend protection to the tree leader.

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Benefits:

- Vexar tubes offer effective protection, when substantially staked, against voles, elk, and deer.
- Vexar tubes are less expensive and easier to maintain than solid tubes.
- There are fewer temperature, moisture, and light concerns with Vexar tubes than with solid tubes.
- Tube protected trees are easy to find.

Lessons learned:

- Vexar tubes are not effective for beaver predation.
- Tubes can impact the growth form of trees, especially cedar, so care must be taken to ensure that the leader and major branches are upright.
- If not well staked, Vexar tubes can blow off, float away, or be pulled off, and can generally be a nuisance.
- Side branches extending out of the Vexar tube netting are exposed to browse.
- Vexar tubes offer less protection from mechanical damage and no protection from herbicide overspray in release treatments.

Tin Foil Wraps

Tin foil has been used to discourage vole predation on small trees, especially in the first two years after planting. A roll of household variety foil is cut in half with a hack saw, and pieces approximately 6"x6" or 6"x8" are used to wrap the base of the tree at least twice, and squeezed by hand to get good contact with the tree. Although tin foil degrades within a couple of years, foil replacement shouldn't be required with good tree vigor and growth.


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Benefits:

- Tin foil wraps offer effective protection for vole damage.
- Wraps are very inexpensive with little to no maintenance required.
- Wraps can complement weed mat placements, grove fencing, tree cages, or other protection strategies that encourage vole populations.

Lessons learned:

- Tin foil wraps are not effective protection from any other form of damage—animal, chemical, or mechanical.
- Tin foil wraps are not a substitute for grass release treatments. In some heavily grassed areas (i.e., reed canarygrass), vole damage can extend 12-18 inches up the stem.

Cages

Tree cages are essentially woven wire or chicken wire fences surrounding individual trees that can take a variety of forms. Cages are useful in situations where beaver predation is heavy and trees are larger than a tree tube can protect. Cages around individual trees and fences around groves have also been proposed as alternatives to total livestock exclusion—which could make cages a very good choice in areas where robust blackberry populations will be controlled by livestock grazing. According to the experience of the Beaver Creek study near Newport (see case study below), cages must be at least three feet tall to be effective for controlling beaver and have to be very sturdy to withstand rubbing and leaning by livestock (by using metal fenceposts, for example). For beaver protection within an enclosed pasture, wooden stakes with chicken wire wraps have been used successfully. Wooden stakes do eventually rot, however, requiring replacement.

Benefits:

- Cages offer effective protection from beaver, especially for larger trees.
- Cages require minimal maintenance once in place, especially within an exclosure.

Lessons learned:

- Tree cages are expensive, per tree, both in terms of materials and labor.
- Cages can inhibit control of grass competition for young trees and can encourage vole predation in young trees.
- If used within active livestock pastures, care must be taken for adequate fence strength (cages must survive livestock rubbing), as well as adequate fence height (to exclude livestock leaning in and browsing trees).

Printing Plates

One creative protection strategy was devised for protection from beaver predation in the Coos watershed. The watershed council there obtained 30"x24" aluminum printing plates from the local newspaper and wrapped them around the bases of trees into a 2 foot cylinder with an approximately 8 inch diameter. Cylinders were held in place by plastic zip ties and stabilized with bamboo or wooden stakes.

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Benefits:

- Printing plates have been effective in discouraging beaver predation.
- Printing plates incur minimal cost.
- Printing plates make trees easy to find for maintenance and monitoring.
- Printing plates may be effective against voles if secured close to the soil.
- Printing plates leave plenty of room for diameter growth.
- Printing plates are effective for larger trees, but may also be effective for newly planted trees.

Lessons learned:

- Printing plates are not effective for deer or elk predation.
- Plates may need to be painted for aesthetics.

Camouflage

Some groups, especially in areas with high deer and elk populations, use the camouflage planting technique: planting where animals don't go. Trees are planted in brush, slash, salmonberry, and/or snowberries in order to hide them from browsers. One twist on this concept is to place two trees of different species in the same hole, or at least very close together. For example, a Sitka spruce with sharp needles and lower palatability can afford protection to a more tender-leaved, sought-after, and shade-tolerant western red cedar. In time, after the spruce has grown above browsing level, the leader can be trimmed to allow the cedar to grow above the spruce and flourish. In some areas, spruce beetles will take care of the leader trimming and keep the spruce in a more shrubby form.

In some cases, some stock or seedlings can be planted on stumps or fallen trees for an extra bit of elevation. The heightened elevation and different substrate can provide additional protection against elk, deer, beaver, and vole damage.

Camouflage has also proven effective in sites with considerable human traffic; for example, in the situation where one group had a good diversity of large trees planted at the local park. (Such camouflage does bring special challenges, however: even after discussions with park managers, many trees were lost to mowers, weed-eaters, and other equipment. Of the trees spared by city maintenance crews, many of the others, planted in obvious places, were lost to vandalism. Trees and shrubs that survived the first year were nearly all buried in tall grass, planted under shrubs, or in wetter areas that were harder to get to.)

Benefits:

- Camouflage has a low cost.
- Camouflage is very compatible with some species' growth patterns (i.e., hemlock and cedar).

Lessons learned:

- Camouflage can also make it difficult for people to find trees again for monitoring or maintenance.
- This technique is not effective for all species, particularly for shade intolerant species.
- For trees not in danger of potential damage by vandalism, it may be helpful to mark planted trees with a tall painted stake.

Sprays or Repellents

Repellent sprays have been tried in a number of projects, especially for deer, elk, and beaver problems. A variety of formulas are available; their use has had moderate success.

Benefits:

- Sprays and animal repellents generally have low impact to trees.
- Such techniques are usually low cost.
- Sprays and animal repellents are effective for deer, elk, and beaver predation.

Lessons learned:

- The effects of sprays and repellents are short-lived.
- The application of such measures can be tough on the person applying treatment (burning eyes, nasty smell, etc.).

Weed Mats or Mulch

Weed mats are considered a protection from competition rather than from browse, but do have interactions with browsing animals. Mats can be obtained through commercial sources or created from a variety of materials, such as cardboard, discarded carpet, newspaper, etc. Sizes generally range from 3-4 feet diameter or square, with larger sizes needed for more droughty soils.

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Benefits:

- Mats and mulch are effective at suppressing seedling germination and most root sprouting
- Mats and mulch can help funnel and capture precipitation

Lessons Learned:

- Mats and mulch may provide habitat for voles that can girdle trees. (Tin foil wraps can provide a counter measure.)
- Mats and mulch may increase the plantings' exposure to deer, elk, and beaver predation.
- Mats and mulch can alter temperature patterns, heating the soil in some cases, and possibly altering insect and microbe activities.
- Temperatures above the mat may also increase, stressing some species (notably cedar).
- Mats are difficult to secure in windy sites and may require extra maintenance.
- Mats often collect soil on top, creating sites for competing seedlings.
- Mats may promote mildew and fungus growth (souring) on soil surface.

Case Studies

Beaver Creek (beaver damage)

Fencing is a proven effective means of protecting seedlings from damage by livestock. Bishaw et al. (2001) used conventional barbed-wire fencing to exclude cattle in their experiment on Beaver Creek in Lincoln County (on the central Oregon coast). Fencing was adequate for restricting cattle use, but the most devastating damage to plantings came in the form of beaver clipping in the spring. In some plots, nearly all of their trees were removed. Vexar tubes were placed around all trees but were ineffective at preventing damage. Three and five foot tall, smooth tubes were placed around trees with much better success. When the alder trees within the cattle enclosure outgrew the 4" diameter tubes, cages were built around them. Each cage involved three or four wooden stakes and chicken wire. The authors stated that Protex tubes required yearly maintenance to check for damage and constriction of the tree. Further, some of the tubes were lost in flood events during 1996. One other tree protection strategy that was deemed effective, if short lived, was the use of Magic Circle animal repellent: browse was stopped for a few weeks.

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Yamhill Basin (vole and deer damage)

Animal damage in the form of small rodent girdling, beaver clipping, and deer browsing and rubbing were prevalent in a BLM project in the Yamhill basin (Heckeroth unpublished). Small-rodent damage was the most severe after the first year of planting and was related to cover provided by reed canarygrass stands. In order to protect replanted trees, mesh tree tubing was tied to the base of each tree and secured with a diagonally placed bamboo stake. Reed canarygrass stands were more aggressively controlled after the replanting, and no damage was reported after installation of the tubes.

Sporadic clipping by river beaver was present on site, but was planned for in the original stocking numbers. (Beaver trapping and relocation release sites have been identified if damage exceeds acceptable levels.) Deer browse is prevalent on the Yamhill site, especially for trees in areas with release from grass competition. Mortality is not common, but plant heights are reduced in an environment where height is essential for establishment. If needed, foliar repellent sprays may be tried.

Notes

Maintenance

It is becoming increasingly clear that successful plantings require maintenance. Not the so-called maintenance that is dependent only on free time and available money, but maintenance that is planned, scheduled to take place at the most effective time, and included in the project budget. Maintenance activities are much more critical in the early years after planting; how well they are performed will often determine how quickly a project will achieve its objectives. Some watershed councils have expressed frustration about having to manually maintain plantings for five or six years that are still not free-to-grow. In many cases, mortality rates have been so high that projects must be inter-planted, sometimes several times, and the period of intensive maintenance has been greatly expanded. The first and most important goal for cost, efficiency, and landowner objectives is to achieve free-to-grow status and to move the project from "High Maintenance" to "Low Maintenance" as quickly as possible.

High Maintenance (before plants are free-to-grow; requires several visits per year) needs:

- reduced competition
- fencing
- irrigation
- tree protection (tubes, mats, stakes, etc.)
- fertilizing

Low Maintenance (after free-to-grow; requires one visit per two years) needs:

- beaver protection
- stand management (thinning, diseases, insects, etc.)
- fencing

The first and most important goal for cost, efficiency, and landowner objectives is to achieve free-to-grow status and to move the project from "High Maintenance" to "Low Maintenance" as quickly as possible.

