



Transmittal Number PT 17-054	Date October 2017
Publication Distribution To: <i>Roadside Manual</i> holders	
Publication Title <i>Roadside Manual</i> – October 2017	Publication Number M 25-30.04
Originating Organization WSDOT Development Division, Design Office – Roadside and Site Development Section	

Remarks and Instructions

What's changed in the Roadside Manual for October 2017?

Roadside Manual changes include the following:

- Chapter 830, Revegetation for Stream Restoration and Fish Passage Projects, has been added.

Purpose:

WSDOT will construct a large number of projects to replace culverts that have become impassable to migrating fish. This guidance represents minimum standards for the restoration of impacts resulting from these fish passage projects. The goal is to achieve efficiency and efficacy in the designs, as well as expediting the permitting process. This guidance meets WSDOT's policies while also responding to regulatory needs, including WSDOT's policy of practical solutions thinking.

Remove/Insert instructions for those who maintain a printed manual:

CHAPTER	REMOVE PAGES	INSERT PAGES
Title Page	All	i - ii
Table of Contents	1 - 2	1 - 2
Chapter 830 - Revegetation for Stream Restoration and Fish Passage Projects		1 - 28
Appendices – A through D	A1 - A4	
Appendix A – Signature Authority		A1 - A2
Appendix B – Slope Visualization		B1 - B2
Appendix C – Sun Angles and Solar Exposure		C1 - C2
Appendix D – Plant Spacing		D1 - D2
Appendix E – Native Plant List - Eastern		E1 - E4
Appendix F – Native Plant List - Western		F1 - F4

Revision marks:

- A new date appears on the footer of each page that has changes or different pagination.
- Revision marks (underlines/sidebars) are used as a convenience to show designers what has changed.
- When a chapter is new or substantially rewritten, no revision marks are applied.

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HQ Design Office Signature /s/ Juli Hartwig	Phone Number 360-705-7242
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**Washington State
Department of Transportation**

Roadside Manual

M 25-30.04

October 2017

Engineering and Regional Operations

Development Division, Design Office

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Contents

Chapters

100 – Manual Description	100-1
110 – Roadside Functions	110-1
120 – Sustainable Roadsides	120-1
200 – Roadside Policy	200-1
210 – Federal Legislation and Directives	210-1
220 – State Legislation and Directives	220-1
230 – Departmental of Policy and Planning	230-1
300 – Operational Functions	300-1
310 – Roadside Safety	310-1
320 – Signing	320-1
400 – Environmental Functions	400-1
500 – Visual Functions	500-1
600 – Auxiliary Functions	600-1
610 – Safety Rest Areas & Traveler Services	610-1
620 – Universal Access	620-1
630 – Parking Area Design	630-1
700 – Soil and Soil Amendments	700-1
710 – Erosion Prevention and Sediment Control	710-1
720 – Contour Grading	720-1
740 – Soil Bioengineering	740-1
800 – Vegetation	800-1
810 – Vegetation Restoration	810-1
820 – Irrigation	820-1
830 – Revegetation for Stream Restoration and Fish Passage Projects	830-1
910 – Design Enhancement	910-1

Appendices

Appendix A – Signature Authority	A-1
Appendix B – Slope Visualization Diagram	B-1
Appendix C – Sun Angles and Solar Exposure	C-1
Appendix D – Plant Spacing	D-1
Appendix E – Native Plant List - Eastern	E-1
Appendix F – Native Plant List - Western	F-1
Glossary	G-1

Chapter 830

Revegetation for Stream Restoration and Fish Passage Projects

- 830.01 General
- 830.02 References
- 830.03 Resources
- 830.04 Definitions
- 830.05 Planning
- 830.06 Design
- 830.07 Restoration Considerations
- 830.08 Construction
- 830.09 Maintenance (Plant Establishment)
- 830.10 Additional Sources of Information

830.01 General

WSDOT will construct a large number of projects to replace culverts that have become impassable to migrating fish. This guidance represents minimum standards for the restoration of impacts resulting from these fish passage projects. The goal is to achieve efficiency and efficacy in the designs, as well as expediting the permitting process. This guidance meets WSDOT's policies while also responding to regulatory needs, including WSDOT's policy of practical solutions thinking.