Reduce Competition

Competition for light, water, and nutrients can be intense in all plant communities and riparian areas are no exception. **All of the care in planning, site preparation, handling, and planting are displayed in the vigor of seedlings, how well they hold their own against other plants, and how quickly they are above the competition and free-to-grow.** Prior to that point, seedlings are often overshadowed by competing vegetation. Duddles and Cloughesy (1998) recommend release treatments if:

- trees are shorter than surrounding vegetation (including grasses) and shade is reducing growth;
- crowns of competing vegetation are in contact with and crowding seedlings; or
- dense grasses and forbs are creating habitat for seedling-eating animals.

Controlling competing vegetation is a longer term extension of site preparation. The goals are basically to:

- suppress vegetative spread of competitors-canes, runners, rhizomes, etc.;
- discourage seedling germination and establishment; and
- continue suppression of root sprouts.

The two major means of releasing seedlings from competition discussed in the literature are mechanical and chemical. Rose and Morgan (2000), from an upland forestry perspective, state that two to four years of continuous vegetation control can more than double the volume production of seedlings on good sites and more than triple growth on poorer sites.

> ***In sites with droughty soils, competition is for water—most often from grasses and herbs. In sites with more moist soils, competition for light can come from grasses and herbs as well as from shrubs and trees (Rose and Morgan 2000).***

Table 3. Control Methods for Competing Vegetation in Riparian Plantings (adapted from Rose and Morgan 2000)

method	advantages	disadvantages
manual	low knowledge needed low weather dependence low risk to nearby streams low controversy	high cost (labor, repeat visits) low numbers of sites treated high capital cost high soil disturbance potential damage to seedlings often leaves target roots intact potential spreading of noxious weeds
chemical	low cost (labor, repeat visits) high number of sites treated low capital cost low soil disturbance few access problems effective at killing target roots	high knowledge need (licensing) high weather dependence potential risk to nearby streams high controversy potential drift to seedlings

Mechanical/Manual Treatments

Mechanical control has been widely used by watershed councils for reducing competition. Scalping, mowing, and weed-eating have been attempted for grass control, with mixed results; machetes and brush mowers have been tried for shrubs. Mechanical and/or manual maintenance treatments typically address only above-ground biomass, leaving below-ground structures to possibly sprout or propagate. With that in mind, treatments need to be timed carefully and repeated often enough to damage target plant rootstock. For **reed canarygrass**, as many as five mowings per growing season are required to damage rootstock and provide competition release (Lyons 2000). **Japanese knotweed** requires at least three cuttings during the growing season to offset rhizome production (Seiger 1992). Repeated cutting of **blackberry** will greatly reduce vegetative spread, especially during summer, but herbicides or grubbing roots appear to be the only way to kill roots and prevent regrowth (Hoshovsky 1989b). Volunteers and other sources of inexpensive labor can readily perform competition release treatments. The Coquille Watershed Council has successfully utilized prison work crews for such labor-intensive projects as fence building and release treatments.

One of the major concerns with mechanical removal of competition is the risk of damage to seedlings. Many seedlings, lost in a sea of grass, have been accidentally removed with a weed eater or mower blade that was aimed at the seedling's competition. Even if the planted seedling is not directly removed, its vigor can be greatly reduced by incidental damage to the stem. Machetes and chainsaws, when used on blackberries and other shrubs, have a high probability of finding a planted tree—especially when the tree is completely surrounded by competing stems. Repeat scalping, if not done carefully, may also damage seedling roots.

Chemical Treatments

Herbicide use for maintenance, whether by councils, individual landowners, or within industry projects, can be very effective with careful planning, timing, and application. In most cases, only two or three treatments of herbicide are needed to get a tree through the most challenging establishment period. In all cases, it is important to minimize the amount of herbicide needed without compromising the effectiveness of the treatment. **It is critical to read herbicide labels to determine where and how various chemicals are appropriate and to determine restrictions on their use.** Careful consideration must be given to site characteristics, the probability of contacting surface and/or ground water, and the chemical's persistence, mobility, and toxicity. Several other herbicides besides glyphosate and triclopyr are listed for use in or near wetlands, though most are either toxic to fish, designed for aquatic plants, or have legal restrictions on using the water after treatment.

Backpack and hand-pump sprayers are efficient and probably the most common application technique for riparian plantings. Spot treatments of 30" circles around planted trees are most commonly recommended for control of grass. Wiping herbicide onto the target plant is feasible in some situations, such as to control blackberry re-sprouts after manual clearing or site preparation treatments. Other devices include a "hockey-stick" for grass treatments that uses a roller resembling a paint roller and a wand that delivers a foam spray. Timing of treatment should coincide with active plant growth and translocation of resources to roots—preferably late summer/fall for blackberries.

While herbicides can be very effective for controlling competition, losing trees to herbicide drift can be very disheartening. Drift can be minimized by increasing the sprayer's drop size, using permanent or temporary tree tubes, or employing some of the devices mentioned above. One very experienced tree-planting landowner suggested placing a stovepipe over the tree, spraying the herbicide, and then removing the stovepipe. While he dislikes the use of herbicide, as many of us do, he has not found a more effective way to control competition and encourage quick establishment.

Grazing

The use of grazing to reduce competition has promise, depending on the target plants to be controlled/grazed, the planted stock's sensitivity and need for protection, and the nature and function of animals to be used. Grazing by cattle, goats, and sheep is highly effective at discouraging vegetative blackberry growth (Hoshovsky 1989b). Depending on the "training" of the animals, high intensity, short duration grazing could greatly enhance blackberry control, though only if planted stock is adequately protected or has grown out of reach. Considerations include:

- Increasing the level of control of the target plants also increases the likelihood that grazers will damage the planted stock. For example, if cattle are allowed in a riparian area long enough to exhaust grass forage, the animals will likely begin browsing on planted stock and disturb the soil surface.

- Grazing should be timed to do the greatest damage to target plants while desired plants are least palatable. For example, timing grazing after blackberries have begun leafing out, but before budbreak on deciduous trees.
- Animals are curious and will examine anything out or the ordinary—such as tree tubes, stakes, fence posts, etc.—and have been known to remove such structures by rubbing, stomping, or biting.
- Goats (whose diets are quite variable) are quite able to stand on their hind legs to access forage, and have been known to strip bark and girdle trees. However, goats have also been known to favor blackberry even when other pasture and forage is available. (Hoshovsky 1989b)
- Sheep are more selective in their grazing preferences than goats are, and may be used as an alternative to mowing—provided trees are protected and soil damage is prevented (Hoshovsky 1989b).
- The palatability of reed canarygrass is questionable (Lyons 2000).
- Pasture grasses are highly tolerant of grazing, and would be little affected by prescribed treatments.
- Care must be taken to not move noxious weeds from one site to another via animal fur and manure.
- In areas with persistent, long-lived, large-seeded plants, chickens may be an option for reducing seed banks after mature vegetation is removed.
- The amount of natural predation on grazers increases with smaller animals such as sheep, goats, and (especially) birds.

Integrated Approaches

An integrated approach using a combination of the above techniques has the best probability of success in reducing competition. Consistent focus on three major points will help:

1) **Prevention**: maintain good herbaceous soil coverage—such as grass—to discourage competitive seedlings (to limit grass competing with planted stock, leave at least 18" around planted seedling stems bare) *via*:
   a. fencing;
   b. very light grazing with plant protection to stimulate grasses between trees.
2) **Above-ground control**: aggressively remove or discourage vegetative growth of competing plants *via*:
   a. manual removal—mowing, weed-eating;
   b. light grazing with planted stock protection;
   c. herbicide wipes or sprays.
3) **Below-ground control**: aggressively remove or kill rootstock of competing vegetation within 18" of seedling stems (grasses) and highly competitive shrubs between planted stock *via*:
   a. herbicide wipes on root sprouts, spray or wipe on grasses near planted stock;
   b. manual removal, digging, grubbing, or pulling roots;
   c. multiple per-season mowing, weed-eating.

Irrigation

Watering trees during the first and sometimes second growing season can greatly decrease mortality due to water stress, especially for plants in sandy or "droughty" soils or those subjected to drying summer winds. Light and frequent watering will often predispose a plant to drought stress, as roots then grow near the surface of the soil rather than searching lower depths. Deep watering at greater intervals is more appropriate, and should be tailored to soil.

In the Long Tom Watershed, northeast of Eugene, Oregon, young trees have been effectively and efficiently watered with 5-gallon buckets. Each bucket has a small (3/16" hole) drilled in the bottom; the buckets are set next to the tree and filled with water. The outside of the bucket is marked to indicate the location of the hole for placement nearest the tree and to make clogged holes easier to locate for cleaning. The drip of the emptying bucket waters the tree slowly (in 20-30 minutes) and thoroughly while neighboring trees are attended to. The slow, measured watering encourages healthy, deep root development. (Elkins 2004)

Several council members have noted, however, that while they are spending time and money watering trees, natural seedlings of the same species on the same site seem to thrive with no additional moisture. Controlling competing vegetation (especially grasses) can be very effective at making more moisture available to the seedling, and may be more efficient than watering. Trees planted in deep, loose, silt/loam soils, likely need no watering at all.

Fertilization

Opinions on the need for fertilization in planted stock are widely mixed, depending on stock type, soil deficiencies, and consequences of application. Managers using fertilizers recommend a complete formula, i.e., 20:10:5, or 15:15:15. Specific balances should reflect soil deficiencies. This is a topic area where few studies have been conducted for riparian tree plantings. Recommendations and considerations from focus groups and literature include:

- Do not fertilize the competition; avoid broadcast fertilizers and in-ground fertilizers if competing roots are present.
- Fertilizers added with stock can considerably enhance vigor and capacity to out-grow competition.
- Slow-release tablets in the planting hole can provide consistent feeding for two to three years (Platts et al. 1987), though care should be taken to avoid direct contact with seedling roots.
- For larger trees, fertilizer stakes used in orchards and landscaping may be appropriate, as may burying granules about 3" above the roots.
- Fertilizers may alter water potential near roots, increasing water stress.
- Fertilizers can increase palatability to browsers.
- Fertilizers may be unnecessary.

Notes

Monitoring and Assessment

Monitoring is a crucial part of any integrated restoration project or adaptive management plan (Tu et al. 2001; IMST 2002). Managers need quantitative measurements of meaningful characteristics in a timely manner to determine what works—and what doesn't. Data collection needs to be structured enough to provide consistency within a single project from year to year, as well as between projects. Monitoring must be done frequently enough that changes can be made and still expect positive results; for example, collecting establishment information two years after planting, only to find trees buried in blackberries, is at best counterproductive. At that point it is difficult, if not impossible, to salvage the project. However, if site visits made six months into the project revealed poor vigor and growth due to unexpected competition, corrective actions could still be taken.

Monitoring data also provides information that is critical for designing future planting projects. All the care we provide for planted stock before, during, and after planting is revealed in vigor, quick establishment, and speed to free-to-grow. But how much care is truly needed? And how much care is beyond what is cost effective for expected results? With consistent and available monitoring data, we can hope to better match site potential with growth rates and better plan for foreseeable hazards.

Select Monitoring Type

Implementation and effectiveness monitoring will be discussed here. Implementation will be assumed complete when planted stock achieves free-to-grow status. Once that milestone is reached, effectiveness monitoring will track longer-term habitat objectives such as water quality improvements, large wood production, and other landowner objectives.

> ***"Effectiveness monitoring and evaluation are prerequisites for effective adaptive management." (IMST 2002)***
>
> ***Project implementation will be assumed complete when stock is free-to-grow.***

Implementation monitoring protocols in this guide will include a detailed record of planting efforts, planted stock, and initial establishment (inspections up to one year). Also included in implementation monitoring is at least yearly data collection on survival, vigor, damage, competition, etc. in both extensive (covering the whole project) and intensive (measurements of stock within set plots) formats. Coastal watershed councils have tested and refined both the intensive and extensive monitoring protocols in both new and established projects.

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Implementation Monitoring

The **Planting and Establishment Record** (Appendix B1) is designed to track a number of variables that are directly related to project success and is to be completed at the time of planting. Plant and planting details such as species, stock type, planting method, stock protection, source, and time in transport and storage are recorded. Weather at the time of planting can be a large factor in mortality in some situations, and is worth documenting.

Spring and fall inspections are fairly standard in upland planting projects, as mortality rates at different seasons the first year after planting can provide insight into changes needed—or not needed—in future projects. Spring inspections will often reveal problems with stock quality, handling, planting, and animal damage. Fall inspections (1-year survival) can point to problems with competing vegetation, soil/site incompatibilities, and animal damage.

The **Extensive Monitoring** protocol (Appendix B2) is a generalized survey that provides basic information on a project site and is especially useful on projects that have not been visited for a while. It is designed to produce a rough map of the entire project area that identifies areas of higher/lower survival, vigor, damage, and competition. Information collected can be used to describe stocking rates for past planted, free-to-grow sites, as well as document establishment problems due to low vigor, animal damage, and competition on newer sites.

The extensive monitoring survey records the number, species, and condition of trees within identified "segments" of riparian area. Segment breaks are located with a GPS reading and also marked on a map or aerial photo. Segments are identified by large changes in soil type, management, existing vegetation/competition (including noxious weeds), landform, damage, vigor, and/or survival. Length and average width of the segment are recorded and a representative photo is taken.

The plot-based **Intensive Monitoring** procedures (Appendix B3) are designed to streamline monitoring efforts into fixed representative plots and avoid having to cover the entire project, especially large ones. This survey is dependent on a rough map of the area in order to place plots in a way that captures the variability of a site, and to estimate the length or area needed within plots. Magnified aerial photographs are extremely useful for both intensive and extensive methods (though topographic maps work well, too).

Riparian planting projects in coastal Oregon range in size from narrow to broad, short to long, less than a tenth of an acre to nearly ten acres extending over three miles of stream length. The high diversity in size and shape has called for a sliding scale of area to be covered as well as a design that can accommodate a variety of planted species and planted surfaces. For all areas, a random (or at least unbiased selection) of monitoring sites is suggested for accuracy and statistical relevance. Area coverage for plots is based on a starting point of ten percent of the total project area, but is modified from there. The dominant concern is to capture site variability within plots at the time of planting, but to also have the flexibility of adding or dropping plots if necessary. In all sites, five to ten percent area coverage is recommended, though for small projects, a much higher percentage may be necessary.

A grid placement and random selection of circular monitoring plots is recommended for wide plantings, while a "forced interval" of sorts may be the most practical for long, narrow planting projects. One example would be to use every 25th fence post as a permanent plot marker, with the appropriately sized rectangular plot proceeding from that point. Adjustments may be needed to avoid outside bends in the stream channel, road crossings, and other features. In large and/or diverse areas, several small monitoring plots may be more appropriate than a single large plot for capturing site variability, relative to tree growth potential or hazards. In subsequent monitoring years, when variability is better understood, plots can be added or dropped in a similar randomized fashion. Tables 4 and 5, below, show some of the options available for plot sizes and shapes.

For each Intensive Monitoring plot established, trees and shrubs are identified and measured. Data gathered for each tree will include species, height, live crown or stem count, the landform it is planted on, slope, a description of competing vegetation, and a description of damage. Plots are most effectively monitored when each tree or shrub is tagged with a unique number; one suggestion is to place a stout bamboo stake near each tree (possibly part of the tree protection or simply a way to more easily find the tree), and tag the stake.

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Table 4: Examples of Rectangular Monitoring Plots.

length covered	transect length	number of plots	length of plots
4000 ft.	400 ft.	4	100 ft.
		6	67 ft.
		8	50 ft.
1500 ft	150	3	50 ft.
		4	38 ft.
		6	25 ft.
300 ft	100	4	25 ft.

Table 5: Examples of Circular Monitoring Plots.

portion of acre	number of plots	square feet	radius (feet)
1/10 (4356 sq. ft.)	1	4356	37
	2	2178	26
	3	1452	22
	4	1091	19
1/20 (2178 sq. ft.)	1	2178	26
	2	1089	19
	3	726	15
1/100 (436 sq. ft.)	1	436	12

Effectiveness Monitoring

Effectiveness monitoring tracks the specific characteristics of the riparian area or stream that planting projects are designed to change—the objectives of the project determined at the onset. Effectiveness of a project and successful planting efforts are sometimes quite different. One follow-up study of riparian projects in the American Southwest found several instances where objectives of the project were met (improving shade, fish habitat quality, channel dimensions), though planting efforts were a near-total failure. With changes in management, natural re-vegetation was often so vigorous that remaining planted stock could not be found (Briggs et al. 1994). Conversely, planting efforts can be fully successful and not meet the listed objective. One example of this would be free-to-grow willow stands on a large stream or river, with an objective of providing shade. Another example would be listing large wood recruitment as a primary objective, when measurement of success would not be possible within our lifetimes.

Pre-planting measurements, needed for quantified results, are often missed. Measurement protocols for shade, water quality, plant community structure, and channel characteristics are well documented (see Table 6, below). Planning measurements for detecting change due to "treatments" is often more involved than measurements for inventory or prioritizing, and needs to be carefully arranged.

For these reasons, objectives must be well thought out in order to be measurable in a reasonable time frame, realistic for a given site, and documented in such a way that showing success is possible.

Table 6. Common objectives for planting projects and references for measurement protocols.

objective	references for measurement protocols
shade	Oregon Plan Water Quality Monitoring Technical Guidebook, Chapter14: Shade and Cover
bank stability	DEQ, Coos Watershed protocols
high quality nutrient inputs	Invertebrate Sampling, Oregon Plan protocol
water quality	Oregon Plan Water Quality Monitoring Technical Guidebook, Chapter 6: Stream Temperature
large wood recruitment	ODFW Aquatic Inventory, riparian survey
fish habitat improvement	ODFW Aquatic Inventory, channel cross-sections
increased community diversity	USFS Monitoring Riparian Resources (Greenline), plant ecology methods (vegetation transects)
noxious weed control	USFS Monitoring Riparian Resources (Greenline), plant ecology methods (vegetation transects)

Collect and Manage Data

Data management and project tracking is needed to answer long-term as well as short-term questions. It is impossible, for example, to calculate survival with incomplete records of total planting numbers.

The **Planting Project Summary** (Appendix B4) is designed as a central point for planting project documentation that includes location, name, size, fencing, and a summary of plant numbers and species. Also included is a record of effectiveness monitoring, both before and after project implementation.

Photographs are a simple monitoring tool that can be a powerful record of change when set up in a repeatable format. This form provides a place to record dates and descriptions of photographs at various stages in the planting project.

Control of competing vegetation is a critical part of project success, especially in the first years; documentation of site preparation will help track how much effort is enough and predict which future projects may need more effort.

The maintenance record will provide tracking of efforts on projects and help estimate costs for future projects. Maintenance activities can range from checking tree tubes or replacing stakes to project-wide competition release treatments.

Site maps and marked aerial photographs should be kept in a central project file with the Planting Project Summary. With readily available digital orthographic photographs and GPS recorders, general plot and photo point locations are easily marked and recorded for long-term tracking. Detailed site maps of individual projects can lend considerable insight into why plants in certain locations performed better or worse than in other locations, and can help to determine initial and established tree stocking densities.

Measure Results

The results of efforts in site preparation, planting, and maintenance will be revealed in survival, growth, and vigor. These variables should be tracked independently, as they can tell us different things about the success of a project.

Survival is a basic measure of how many plants are alive out of those that were originally planted and is translated into stocking densities later in the project.

Growth is a measure of the height of the plant (for trees) or the height and number of stems emerging from a common rootstock (shrubs). Growth rates obtained from monitoring data will allow us to estimate the time to achieve objectives such as stream shade or large wood production. Differences in growth rates can reveal variations in planting, protection, or levels of competition, as well as variations in soil conditions and suitability of planted stock.