The majority of fish passage barrier removal projects do not require state or federal mitigation in addition to the on-site restoration for buffer or wetland impacts. The benefits of the projects on aquatic resource functions and services generally outweigh the temporary impacts to the streams and wetlands. This is called a net-benefit or net-increase. For a project to have a net-benefit, maximum available onsite restoration is required to provide the highest possible function within the project limits. This may include retaining trees that are removed and replacing them onsite to benefit the stream and fish habitat.

Projects restore sites according to the strategies and guidance in the Roadside Manual. The designer applies best practices in developing the restoration plan with the intent of restoring the highest possible ecological and functional potential within the project limits. While the context, habitat needs, and system requirements are unique to each site and determine the restoration strategy for each project, this guidance ensures consistency in meeting regulatory and stakeholder needs and expectations.

This chapter deals with the restoration of stream banks and riparian systems. For help with installation of large woody material (LWM), or protecting the roadway embankment when a river is next to the roadway, contact the region or headquarters Hydraulics and Materials Engineers.

830.02 References

Environmental Procedures Manual, M 31- 11, WSDOT

Highway Runoff Manual, M 31-16, WSDOT

Hydraulics Manual, M 23-03, WSDOT

Roadside Manual, M 25-30, WSDOT Soil Bioengineering, Vegetation and Vegetation Restoration chapter

Integrated Streambank Protection Guidelines. Washington State Department of Fish and Wildlife. 2003. <http://wdfw.wa.gov/hab/ahg/ispgdoc.htm>. This document focuses on repairing bank erosion and preventing future erosion while creating or enhancing habitat.

FISRWG 1998. *Federal Stream Corridor Restoration Handbook* (NEH-653). Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US gov't). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3.
<http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/restoration/?&cid=stelprdb1043244>

National Engineering Handbook (210-VI-NEH) 2007. *Stream Restoration Design* (NEH-654. Bernard J., J.F. Fripp & K.R. Robinson (Eds.),. Washington, D.C.: USDA Natural Resources Conservation Service.
<http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/quality/?&cid=stelprdb1044707>

The Practical Streambank Bioengineering Guide. User's Guide for Natural Streambank Stabilization Techniques in the Arid and Semi-arid Great Basin and Intermountain West. 1998. Bentrup, G. and J.C. Hoag, Contributors. USDA-NRCS Plant Materials Center, Interagency Riparian/Wetland Project.
<http://www.plant-materials.nrcs.usda.gov/pubs/idpmcpu116.pdf>

Roadside Revegetation: An Integrated Approach to Establishing Native Plants, FHWA,
http://www.nativerrevegetation.org/learn/manual/ch_1.aspx

A Soil Bioengineering Guide for Streambank and Lakeshore Stabilization. 2002. USDA United States Forest Service (FS-683). <http://www.fs.fed.us/publications/soil-bio-guide/>

The Role of Large Woody Debris in Lowland Puget Sound Streams and Rivers. 2004. Booth, Derek B. and Fox, Martin J., Seattle, WA: Center for Water and Watershed Studies.

Stream Habitat Restoration Guidelines. 2012. Cramer, Michelle L. (managing editor). 2012. Co-published by the Washington Departments of Fish and Wildlife, Natural Resources, Transportation and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service. Olympia, Washington. This document focuses on watershed assessment, problem identification, and general approaches to restoring stream and riparian habitat.

Why Streamside Buffers are Voluntary for Farms in Washington State. 2016. Northwest Treaty Tribes

WSDOT [Standard Specifications](#) and [Standard Plans](#)

830.03 Resources

STREAM IDT FOR DESIGN AND CONSTRUCTION. 2017 Stream Inter-Disciplinary Team Project. Involvement. Acronyms Used. BIO Biologist. BM Environmental Business Manager.
<http://wwwi.wsdot.wa.gov/NR/rdonlyres/COE47A16-0420-4754-969D-1C6528E9909D/59341/STREAMIDTWORKINGDRAFT142014.docx>

Environmental Bulletin. 2017. Page 1. Environmental Bulletin April 2012 Subject of the Month: What role do NWR Construction offices play in the Stream IDT.

http://wwwi.wsdot.wa.gov/NR/rdonlyres/AF23A4C3-A4C6-499B-B79A-63AD41BA2909/50172/April2012_EnviroBulletin_ConstructionRoleInStreamI.pdf

830.04 Definitions

Green Infrastructure Green infrastructure is an approach to water management that protects, restores, or mimics the natural water cycle. Green infrastructure is effective, economical, and enhances community safety and quality of life.