Vigor, as measured by the amount of crown vs. stem height for trees, is a more difficult characteristic to quantify, but is the most critical to project success. Vigorous trees are better able to tolerate moderate browse, repel and survive insect and disease attacks, and more quickly become free-to-grow. Vigor is also a reflection of how well a plant is suited to the site, and can thus help us to tailor future planting plans.

Using Benchmarks to Assess Success

The success of individual re-vegetation projects needs to be related to stream processes and functional condition. Now that you have big trees and a diverse community, is the stream functioning better? According to Prichard et al. (1998), riparian area that is functioning will:

- dissipate stream energy associated with high flows, thereby reducing erosion and improving water quality;
- filter sediment, capture bedload, and aid floodplain development;

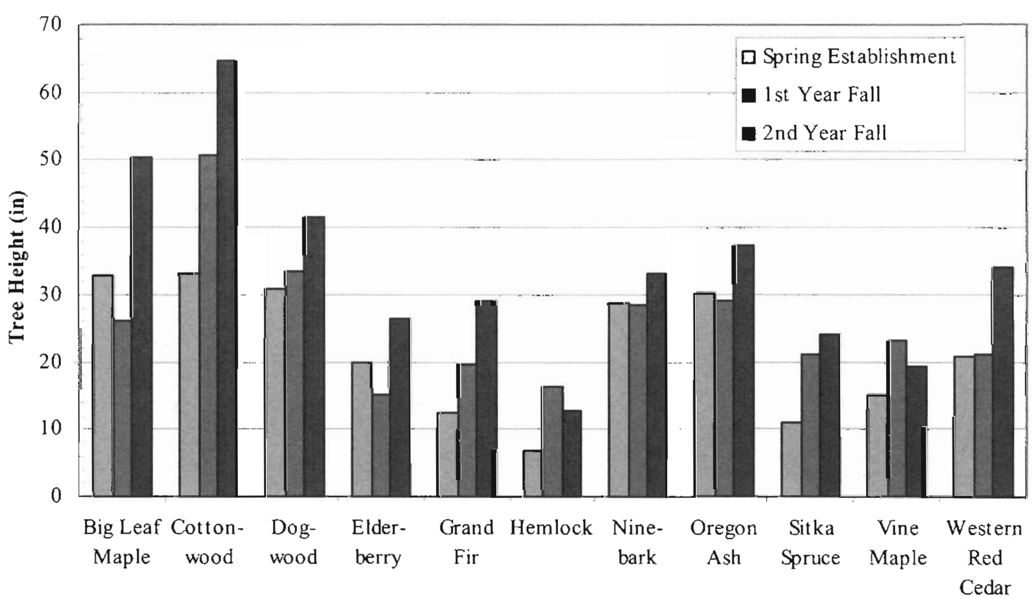
- improve flood-water retention and ground water recharge; and
- develop root masses that stabilize streambanks against cutting action.

All of these functions will develop and/or maintain the high quality habitat that is crucial to recovering salmon populations and high water quality. Stream processes are highly variable in intensity and form, and must be compared only to the potential for that stream reach or what it is capable of now, given human caused factors such as roads, bridges, and dams.

For re-vegetation projects, it is important to tailor expectations for planting success by site conditions and species planted. In some cases, with fast growing trees in a productive stream reach, objectives such as canopy closure and floodplain development may be reached within a fairly short time. With other sites, such as those with considerable upper watershed problems, severe summer or winter winds, harsh soils, or extreme predation problems, it may take decades to achieve similar objectives.

It is also important to compare results with the initial condition of the stream reach or project area, and to compare results with the initial surveys that determined project locations. An example of this would be to compare reaches with increased shade to those identified by the Shadow Model as needing shade (Ricks Myers 2001) and estimating the number of years needed to achieve full site potential tree growth. It may also be helpful to compare the extent and intensity of noxious weed infestations before and after the planting project.

Once past the most demanding maintenance period, most projects will need fairly infrequent visits to check on tree growth, predation problems, and stand development. While it is appealing to think that once a tree is free-to-grow it is on its own, it is discouraging to find that an entire stand of six-year-old trees were taken down by beaver or that overcrowding stress caused disease to kill half of the stand.



Data gathered in monitoring can be graphed for a visual representation of results; for example, to readily compare the survival of various species.

Final Assessment

Was your project successful?

The formal measure of a project's success is determined by evaluating whether or not the specific objectives set at the beginning of the project are met at the end of the project. That determination is made by comparing the pre-project condition with the post-project condition, in regards to the details identified for change; the comparison is made with the observations and records made throughout the project. Those comparisons must take outside and unforeseen affects into account, as well as unexpected challenges, windfalls, or benefits.

Such formal evaluations are often required by granting or permitting agencies, and may be required in the project's final report.

Even if a formal evaluation is not required, future riparian restoration projects—yours or others'—could significantly benefit from the information gained from your project. To that end, project managers are strongly encouraged to share their experiences with OWEB, local and neighboring watershed councils, local and neighboring soil and water conservation districts, and their local agricultural extension agents.

In reality, many projects are successful in improving the overall functional condition of the riparian habitat without meeting the specific objectives of the project.

Final Thoughts

In all of our coastal watersheds, it is important to review the suite of tools available for protection and restoration work and choose those that make the most sense in terms of stream function and the best return on investment. Riparian planting projects have great potential for restoring community diversity and seed sources, controlling noxious weed spread, educating the public, and improving stream functions. After many years of trial and error in many different watersheds, it has become quite clear that planting projects take a considerable amount of time, effort, and money in order to be successful. The biggest challenge in the future will be to determine where we can achieve the biggest improvements with the resources available.

Notes

Supplemental Information

Relationship of Riparian Vegetation to Salmon Recovery

According to the Oregon State of the Environment Report 2000, the amount of intact or functional riparian vegetation found along streams and rivers is a key indicator of the health of Oregon's riparian areas. Restoration of these riparian areas, for both structure and function, is a common activity for watershed councils throughout the state and is a primary goal of the Oregon Plan for Salmon and Watersheds.

Recovery of riparian areas is closely tied to protecting and enhancing salmon stocks, as riparian corridors provide shade, filter sediments, capture excessive nutrients, stabilize floodplain soils, provide energy inputs to food webs, and produce large wood for habitat structure (SOER 2000).

The Independent Multidisciplinary Science Team (IMST), in their report *Recovery of Wild Salmonids in Western Oregon Lowlands,* state that large wood, undercut banks, complex floodplains and channels, and riparian and aquatic vegetation, create complex habitats that provide refuges from predators for salmonids during the upstream migration of adults and the downstream migrations of juveniles. Maintaining habitat complexity in lowland streams is critical to the completion of salmonid life histories and restoration of western Oregon lowland ecosystems is essential in meeting the objectives defined in the Oregon Plan (IMST 2002).

The National Research Council (2002) states that a large portion of the concern about riparian areas, particularly here in the Pacific Northwest, has come for the need to maintain viable fish populations. Fish are dependent on riparian vegetation for its effect on water temperature, food supply, large wood, channel structure, and sediment transport.

Riparian areas in coastal Oregon have attributes of forested streams, depending on large wood for structure, as well as attributes of non-forested streams; riparian areas need a diverse community of shrubs, grass-like plants, and forbs to maintain stream channel dimensions and integrity. Lowland streams on the coast have had the combined impacts of losing vast quantities of woody material that used to flow from the uplands, clearing of streamside vegetation with development of agriculture, and loss of beaver populations that once radically altered the hydrology of small streams. Ditching, straightening, culverts, bridges, levees, and tidegates have so changed the hydrology of many of these rivers and streams that native, potential vegetation is either absent from the system or is unable to germinate and maintain. Upland land uses have often changed the delivery of storm flow so that it comes in higher quantities for a shorter duration and carries more energy and sediment than before. Noxious weeds are particularly prevalent in many of our coastal lowland streams, and pose serious threats to recovering and restoring riparian vegetation as they often block or eliminate natural vegetative processes.

Benefits of Riparian Vegetation in Lowland, Non-Forested Areas

In a report to the Governor in 2000, the Riparian Management Work Group identified the important functions provided by the riparian zones. Those functions and benefits are summarized as follows within Oregon's Statewide Riparian Restoration and Management Policy:

Aquatic shade and water temperatures
Stream temperature is critical to maintaining viable salmonid populations and other aquatic life. Stream temperature conditions are influenced by shade through vegetation and stream channel morphology.

Streambank stability and erosion processes
Well-vegetated riparian areas help maintain the stability of stream banks, reduce bank erosion, and foster the development of complex habitats along channel margins. Riparian plants produce root mass that is distributed throughout the soil column, thereby providing additional resistance to elevated stream velocities. Outside the channel, healthy stands of riparian vegetation can significantly dampen off-channel floodplain velocities and create backwater conditions. Sediments and nutrients deposited in slack water contribute to water quality and the health and stability of riparian areas.

Floodplain complexity and riparian vegetation
Riparian forests can produce large amounts of wood. This wood plays a critical role in aquatic ecosystems by dissipating the force of water and helping to create complex habitats. When high energy streams enter lowlands and valleys, deposition of sediments causes increased interaction between the channel and floodplain, and results in floodplain complexity, such as side channels, sloughs, oxbow lakes, and spring-fed creeks.

Nutrient and sediment sources
Riparian vegetation provides a nearly constant input of leaves, wood, insects, spores, and other materials, which represent an important part of the aquatic food chain and contributes to the overall productivity of aquatic systems. Riparian areas may also be a source of sand and gravel for transport and the creation of instream bars, new riparian areas, and channel complexity downstream.

Filtration of sediments, organic material, and toxic substances in surface runoff
All streams, under natural conditions, produce sediment and other inputs at varying levels. Human activities can increase these inputs to a point where they have a negative effect on the health and productivity of the stream. The magnitude of these inputs depends on local soil types and substrates, topography, vegetation, and precipitation. Healthy riparian vegetation can capture and hold these materials, thus keeping them out of the water.

Wildlife habitat
When compared to most upland areas, riparian areas provide greater habitat diversity, and often support higher species diversity. In healthy riparian ecosystems, structural complexity and habitat diversity result from diverse plant species, multiple canopy layers, and a range of plant age classes."

The benefits of riparian buffers are very well supported in the scientific literature as a means to capture excessive organic and inorganic nutrients coming from upland or terrace areas. Functioning riparian areas act as a "sink" for nitrate and phosphate (Green and Kauffman 1989). Microbial action within the soil as well as retention by vegetation serves to remove significant amounts of these two nutrients. Peterjohn and Correll (1984) measured nutrients in surface runoff and shallow groundwater as they moved across an agricultural watershed. As runoff and groundwater moved through intact, forested riparian areas, significant losses of nitrate and phosphate were reported. Jacobs and Gilliam (1985) had comparable results with nitrate reduction in a similar experiment. Lowrance (1992) found that most denitrification occurred within the top 10 cm of soil, and especially in the surface soils near the stream. Highest potential for denitrification was in the late summer and fall. Hunt et al. (1999) documented a 37 percent total annual removal of nitrogen through an in-stream wetland (beaver pond).

Sediment capture and retention is another aspect of intact riparian areas that involves woody and herbaceous communities. Elmore and Beschta (1987) discuss the role of vegetation in building floodplains by capturing sediments deposited in high flow events. An experiment in 1993 by Abt et al. (1993) showed that presence of vegetation significantly increases sediment deposition and also the entrapment of sediment in a constructed stream channel. The vegetation, after being subjected to sediment free flushing flows, retained thirty to seventy percent of deposited sediment.

Naiman et al. (2000) state that while riparian community characteristics influence the age and species of wood entering the channel, channel processes are altered by wood and greatly influence plant succession in riparian forests. The authors assert that wood sources are quite variable depending on the nature of the watershed, and may come from upstream or upslope as delivered by avalanches, debris flows or floods, as well as from riparian communities delivered by lateral bank erosion and wind throw. Large wood deposited within the channel, especially with an intact root wad, will likely capture other wood, create gravel and sand bars ideal for riparian colonization, and eventually develop into a stable island. These vegetated islands coalesce to form riparian forests (Naiman et al. 2000).

Costs Associated with Successful Planting Projects

Bishaw et al. (2002) estimated that total cost of fencing, site preparation, planting, protection, and maintenance of alder trees in an agricultural area with strong beaver influences can be as much as $57 per established tree. The Coos Watershed Association has a carefully monitored demonstration project involving bank pullback, control of noxious weeds, fencing, planting of ground cover grass and a wide variety of shrubs and trees. The project will have an estimated total cost of $30,000 for approximately 3 acres of riparian area—an estimated total cost of $16 per tree (Souder personal communication 2002).

Costs associated with planting projects typically include:

- **Functional Assessment** of riparian areas within the basin or sub-basin, or an assessment of shade (potential and existing), to determine objectives. These objectives may be highlighted within watershed assessments and action plans. A functional assessment can be costly if done basin-wide with a Shadow Model, Hydrogeomorphic Assessment, or Proper Functioning Condition assessment, but will provide information for focusing directed actions that are more likely to address limiting factors. OWEB is developing a riparian assessment framework to assist with this step.

- **Site Plan**. Reconnaissance of site conditions, historic vegetation, existing vegetation (including noxious species) soil conditions, flood regime, and protection needed. A site plan includes selection of appropriate species and identification of desired spacing and planting areas, and is typically mapped.

- **Site Preparation**. Removal of existing vegetation, often noxious weeds, in order to reduce initial competition. Site preparation can range from fairly inexpensive herbicide treatments to the more costly use of heavy equipment and extensive manual labor.

- **Planted Stock**. The cost of the stock can vary considerably depending on the size, age, and type. Some stock types, i.e., willow, cottonwood, or dogwood cuttings, are typically free, though they require more time for harvesting. Bareroot and container stock have to be ordered early (increasing planning time), picked up from the nursery (increasing time and cost), and must have careful transportation to maintain temperatures and moisture content (increasing equipment cost).

- **Planting Efforts and Recordkeeping**. Documentation of planting activities on a site, including numbers of plants of each species, type of stock, planting method, timing, and source, is critical to interpreting monitoring data collected in following years. Costs will include time for completing the record, including maps and aerial photos, as well as the purchase/ use of global positioning equipment (GPS unit).

- **Stock Protection**. Fencing of riparian areas has been and will likely continue to be a major cost consideration for planting projects. Other costs for individual tree protection may include tree tubes and stakes, tin foil, or cages. Costs include both the price of materials as well as the labor to install and maintain them.

- **Monitoring**. Some level of monitoring is required to ensure that the planting was completed and trees are free-to-grow (implementation), and that objectives for the project are met (effectiveness). Monitoring can be as simple as photo documentation and tree counts, or can be as complex as determining plots, measuring trees, estimating competition, and tracking the success of individual species or planting strategies. (Monitoring strategies, protocols, and data sheets are provided in this document.)

- **Maintenance**. Maintenance can be a significant cost, especially in the first years of the project. Time must be allotted for controlling competing vegetation, watering trees (if needed), replacing tree tubes or stakes, and mending fences. Equipment may also be necessary, such as pumps for watering, herbicide spray equipment, weed eaters, mowers, etc.

Appendix A – *Species Lists*

Species Characteristics of Riparian Associates in Western Oregon

Information from Dr. David Hibbs at OSU Forestry and Rose et al. (1998). Rose et al. (1998) has detailed information on propagation of all species with codes in the Propagation method column, below.

	Shade Tolerance*	Flood Tolerance	Longevity (in years)	Silvics Information	Propagation Method*
Coniferous Trees					
Douglas fir	2	1	800	excellent	S, C
western red cedar	5	4	800	some	S, C
redwood	3	4	1000	much	
Sitka spruce	5	4	300	little	S
shore pine	1	4	150	none	
ponderosa pine	1	4	200	little	S, G
western hemlock	5	2	250	much	S, C, G
grand fir	4	3	150	little	S
Hardwood Trees					
red alder	1	3	150	much	S, H, C
white alder	1	5	100	none	
cottonwood	1	4	100	some	S, C,
Oregon ash	3	5	150	little	
big-leaf maple	4	3	200	little	S, H
Oregon white oak	1	3	500	none	S
willows	1	5	75	little	S, C
Pacific dogwood	4	3	75	none	S, C
cascara	2	4	75	none	S, C
Shrubs					
salmonberry	2	4	clonal		S, C, RC
Pacific serviceberry	3	3			S, RC
snowberry	4	4	clonal		S, RC
Spirea	2	5	clonal		S, C
vine maple	5	3	clonal		S, H
Indian plum	3	4			
hazel	3	2	clonal		
thimbleberry	3	4	clonal		S, C, RC
devil's club	4	5	clonal		S, C
stink currant	4	4	clonal		S, C
ninebark	2	3			S, C
red-osier dogwood	2	4	clonal		S, C
fool's huckleberry	3	2			
red huckleberry	4	2			S, C
back twinberry					S, C
rhododendron					S, C
red elderberry					S, C, RC

* 1 = very intolerant; 5 = very tolerant

** S = seed; C = cutting; H = harvest; RC = root cutting or rhizome; G = grafting

Plant List for Riparian Zones on the South Coast of Oregon

Estuary/Sitka Spruce Zone

Overstory Trees

Sitka spruce *(Picea sitchensis)*
shore pine *(Pinus contorta contorta)*
red alder *(Alnus rubra)*

Understory Trees

coastal willow *(Salix hookeriana)*
red elderberry *(Sambucus calicarpa)*
hawthorn *(Crataegus suksdorfii)*

Woody Shrubs

twinberry *(Lonicera involucrata)*
red flowering currant *(Ribes sanguineum)*
waxmyrtle *(Myrica californica)*
silk tassel *(Garrya sp.)*
evergreen huckleberry *(Vaccinium ovatum)*
western azalea *(Rhododendron occidentale)*

Other Species

salal *(Gaultheria shallon)*
snowberry (*Symphoricarpos albus)*
coyote brush *(Baccharis pilularis consanguinea)*
thimbleberry *(Rubus parviflorus)*
purple bush lupine *(Lupinus sp.)*
coast strawberry *(Fragaria chiloensis)*
yarrow *(Achillea millefolium)*
sedge *(Carex spp.)*
Pacific silverweed *(Potentilla pacifica)*
angelica *(Angelica sp.)*
bearberry *(Arctostaphylos uva-ursi)*
sea pink *(Armeria maritima)*
seaside daisy *(Erigeron glaucus)*

River Mainstem/Low-gradient Stream Zone (South Coast)

Overstory Trees
- Sitka spruce *(Picea sitchensis)*
- grand fir *(Abies grandis)*
- western hemlock *(Tsuga heterophylla)*
- western red cedar *(Thuja plicata)*
- myrtle *(Umbellularia californica)*
- big-leaf maple *(Acer macrophyllum)*
- black cottonwood *(Populus trichocarpa)*
- Oregon ash *(Fraxinus latifolia)*
- tanoak *(Lithocarpus densiflorus)*
- red alder *(Alnus rubra)*

Understory Trees
- willow *(Salix hookeriana, S. delnortensis, S., lasiolepis, S. laevigata, S. lasiandra, S. sitchensis)*
- red elderberry *(Sambucus calicarpa)*
- hawthorn *(Crataegus suksdorfii)*
- cascara *(Rhamnus purshiana)*
- Pacific ninebark *(Physocarpus capitatus)*
- vine maple *(Acer circinatum)*

Woody Shrubs
- ocean spray *(Holodiscus discolor)*
- red flowering currant *(Ribes sanguineum)*
- Douglas spirea *(Spiraea douglasii)*
- Indian plum *(Oemleria cerasiformis)*
- red osier dogwood *(Cornus sericea)*
- service berry *(Amelanchier alnifolia)*
- evergreen huckleberry *(Vaccinium ovatum)*
- western azalea *(Rhododendron occidentale)*