Interdisciplinary Team Group of related disciplines including engineers, biologists, landscape architects, real estate professionals, hydrologists, etc. working as a team to develop the project.

Low Impact Development The term low impact development (LID) refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat.

Practical Solutions Practical Solutions is a performance-based data-driven approach to transportation decision-making using the latest tools and performance measures to support lower cost efficiencies in the operation and replacement of transportation infrastructure.

Plant Establishment Crew A landscape maintenance crew that works on roadside and environmental restoration planting areas. The purpose of the crew is to meet planting area permit and WSDOT policy obligations on a project-by-project basis. The goal for the plant establishment crew is to take advantage of task efficiencies to exceed expectations earlier than the anticipated project duration. Therefore, the project can closeout early. The funding for the crew comes from each individual project and early closeouts will keep Program costs down. An additional project completion goal is to release established planting areas to WSDOT area maintenance personnel in a condition that will minimize ongoing maintenance costs.

Stream Simulation Method of stream design based on the assumption that geologic and hydraulic conditions in natural channels define passage characteristics for migrating fish and that appropriate design of culverts/channel-spanning structures allow for relatively natural channel configurations / flows can achieve fish passage characteristics.

830.05 Planning

During the planning phase, best practices call for the use of an interdisciplinary team to determine goals and methods, and to ensure efficiency of delivery. The team brings knowledge to the table from all areas of expertise and avoids the redo loop that could occur when one area or concern is not included as the project moves forward.

The Interdisciplinary Team generally includes, but is not limited to:

- Project Engineer Office (PEO): The project is assigned to a PEO that is ultimately responsible for delivering the fish passage project.
- HQ Hydrology: Provides reach assessment, reference reach analysis, and large woody material recommendations.

- HQ Stream Hydraulics: The stream engineer/hydrologist determines the design of the stream channel, channel morphology, and bankfull width.
- HQ Bridge and Structures (B&S): The B&S office determines the type and design of a structure spanning the stream to accommodate the roadway.
- HQ Stream Restoration/ Fish Passage Biologist: The HQ Stream Restoration biologist verifies bank full width, writes the biological section of the Project Basis of Design (PBOD,) and provides guidance on fish passage and habitat components of the project design.
- Region Real Estate Services (RES): The RES office purchases property or sets up construction easements where needed, as determined by the PEO.
- Region Permit Coordinator: The region permit coordinator ensures that all regulatory requirements are identified and addressed, to facilitate efficient delivery.
- Region Biologist: The region biologist prepares the biological assessment and the stream mitigation report, which identifies the best practices to meet the environmental functions and needs within the context of the fish passage project.
- Region Landscape Architect: The landscape architect provides impact avoidance input, restoration plans, and oversight to meet permit needs and respond to the environmental needs through the plant establishment period. The Landscape Architect can also help identify site and system-specific opportunities to improve biological functionality.

830.05(1) Goals for the project

Overall, the goal is to restore fish passage by replacing culverts that are undersized, placed at too steep of a gradient, or have large drops that impede or block fish passage with more fish passable structures. Once the engineering aspects of the project are identified, the interdisciplinary team identifies functional goals for the project. Habitat components such as instream LWM, shade provided by a vegetative canopy, and available food for juvenile salmonids provided by invertebrate in, above, and adjacent to the stream, improve functionality of the stream for aquatic life at road crossings.