Other Species
- snowberry *(Symphoricarpos albus)*
- thimbleberry *(Rubus parviflorus)*
- sword fern *(Polystichum munitum)*
- sedge *(Carex spp.)*
- blue wildrye *(Elymus glaucus)*
- monkey flower *(Mimulus guttatus)*
- mugwort *(Artemesia douglasiana, A. suksdorfii)*

(Follansbee 1999)

Plant List for Riparian Zones on the North Coast of Oregon

Estuary/Sitka Spruce Zone

Overstory Trees
- Sitka spruce *(Picea sitchensis)*
- shore pine *(Pinus contorta contorta)*
- red alder *(Alnus rubra)*
- western hemlock *(Tsuga heterophylla)*
- western redcedar *(Thuja plicata)*

Understory Trees
- coastal willow *(Salix hookeriana)*
- red elderberry *(Sambucus calicarpa)*
- hawthorn *(Crataegus suksdorfii)*
- cascara *(Rhamnus purshiana)*
- crabapple *(Malus fusca)*

Woody Shrubs
- twinberry *(Lonicera involucrata)*
- waxmyrtle *(Myrica californica)*
- silk tassel *(Garrya elliptica)*
- evergreen huckleberry *(Vaccinium ovatum)*
- western azalea *(Rhododendron occidentale)*
- coyote bush *(Baccharis pilularis consanguinea)*
- Douglas spirea *(Spiraea douglasii)*

Other Species
- salal *(Gaultheria shallon)*
- snowberry *(Symphoricarpus albus)*
- thimbleberry *(Rubus parviflorus)*
- purple bush lupine *(Lupinus sp.)*
- coast strawberry *(Fragaria chiloensis)*
- yarrow *(Achillea millefolium)*
- slough sedge *(Carex obnupta)*
- Pacific silverweed *(Potentilla pacifica)*
- angelica *(Angelica sp.)*
- bearberry *(Arctostaphylos uva-ursi)*
- sea pink *(Armeria maritima)*
- seaside daisy *(Erigeron glaucus)*
- mugwort *(Artemesia douglasiana)*
- salmonberry *(Rubus spectabilis)*
- spikerush *(Juncus sp.)*

River Mainstem/Low-gradient Stream Zone (North Coast)

Overstory Trees

- Sitka spruce *(Picea sitchensis)*
- grand fir *(Abies grandis)*
- western hemlock *(Tsuga heterophylla)*
- western redcedar *(Thuja plicata)*
- big-leaf maple *(Acer macrophyllum)*
- black cottonwood *(Populus trichocarpa)*
- Oregon ash *(Fraxinus latifolia)*
- red alder *(Alnus rubra)*

Understory Trees

- willow *(Salix hookeriana, S. delnortensis, S. lasiolepis, S. laevigata, S. lasiandra, S. sitchensis)*
- red elderberry *(Sambucus calicarpa)*
- hawthorn *(Crataegus suksdorfii)*
- cascara *(Rhamnus purshiana)*
- vine maple *(Acer circinatum)*
- bitter cherry *(Prunus emarginata)*
- crabapple *(Malus fusca)*

Woody Shrubs

- ocean spray *(Holodiscus discolor)*
- red flowering currant *(Ribes sanguineum)*
- Douglas spirea *(Spiraea douglasii)*
- Indian plum *(Oemleria cerasiformis)*
- red osier dogwood *(Cornus sericea)*
- service berry *(Amelanchier alnifolia)*
- evergreen huckleberry *(Vaccinium ovatum)*
- western azalea *(Rhododendron occidentale)*
- Pacific ninebark *(Physocarpus capitatus)*
- hazel *(Corylus cornuta)*
- twinberry *(Lonicera involucrata)*
- wild rose *(Rosa nootka, R. pisocarpa)*
- black gooseberry *(Ribes lacustre)*
- sticky currant *(Ribes viscosissimum)*
- stink currant *(Ribes bracteosum)*

Other Species

- snowberry *(Symphoricarpus albus)*
- thimbleberry *(Rubus parviflorus)*
- sword fern *(Polystichum munitum)*
- sedge *(Carex spp.)*
- blue wildrye *(Elymus glaucus)*
- monkey flower *(Mimulus guttatus)*
- mugwort *(Artemesia douglasiana, A. suksdorfii)*
- salmonberry *(Rubus spectabilis)*
- spikerush *(Juncus sp.)*
- salal *(Gaultheria shallon)*

(Follansbee 2002)

Notes

Appendix B – *Forms*

Forms follow this section title page; specific instructions follow each form.

Planting and Establishment Record Form
Extensive Monitoring Form
Intensive Monitoring Form
Planting Project Summary Form

Planting and Establishment Record

property owner/project name		date
stream/watershed name	planting crew	
weather (cloud cover, precipitation, wind, humidity, temperature)		

species	# of plants	stock type/age	how planted	protection/staking	nursery/source	time since lifting/cutting	spring survival	fall survival

comments from spring inspection
date:

comments from fall (1 year) inspection
date:

property owner/project name Name of project.
date Date of planting.
stream/watershed name Name of stream and watershed.
planting crew Names or initials of individuals planting trees.
weather Identify climate conditions at the time of planting. Is the weather warm with a dry wind, cool and rainy, or foggy with no wind? Seedling care is very closely tied to weather the day of planting and is crucial for project success.
species Use codes that are convenient. List a key somewhere on data sheet.

Examples include:

SS – Sitka Spruce	**W** – Willow
DF – Douglas Fir	**Ash** – Oregon Ash
RW – Redwood	**CW** – Cottonwood

Another option is to use the standardized coding system available in forestry manuals that uses the first two letters of the genus name and the first two letters of the species name. For example, *Pinus ponderosa* would have the code PIPO.

# of plants Identify the number of individual stock planted at the project site.
stock type/age Identify the type of planting stock. Common stock types are bare root, container stock, cuttings, wildlings, and rooted cuttings. For plants from a nursery, identify the age of stock. Common ages are 1+1, 2+0, 2+1.
how planted Identify how plants of each type and species are place into the ground. Common methods include auguring, shovel planting, hoedad planting, as well as planting bar or pushing for cutting stock.
protection/staking Identify methods used to protect/identify/support plants at or near the time of planting; vexar tubes, bamboo stakes, fir strips, and tree tubes are common examples.
nursery/source Identify where planted stock came from; include the name of the nursery and/or the sites of hardwood and shrub harvest.
time since lifting/cutting How many hours, days or weeks have plants been out of the soil or separated from the "mother" plant?
spring survival Number of individual plants still alive in Spring. (Survival can be estimated from plot data when using the intensive monitoring protocol.) Inspection should take place after normal bud-break or leaf-out stage. Mortality before spring often indicates planting and/or stock problems.
fall survival The number of individual plants alive at the end of the first year. Mortality before the end of the first year is often related to competition and site conditions.
comments from spring inspection General condition of seedlings, evidence of herbivory or wind/water damage, level of competition.
comments from fall inspection General condition of seedlings after exposure to warm weather: vigor, damage, level of competition, etc.

Extensive Monitoring Form

landowner/project name		observer	date
stream	watershed	GPS of start point	
access to start point			

seg #	length	avg. width	GPS	mapped?
photo #	description			

species	number	avg. ht.	vigor	damage/source	avg. comp/source

comments

seg #	length	avg. width	GPS	mapped?
photo #	description			

species	number	avg. ht.	vigor	damage/source	avg. comp/source

comments

seg #	length	avg. width	GPS	mapped?
photo #	description			

species	number	avg. ht.	vigor	damage/source	avg. comp/source

comments

property owner/project name Name of landowner or project.
observer Name or initials of individuals completing form.
date Date of extensive survey.
stream Name of the stream.
watershed Name of the watershed.
GPS of start point GPS coordinates of the start point of the survey. Record if it is the upstream or downstream end on the data sheet, and mark it on the aerial photo or topo map.
access to start point Provide a brief description of how to get to the start point of the survey.

For all of the surveyed segments, record the following information:

- **seg#** The segment number from the start point.
- **distance** The distance traveled within the segment.
- **avg. width** The average width of the segment; measured, if necessary, at a place that represents average width.
- **GPS** GPS coordinates for the upper end of the segment.
- **mapped?** Check or mark YES if the upper end of the segment is marked on the aerial photo or topo map.
- **photo#** The number or identifier or representative segment photograph.
- **description** Comments on the contents of representative segment photograph.
- **species** List each species of planted stock observed in the segment.
- **number** Tally and sum the number of each species within the segment.
- **avg. ht.** Provide an average height of trees of each species within the segment. Record the number as a range (2-4 feet) or as a single number (3 ft) as appropriate.
- **vigor** Estimate the average vigor of each species within the segment. Record as
  - High - good color, dense foliage, branches over more than 60% of the stems, stems well able to support top growth
  - Moderate - moderate foliage and color, branches on 40-60% of stems, stems thin but adequate
  - Low - poor color, sparse foliage, branches on less than 40% of the stems, stems thin and likely to topple in wind or flood. For shrubs, look for color and density of foliage, as well as density of stems appropriate for the species.
- **damage/source** Record observed damage within the segment, what portion of the trees of that species are affected, and source, if known.
- **avg. comp/source** Estimate the level of competition from grass and herbs, shrubs, and overstory for each species within the segment. Record competition estimates as Low (vigor and survival not affected), Moderate (vigor affected, survival not affected), or High (vigor and survival affected). Species will have variable tolerances for different kinds of competition that must be considered in the rating. An example rating for well-rooted willow adjacent to blackberry with no overstory might be:

  Grass-L, Shrub-M, Tree-L.

  Some species will have similar reactions to competition and can easily be bracketed together.
- **comments** Record general or specific observations about the segment not captured in the questions above: list noxious weeds present within the segment.