The projects also address stakeholder concerns such as tribal and WDFW concerns, functional needs/goals and goals of the site, and transportation system requirements. Considerations include, but are not limited to:

- Continued roadway functionality
- Fully fish passable stream crossing
- Decreased water temperatures
- Stream inputs from vegetation
- Channel complexity to reduce or level water flow velocity
- Providing high-flow refugia for juvenile salmonids
- Erosion control for streambanks
- Habitat features for target species

To achieve the goals of the project most efficiently, the landscape architect performs a site analysis and works with the interdisciplinary team to identify the soil types, existing hydrology vs proposed hydrology, existing reference vegetation, desired restoration vegetation types, site context, and habitat needs. See Restoration Design section for further discussion.



Exhibit 1: SR 9 Lake Creek. Prior to restoration, the culvert was undersized and water was restricted. Post-construction, stream is free to move through the culvert and buffers are restored with native plants.

830.05(2) Green Infrastructure Opportunities

During the planning stage, the design team should explore opportunities to incorporate LID principles and practices. If the project site is conducive to this approach, strategize with the team how to implement such practices and have them programmed early on in the project scope of work. Examples of LID include bio retention areas (rain gardens), compost amended soils, natural dispersion of stormwater, retention of native vegetation (minimizing clearing and grading), using bioengineering techniques for stream bank stabilization, maintaining natural drainages, replacing curb and gutter with swales along roadways or using permeable paving where possible. By implementing LID principles and practices, water can be managed in a way that reduces the impact of built areas and promotes the natural movement of water within an ecosystem or watershed. Coupled with LID practices, the stream restoration yields a balanced design that maintains or restores a watershed's hydrologic and ecological functions.

830.06 Design

830.06(1) General Process for Restoration Design

Generally, the biologist will identify a reference site within the vicinity of the project. The purpose of the reference site is to identify and describe locally native habitats and ecosystems and use those systematic relationships to guide the site's revegetation species selections. The reference site may also determine the quantity and type of habitat structures that would be consistent in that particular reach of the stream.

The landscape designer should use the reference site as an example to guide vegetation restoration. The design will also be dependent upon the surrounding constraints to habitat such as roadways, which might control the tree species selected due to the ultimate expected height or fragility of trees, or proximity to neighboring uses that may experience safety concerns. The site analysis will identify these constraints and opportunities and the landscape architect should adjust the design accordingly.

The stream's ideal restoration, its "potential," represents the highest ecological status an area can attain, given no political, social, or economic constraints (Prichard et al. 1993). However, this is not always achievable based on real situations. The restoration goals should identify the desired future condition that responds to and incorporates social, political, and physical realities. However, the project must still meet the environmental objectives and comply with permit requirements. For example, a neighbor who maintains her abutting property as a tended, mowed and pristine garden may not be compatible with a natural, unrestrained stream buffer restoration project, potentially making the restoration less sustainable over time. A best practice would be to meet with the neighbor to see if there is a way to design using the appropriate native buffer plants that will meet the ecological needs of the buffer with a layout that supports the neighbor's aesthetics. Further, the neighbor could desire permission to maintain areas within WSDOT right of way to ensure the level of care desired (weed removal, for example). If this is identified early in the project, in many cases, WSDOT can negotiate with permitting agencies and arrange to issue a permit to enter and do this work. This buy-in is even more important to achieve long-term sustainability on non-WSDOT-owned property where projects have been constructed.

Likewise, if a stream buffer is highly degraded with invasive plants located upstream and outside of the construction easement or right of way; it may not be a sustainable design solution to plant or restore the downstream buffer, knowing that the restoration effort is unlikely to succeed due to the weed infestation from upstream. It is the agency's responsibility to provide the highest level of restoration that will be sustainable and work with the agencies to develop that understanding. In such cases, the lower level expectation would need to be coordinated and communicated prior to the project permitting process. Discussions should occur earlier in the project planning process and include all relevant agencies and tribes.

The planning process is also the appropriate time to consider actions or partners that may help to address issues outside the scope of the project. For example, an invasive species infestation immediately adjacent to the project site may compromise newly planted vegetation but coordination with the local noxious weed control board may be able to treat the infestation prior to construction.