Intensive Monitoring Form

site name	GPS (plot stake or post - mark on map)
plot number	description
date	

tag #	species	height/ ht. class	live crown ht./ stem class	landform	slope	ovrstry comp/srce	brush comp/srce	grass comp/srce	status	tree prot.	damage t/s/e	maint.	comments

Instructions for Intensive Monitoring Form

Note: Photocopying code sheets (and, perhaps, instructions) at a reduced size, then laminating them, will make more useful in the field when recording observations.

site name Stream and landowner; i.e., "Euchre Creek, Smith's Property."
plot number Monitoring plot identifier; i.e., SP-A, SP-B.
date Date of monitoring effort.
GPS (plot stake or post) Complete this portion when doing the first site visit. **latitude/ longitude, estimated position error** Digital Degrees or Degrees, minutes, seconds. Identify specific units used.
description of location Location of post from most obvious access point. Refer to planting sketch map and/or aerial photo.
ID tag # The identifying tag number for the tree or shrub.
species Use codes that are convenient. List a key somewhere on data sheet.

Examples include:

SS – Sitka spruce	**W** – willow
DF – Douglas fir	**OA** – Oregon ash
RW – redwood	**CW** – cottonwood

Another option is to use the standardized coding system available in forestry manuals that uses the first two letters of the genus name and the first two letters of the species. For example, *Pinus ponderosa* would have the code PIPO.

height/height class Identify the height in feet/inches or meters of individual trees, or height class for shrubs. For shrubs, use the following height class:

≥1 ft., **1**-2 ft., **2**-4, **4**-6, **6**-8, **8+** ft.

live crown height/stem class For trees, identify the height of the live crown. For example, if a spruce tree is 5 feet tall, and live crown begins at 2 feet off the ground, the Live Crown Height will be 3 feet. Instructions from US Forest Service manual: "Live crown length is assessed from the uppermost live leader or branch to the lowest live branch. Visually adjust large openings in the crown or lopsided crowns by transferring lower branches to fill in the holes. Compressing the live crown length because the crown appears 'sparse' or contains 'unhealthy' foliage is not appropriate." Add observations about quality of crown in the comments column. For shrubs, (clumped, multi- stemmed species; i.e., willows) use the categories below. (Taken from USFS GTR – RMRS- GTR-47, Monitoring the Vegetation Resources in Riparian Areas.)

Sprout	1 stem
Young	2-10 stems
Mature	>10 stems, > ½ stems alive
Decadent	>10 stems, < ½ stems alive
Dead	0 stems alive

landform Identify the shape of the surface that the plant is on.
- **LT** – low terrace
- **HT** – high terrace
- **BF** – within bankfull width
- **HS** – hill slope
- **EB** – on a vertical or steep eroding/erodable bank
- **O** – Other

slope Identify slope class of planted surface.
- **G** – 0 to 10%
- **M** – 11 to 50%
- **S** – 51 to 100%

overstory comp Identify the level and source of overstory competition. For example, a 26-50% shading by red alder would be recorded as 2/RA. Aspect or direction of shade is not considered.
- 0 – no overstory competition
- 1 – overstory competition <25%
- 2 – overstory competition 26-50%
- 3 – overstory competition >51%

brush comp Identify the level and source of brush competition for each tree or shrub. For example >51% by blackberry would be recorded as 3/BB.
- 0 – no brush shading or brush within 2'
- 1 – brush within 2' and shading <25%
- 2 – brush within 2' and shading 26-50%
- 3 – brush within 2' and shading >51%

grass comp Identify the level and source of grass competition for each tree or shrub. Record N/A, not applicable, for trees greater than 5 feet tall. For example, common pasture grass within 12' of the stem would be recorded as 1/PG. Make special note of presence of reed canarygrass (RCG).
- 0 – No sod within 2'
- 1 – Sod within 12"
- 2 – Sod within 6"
- 3 – Sod to stem

status Indicate whether the tree/shrub is **L**iving, **D**ead, or **U**nknown.

damage Record damage to planted stock in a **T**ype/**S**ource/**E**xtent format with the following codes.

For example, if just less than half of the tree stem is stripped of bark near the ground, the damage **type** code should read GI/SM/M. If type is not known, record a dash (-) or question mark.

- **B** – broken or cut stem
- **BC** – bud collar damage
- **GI** – girdling (bark removed)
- **BL** – broken leader
- **CL** – crooked leader
- **DI** – diseased leader
- **DB** – diseased branches
- **DT** – dead top
- **ML** – multiple leaders
- **MS** – multiple stems
- **SW** – sweep (pushed over in past, now growing upright)
- **PO** – pushed over or leaning
- **WE** – weed eater or machine damage
- **TR** – trampled
- **RU** – rubbed or "racked"
- **RE** – roots exposed
- **WI** – wind burn or breakage

For the **source** of damage from animals use:

- **BV** for beaver
- **SM** for voles or gophers
- **DL** for domestic livestock
- **WL** for wildlife.

Record the **extent** of damage as:

- **L**ight <25%
- **M**oderate 26-75%
- **H**eavy >76%.

tree prot Identify tree protection methods used: cages, tree shelters, vexar tubes, super tubes, etc. Provide key to abbreviations.

maint Maintenance needed or suggested.

- **BR** – Brush control
- **GR** – Grass control
- **FR** – Fence repair
- **TP** – Tree protection devices need adjustment or replacement
- **O** – Other

Intensive Monitoring Codes

species codes

WRC – western red cedar
GF – grand fir
BLM – big leaf maple
CW – black cottonwood
HL – western hemlock
OA – Oregon ash
SS – Sitka spruce
DW – red-osier dogwood
EB – red elderberry
NB – Pacific ninebark

stem class

Sprout	1 stem
Young	2-10 stems
Mature	> 10, > ½ stems alive
Decadent	> 10, < ½ stems alive
Dead	0 stems alive

slope

G	0 to 10%
M	11 to 50%
S	51 to 100%

overstory and brush competition

none
<25%
26-50%
>51%

grass competition

no sod w/in 2'
sod w/in 12"
sod w/in 6"
sod to stem

damage - cause

BV – beaver
SM – small mammal
DL – domestic livestock
WL – wildlife

damage - intensity

Light	>25%
Moderate	26-75%
Heavy	>75%

damage – type

B – broken or cut stem
BC – bud collar damage
GI – girdling (bark removed)
BL – broken leader
CL – crooked leader
DI – diseased leader
DB – diseased branches
DT – dead top
ML – multiple leaders
MS – multiple stems
SW – sweep (pushed over in past, now growing upright)
PO – pushed over or leaning
WE – weed eater or machine damage
TR – trampled
RU – rubbed or "racked"
RE – roots exposed
WI – wind burn or breakage

tree protection

PT – protex tubes
VT – vexar tubes
TF – tin foil
CG – cages
PP – printing Plates
WM – weed mat
O – other

maintenance

BR – brush control
GR – grass control
FR – fence repair
TP – tree protection devices need adjustment or replacement
O – other

brush and grass

TH – thistle
YA – yarrow
KW – knotweed
MG – morning glory
PG – prairie grass
BB – blackberry

Notes

Planting Project Summary

landowner/project name	stream/watershed name	date
planting length avg. width	# of plants	GPS top
topo map/photo name	# of species	GPS bottom
fence type	installation date	condition at planting

Effectiveness Monitoring

objectives	pre-planting monitoring		post-planting monitoring	
	method	date	method	date

Photograph Log

photo timing	date	GPS location	comments	mapped?
pre-site prep photo				
planting photo				
post planting photo (1-yr+)				

Site Preparation

target	method	date	follow-up	date
grass/forb				
shrub				
tree (if any)				

Maintenance Record

date	action	comment	date	action	comment

Instructions for Planting Project Summary Form

property owner/project name Name of project.
stream/watershed name Location name.
date Date of planting project initiation.
planting length Linear distance of planting project.
width Average width of planting project.
# of plants Total number of stock planted at the site.
# of species Total number of species planted at the site.
GPS top The upstream end of the planting project.
GPS bottom The downstream end of the planting project.
topo map/photo name Name and or source of the map or aerial photograph to be used in all phases of monitoring.
fence type Identify the kind of fence use for stock protection: for example, pole, electric, wildlife, etc.
installation date Identify when the fence was put in.
condition at planting Identify the integrity of the fence at the time of planting; for example, incomplete, functioning, needs repair, etc.

Effectiveness Monitoring

objectives Purpose for the planting. One common example is "Increase shade to water surface by 50%."
pre-plant monitoring method Identify the monitoring method use to establish baseline level, prior to treatment. I.e., "existing shade measured by Solar Pathfinder."
date Date of pre-plant monitoring.
post-plant monitoring method Identify the monitoring method used to determine if objectives are being met. For example, repeating Solar Pathfinder measurements after trees are free-to-grow, and again at 10-20 feet high.

Photographic Log

photo timing Identify photographs taken at various phases of the planting project.
date Date of the photographs.
GPS location Location of photo point using GPS for better reproducibility.
comments Specific features of photo or photo site; i.e., upstream view of new growth from center of county bridge.
mapped? Mark photo points on a map or aerial photograph.

Site Preparation

target Component of existing vegetation identified as competition.
method Method used for control competition. For herbicide treatment, identify brand and application process used. For mechanical, describe procedure, i.e., grubbing, brush mower, placement of carpet squares, etc.
date Date of site preparation treatment.
follow-up Describe follow-up treatment, if used. I.e., removal of re-sprouting blackberries, removal of carpet squares, checking effectiveness of herbicide, etc.
date Date of follow-up site-preparation.

Maintenance Record

date Date of maintenance activity.
action Description of maintenance activity, i.e., watering, shrub control, fence repair, adjusting or replacing tree tubes, etc.
crew Individual(s) performing maintenance.

Notes

Glossary

These are words found in the text, defined as they relate to this document.

Active Channel – Area of channel that is occupied by flood flow every year or every other year.

Active Restoration – Artificially replacing elements of an ecosystem that are impaired or missing (i.e., addition of large wood, planting trees).