Exhibit 2: Surrounding conditions can make sustainable buffers a challenge. Treaty rights, agricultural land not owned by WSDOT, and other considerations require adaptation to the site as a key consideration in creating a sustainable stream buffer. When restoration cannot be sustained due to allowed land use, agencies should come to agreement on how to approach it. ¹

830.06(2) Communication during design

The project design process will be significantly more efficient and effective with open frequent meetings including the full design team. This enables the various disciplines to address problems as they arise, rather than getting too far along in the design, only to run into a slowdown due to an issue already known by a team member. Design will go more smoothly and construction is less likely to experience lapses or needs for change orders. For most projects, bi-weekly team meetings are sufficient. Other higher-level meetings such as community meetings may be needed as well.

Team progress communication can keep others up to date and precipitate questions and comments that will help provide high value solutions. People to consider including in frequent communications:

- Maintenance staff
- Interdisciplinary team
- Construction office
- Traffic

Higher level communication that may be needed includes:

- Public meetings
- Project neighbor communications
- Permitting agency meetings

¹ Why Streamside Buffers are Voluntary for Farms in Washington State. Northwest Treaty Tribes. <https://nwtreatytribes.org/streamside-buffers-voluntary-farms-washington-state/> October, 31, 2016.

Issues to consider during these coordination meetings:

- Safety
- Constructability
- Type of structure (culvert, 3-sided culvert, bridge, etc.)
- Cost, including acquisition, installation, maintenance
- Construction access
- Measures to save vegetation
- Architectural treatment (texture, color, railing, fall restraint, etc.)
- Construction easements acquisition:
 - Ideally, by 30% design completion
 - Include construction access for the entire plant establishment period, not just the year of construction
- Permit obligations
- Neighborhood concerns
- Traffic management

830.07 Restoration Considerations

830.07(1) Site Analysis

The entire design team (including specialty groups) should attend at least one of the site visits to mutually understand the scope of the project, summarize the overall project objectives and environmental goals, evaluate existing site conditions, constraints, and opportunities, and understand the site's contextual relationship with adjacent land use. Having diverse expertise onsite could highlight specific aspects of the site or project influences not typically captured when viewed through an individual lens.

Plants have a very low likelihood of thriving in areas with sub-optimal soil conditions. During site analysis, identify the soil properties within the project limits. Different types of soils require different stabilization, amendment, and planting tactics. Identify areas of compacted soil or where the project will place an access road that will later be restored. These areas require careful planning and treatment.

Identify other site conditions that might affect the ability of plants to thrive. Direct sun, complete shade, steep slopes, and rocky conditions will all require special treatment during design. Water availability affects the success of the newly planted areas, especially for a new stream alignment location where vegetation did not previously exist. Determine if the site may need additional irrigation infrastructure during plant establishment and include this need during design development.

830.07(2) Soil

While existing native species on the site suggest good native soils, the intrusion of workers, materials stockpiling and heavy equipment access will affect soil compaction, biology, and micro fauna. Compost, compost tea, and mycorrhizal inoculants have the capacity to restore soil

biotics. Stockpiling and reuse of existing topsoil is a good idea, but sometimes impractical based on the duration of the project and difficulty with stockpiling. On-site stockpiling is challenging due to efforts to minimize impacts within sensitive areas and preventing inadvertent impacts. Soil stockpiling must be carefully considered because it greatly reduces or eliminates the biotic benefits of the existing soil. If adequate techniques are not employed for stockpiling, biotic benefits are harmed by length of time the soil is stockpiled, height of the stockpiles, compaction of the piles, quality of the material placed in the stockpile, etc.

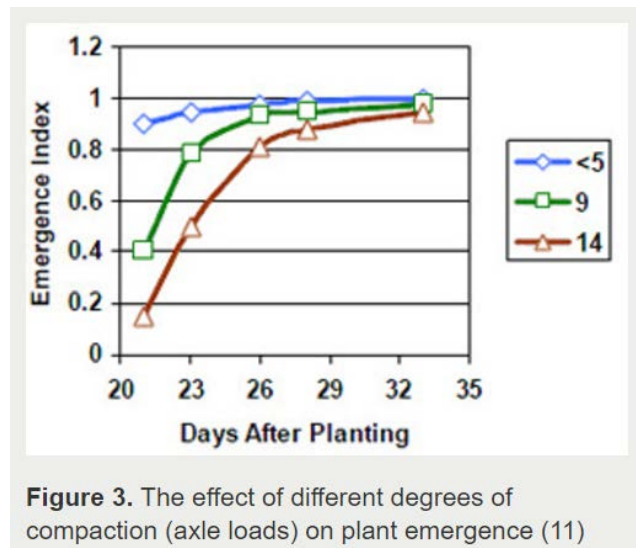


Exhibit 3: Soil compaction and plant growth.²

The type of equipment used to perform the stream and culvert construction will influence soil structure before the restoration work is expected to occur. A best practice is to limit equipment to 4 to 5 psi ground pressure equipment where planting is planned. This may seem like a significant limitation to the project, however, a substantial number of contractors can easily meet this specification with the equipment they already have on hand. This method has been used very successfully in several mitigation projects and in buffer areas.

² Tires, traction and Compaction. Jodi DeJong-Hughes, University of Minnesota Extension.
<https://www.extension.umn.edu/agriculture/soils/tillage/tires-traction-and-compaction/#effects>

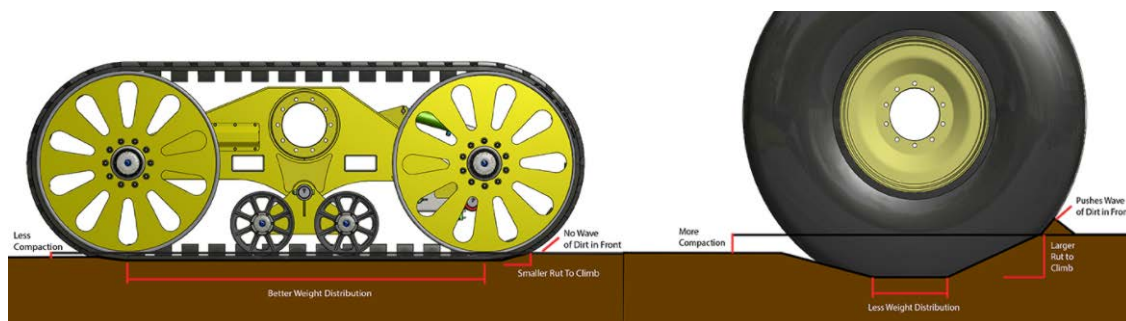


Exhibit 4: Effects of equipment type on soil. ³

Traffic Over the Field

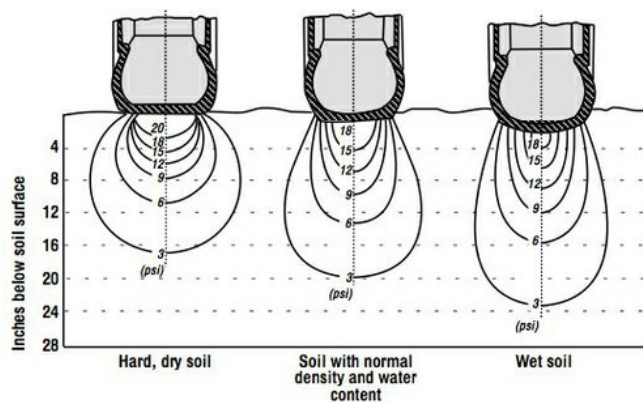


Exhibit 5: Effects of moisture on soil.



Exhibit 6: Examples of 4-5 psi ground pressure equipment.

³ Elmer's Manufacturing. (<https://elmersmfg.com/2016/04/benefits-tracks-vs-tires/>)

830.07(3) Decompaction

Site conditions will dictate the treatment and type of equipment that is necessary to provide for good soil conditions for plant growth. When considering decompaction needs, first consider the location and safety needs. Be cautious about de-compaction on roadway prism areas, as the engineering and roadway safety needs for stable soils will always outweigh the desire to plant and grow woody plants. For example, roadsides where vehicles may leave the pavement may not be appropriate for decompaction and planting simply because the weight of vehicles would deform the soil surface, creating an unsafe situation.

Decompaction to a minimum depth of 12" is required. Tree restoration areas benefit from 24" depth decompaction. This is not always possible, but recognize that any compromise in this area must be compensated through other means. Long-term sustainable plant growth depends upon sufficient air, water flow, and nutrients in the soil.