Adaptive Management – The process of trying new or established management techniques, monitoring, and evaluating results, and modifying those techniques as needed.

Alluvium – Sediments deposited by water.

Anecdotal – Evidence from a site-specific experience or observation outside of a structured experiment.

Anthropogenic – Coming from humans or caused by humans.

Apices – Ends of branches and branchlets (in blackberries, for example, apices are likely to root and form new plants).

Auger – A corkscrew digging tool used to create holes for planting stock.

Bank Stability – The ability of a stream bank to resist erosive forces from flowing water.

Bareroot Stock – Sediment small enough to be moved by the stream, but too large to be suspended.

Bedload – Plant materials obtained with no soil associated with the roots.

Bioengineering, Soft Engineering – Instream projects that are designed to alter stream direction or erosion patterns, using organic materials exclusively or in combination with inorganic materials. Examples are trees placed along banks (rather than previously used rip-rap), or the extensive use of willow or cottonwood cutting to improve bank stability.

Boles – Trunks of heavy woody species, i.e., gorse or scotch broom.

Cadastral Surveys – Mapping expeditions and surveys conducted by the government before intensive European/Euroamerican settlement.

Cambium – The layer of cells within a plant stem that give rise to xylem tissues for transporting water up, as well as phloem tissues that transport sugars and nutrients to the roots.

Canes – Thick stems, such as those of blackberry, bamboo, Japanese knotweed.

Chemical – Disrupting the physiology of competing vegetation through application of herbicides or other substances, such as salt or concentrated micronutrients.

Community – A collection of plant or animal species living in a given area.

Conservation Reserve Enhancement Program (CREP) – A federal program cooperatively administered by the Natural Resource Conservation Service, the Farm Service Administration, and state governments to encourage riparian setbacks and forested buffers. Private landowners are paid a rental fee for riparian or wetlands set aside for a 5-15 year period.

Container Stock – Plant materials with an intact volume of soil associated with the roots. For small volume container stock, see **Plugs**.

Cultivars – Plants that are genetically selected and grown for specific traits such as high growth rates or resistance to disease.

Cutting – Live plant tissues (stems, roots, etc.) removed from an established plant, intended to create new plants.

Denitrification – The process by which nitrate is lost from the soil and released to the atmosphere through microbial activity.

Desiccation – Dehydration; drying out.

Effectiveness – The measure of how well (in this case) a restoration activity has performed in changing a habitat feature. "Effectiveness monitoring" may include recording the presence of fish above a new culvert, the amount of sediment stored, how channels are adjusting to large wood, or the increase of shade due to planted vegetation.

Establishment – The period of time between planting and free-to-grow status.

Extensive Monitoring – Information gathered on the entire project in a rather general fashion. Each project is divided into segments that are characterized by the number of trees per species, the average height of those trees, and the threats to their vigor.

Facultative – Plants that are equally likely to occur in wetlands or non-wetlands.

Floodplain – Typically, a flat surface next to streams and rivers deposited during high flows. Floodplains may be presently active or formed and abandoned some time in the past (see **Terrace**).

Flotsam – Materials (wood, twigs, leaves, trash) carried by floodwaters.

Free-to-grow – The point at which an anthropogenically planted tree or shrub is taller than the competing vegetation, has well established roots, and is likely to remain with little or no additional maintenance (excepting loss to beaver).

Functional Assessment – Determining how well the plant, water, and soil processes in a stream or river are working (in this case); used most often for prioritizing restoration efforts. Not to be confused with inventory (classification) or monitoring.

Geomorphic – Features related to the shape of the valley or other landforms.

Girdle – Remove all or most of the outer and inner bark of a tree stem.

Growth – The addition of biomass typically measured by height or number of stems.

Hoedad – A long-handled tool with a narrow blade set at 90 degrees to the handle. The blade is positioned for scalping and creating a hole for planting trees. Very commonly used in upland forestry planting.

Hydrology – The study of water movement and patterns. For this situation, stream interactions with channel and valley forms, vegetation, and channel elements (rocks, logs, etc.) that dissipate energy.

Implementation – The completion of activities (in this case) for a restoration purpose. Implementation may be the placement of large wood, replacing a culvert, or achievement of free-to-grow status for riparian vegetation.

Integrated Management – A weed-control strategy that uses several approaches specific to the plant targeted. For example, using mechanical and chemical site preparation, followed by carefully controlled grazing or grubbing for re-sprouts.

Intensive Monitoring – Information gathered on a subset of plots within a given project. Such information is fairly detailed, involving information on vigor, growth, and threats to project success, including animal damage, and plant competition on individual trees.

Leader – The topmost bud on a tree, often showing the greatest changes in height as the tree grows. Shrubs and indiscriminate growth forms may have multiple leaders.

Lifting – Taking seedlings from soil beds at the nursery for transportation to the planting site or interim cold storage.

Limiting Factor – Condition or element that is affecting habitat and/or reducing potential populations (i.e., water temperature, predation, lack of refuge habitat).

Live Crown – The live crown is the portion of the tree with actively growing branches. The **live crown ratio** is the proportion of live crown to total tree height and is a general indication of tree vigor. Live crown measurements are not effective for multi-stemmed species.

Lowlands – Flat alluvial bottomlands that typically include both present and historic floodplains (as opposed to "uplands").

Mechanical – Damaging or removing parts of competing vegetation with physical force.

Microsite – Fine-scale habitat characteristics needed for individual species. May include shade, substrate, access to subsurface water, exposure to flood scour, etc.

Mulching – Covering the soil surface with a variety of materials (such as straw, bark dust, wool, etc.) in order to discourage germination of undesirable species and preserve moisture for planted stock.

Mycorrhizal Inoculation – Introducing beneficial fungus to tree roots for increased access to water and nutrients within the soil.

Noxious – A legal definition designated by the Oregon State Weed Board that includes weeds that are judged to be injurious to public health, agriculture, recreation, wildlife, or any public or private property. It is against the law to sell, offer to sell, purchase, or transport plants on Oregon's noxious weed list.

Nutrients – Dissolved organic materials often found in streams. Most recognized are nitrogen, phosphorus, and potassium. Lack of nutrients can limit productivity; excessive nutrients can lead to overly productive systems, including problems such as algal blooms and prolific aquatic plants that that can deprive fish of oxygen.

Passive Restoration – Stopping land uses that are damaging and allowing natural recovery (i.e., *via* fencing, rest, sediment abatement).

Plant Associations – Groups of plant species that are often found together.

Plugs – Rooted stock in very small containers, often used in forestry plantings.

Pole Planting – Using cuttings of relatively large diameter and/or length to establish new plants.

Potential – Relative to stream conditions, potential is the highest ecological state of functioning for any given location.

Propagation – Anthropogenic reproduction of plants by seed, cuttings, tissue culture, etc.

Rate of Recovery – The speed at which an ecosystem can be expected to regain function, or how quickly restoration activities can begin affecting desired changes (i.e., how quickly planted conifers produce stream shade).

Reference Condition or Reference Reach – Areas with intact plant communities, hydrologic functions, and erosion/deposition features. Often includes areas where human land uses have been very limited or absent.

Regeneration – Natural plant reproduction.

Re-sprouts – New top growth emerging from established rootstock.

Rhizomes – Underground stems that often grow laterally under the surface of the soil, serve as food reserves for the plant, and may sprout new to growth.

Root-to-Shoot Ratio – The volume of root mass compared to top growth. Used as a relative measure of the seedling's ability to extract enough nutrients and water to support above ground growth, as well as it's ability to stay firmly in the soil.

Salmonids – Fish with adipose fins; includes Chinook, coho, and chum salmon, as well as steelhead and trout.

Scalping – Physically removing rootstock of grass or other species (sometimes to several inches below the soil surface), in this case with the intent of preventing competition for newly planted stock.

Sediment – Inorganic materials carried by moving water. Sizes range from boulders to clay particles.

Seed Zones – Regions for nursery stock as defined by longitude, latitude, and altitude. Survival and vigor can be greatly impacted if planting is done outside of known seed zones.

Senate Bill 1010 – Directs the Oregon Department of Agriculture to work with farmers and ranchers to develop overall water quality management plans for watersheds listed on the Federal Clean Water Act section 303 (d) list as water quality limited. Those plans identify problems in the watershed involving agriculture that need to be addressed and outline ways to correct them. SB 1010 is outcome-based and provides flexibility so landowners can develop their own approaches to local water quality problems.

Seral Stage – One of a series of plant communities that follows another in time on a specific site.

Setback – The distance between the stream bank and fence.

Solarization – Killing the rootstock and top growth of competing vegetation by covering with (typically) plastic that blocks sunlight and increases soil temperatures.

Substrate – The soil or microsite materials intended to hold plant roots. Substrate may be fine soils on a terrace, course gravels on a bar, or wood in the form of a nurse log or stump.

Survival – The number of trees determined to be alive; generally expressed as a percentage.

Terrace – Historic or abandoned floodplain accessed by floodwaters only during very heavy runoff.

Thatch – Heavy, dense growth of grass, often associated with tall pasture grasses and/or reed canarygrass.

Understory – Cover of shrubs and small trees often found under tree canopy.

Uplands – Areas not prone to high water flow.

Vigor – The relative health of planted stock. Typically measured by live crown ratio (length of stem with dense branches to total length of stem) and by stem diameter. Often estimated by color, density of new growth, and general growth form.

Vole – A small mouse-like rodent that lives in dense grass or other cover, often feeds on the bark of young trees.

Water Quality – A measure of chemical and temperature characteristics for a given water body. Temperature, sediment, nutrients, heavy metals, and conductivity are all examples of water quality measures.

Watershed – An area that collects and discharges runoff though a given point on a stream. Also called drainage basin or catchment.

Weed Mat – Commercially available materials placed on the surface of the soil, often in a 2-3 foot diameter, for discouraging germination of undesirable vegetation. Materials are often tarpaper or specialty fabrics that allow water percolation and some airflow.

Wildling – A plant that has been taken from its seeding site in the wild and transported to a new site to grow.

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