For lightly compacted areas, simply applying and tilling in compost to a ten inch depth will be sufficient to provide adequate growing conditions for the plants to thrive. This treatment is valuable on slopes flatter than 3:1, in fairly open spaces that are accessible to equipment.

For areas used for staging or access, more aggressive equipment such as rippers will be necessary.

Ripping for deeper decompaction can be accomplished to a depth of approximately 18". To decompact to a 24" depth requires other equipment such as a backhoe or track hoe bucket to dig and turn the soil. Deep decompaction requires large equipment, so is not feasible in small spaces. It is useful in flatter areas, but very difficult in steeper areas. It is also not economically feasible for very large areas, so apply judiciously.

A fair amount of controversy has been published over the efficacy of ripping the soil, though most of the research has been done on agricultural fields. For transportation projects where compaction can present very difficult conditions for plant growth, these measures have been used successfully for years.

Tilling and ripping should be done across slopes, rather than uphill and downhill, to avoid rilling. In general, soil protection during construction is the preferred direction for cost savings, efficiency, and effectiveness.



Exhibit 7: Contour tilling is used extensively in farming for soil preservation. For stream passage projects, **contour** tilling also controls erosion within buffers disturbed by construction.

When restoring the soils after construction, consider soil preservation and restoration needs. If incorporating soil amendment, tilling along the contours reduces erosion potential and accomplishes:

- Better plant growth
- Increased infiltration
- Reduced runoff
- Better water quality
- Reduced hydrophobic soil layers

830.07(4) Habitat

During site analysis, determine feasibility of using downed and cleared vegetation to create habitat as part of the restoration design. Though not the primary purpose of reusing cleared vegetation onsite, scattering cleared trees and shrubs on the bank may save costs, making this more attractive to the project manager, while providing the desired ecological benefit.

The project team must consider issues such as:

- Where will the material be stored during construction?
- How much will the materials have to be moved during phases of the project?

A well-orchestrated plan determines and prepares appropriate staging areas to receive material from clearing and grubbing efforts. Site conditions could limit the practicality of this approach, so be sure that it is feasible before committing to it in the permits or requiring it in a contract. In many cases, the costs and challenges of retaining existing plant material or logs on site prove to be impractical, except in small quantities or on very large sites.

Most research regarding the use of wood in stream and buffer areas is related to natural stream morphology and development. Because fish passage projects restore at least a portion of stream with each with each project, WSDOT often uses LWM as an engineering tool to provide stream bank protection and/or improve aquatic habitat. The WSDOT [Hydraulics Manual](#)

contains background information and a detailed description of the use and design of LWM in fish passage and stream restoration projects.

Best practices in habitat creation indicate higher levels of wood retained or replaced in the new channels. Smaller⁴ channels with well-developed riparian zones usually have wood located throughout the channel, because these smaller streams lack the power to mobilize the wood. Distribution is random and related to the inputs of riparian vegetation (decay, debris flows, floods, etc). Larger rivers have more organized LWM accumulations determined by key wood pieces, water conditions, and the sources of wood adjacent to the river (see the WSDOT [Hydraulics Manual](#) for additional background).

Booth and Fox (2004) provide advice for project planning:

“Site conditions and the choice of project objectives determine the prospects for using LWD. If project objectives are primarily for ecological improvement, then the sites that are likely to show the greatest biological response are those where physical disturbance of the channel is the greatest substantive impact (in contrast to, for example, hydrologic alteration or water-quality degradation) and where recruitment potential from adjacent and upstream riparian areas is high. If these conditions are not met, LWD will be a necessary but not sufficient component of ecosystem improvement; in addition, active support for long-term recruitment will be needed. If the project is being constructed primarily for channel stability and (or) grade control, few sites are precluded outright if LWD will be used as an engineered bed or bank reinforcement. But, as with other channel-stabilization methods, success is likely to be limited during a phase of active channel deepening or steepening (e.g., Simon 1989).”⁵

⁴ Fox, Martin & Bolton, Susan. (2007). **A Regional and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins of Washington State**. North American Journal of Fisheries Management. 27. 342-359. 10.1577/M05-024.1.

⁵ Derek B. Booth, Ph.D., P.E., P.G., Martin J. Fox, Ph.D., September 10, 2004. **The Role of Large Woody Debris in Lowland Puget Sound Streams and Rivers**. Center for Water and Watershed Studies



Exhibit 8: Logs and rocks used in restoration.

In addition to wood and rocks used for in-channel effect, leaving large and small slash (brush piles) on a site, where social and ecological considerations allow, can provide potential micro-habitat benefits to plant establishment through water retention, shading, and wind protection. The brush piles provide benefits in increased animal life and input of invertebrates to the adjacent stream. These benefits are associated with increased wood and leaf litter in the stream for invertebrates, which in turn contribute to the aquatic food chain.

830.07(5) Estuarine Sites

In estuarine environments, recognize that soil salinity will limit all but the most adapted species at newly installed culverts or crossings. Be certain that the specified plant species are tolerant to the location's conditions. Use the Biology Assessment report and the reference site data to guide selections towards fitting the restoration into the native locale.

830.07(6) Vegetation⁶

Work with the design office during the early phases of design to save desirable vegetation⁷. It is often possible to vary slopes in the grading plan or slightly realign the stream to avoid having to remove significant vegetation. However, this is only practical if done very early in the design process.

Choose restoration plant species based on natural associations or native plant communities, generally as spelled out in reference community documentation by the project biologist. Incorporate horizontal diversity (multiple species on the site), vertical diversity (variability in ultimate plant heights at maturity), stream dynamics influence, appropriateness to roadway proximity for safety, and appropriateness for bioengineering functions. Maintenance practices may affect design strategy. Know what the maintenance practices and issues are prior to making design decisions on plant spacing, locations and species selection. Other external factors could influence plant selection. Identify the presence of beavers or other animals on the project vicinity and consider alternative types of plants (or fencing) that will facilitate coverage requirements.

Fast-growing, early seral stage, or pioneer, deciduous species such as cottonwood and red alder can provide quick shade for the stream, will help shade-loving species fill in more quickly, and provide a source of leaf litter and natural wood recruitment. Most native coniferous/evergreen species in the Pacific Northwest have evolved to grow in the shade of these deciduous trees. Plant larger conifers in locations that would provide spring/summer/fall shading. Be sure to apply appropriate setbacks for these tree species to minimize future risk and maintenance issues. Where safety issues preclude longer-term presence of the pioneer species, consider in some cases using them as sacrificial plants, tools to assist in the establishment of the permanent community, knowing they will be cleared towards the end of plant establishment. This strategy requires communication with Maintenance and the permitting agencies in advance to ensure a common understanding of the plan.

Plant spacing depends upon location and species, but generally, when using live stakes, install at 3' o.c. spacing to account for projected mortality after the plant establishment period is over. For container shrubs, plant at 4' o.c. spacing to avoid plant die-out due to overcrowding. Trees should not be planted closer than 8' o.c. spacing, but 10-12' o.c. is more aligned with full canopy cover, without overcrowding. The species rate of growth can influence the decisions for on-

⁶ WAC : 220-660-120(13)(j) The department must approve species composition, planting densities, and a maintenance plan for replanting on a site-specific basis. The species composition should be similar to the surrounding native vegetation whenever feasible.

⁷ WAC: 220-660-120(4)(d) Limit removal of native vegetation to one side of the channel to maintain the best shade coverage whenever feasible. Locate the project access site to minimize the need to remove woody vegetation. Woody vegetation greater than four inches diameter that must be removed to construct the hydraulic project must be marked in the field by the applicant and approved for removal by the department.

center spacing; the purpose is to ensure appropriate shading for cooler water, reduction in weed pressure, and providing the earliest possible habitat benefits.

830.07(7) Current best practices

830.07(a) Stream buffer design requirements

Depending on the context of the project, the stream buffer treatment will vary. For instance, adjacent land use, limited right of way or maintenance practices will influence vegetation selection within the stream buffer with regard to growth habit and height at maturity. Operational setbacks or visual clearance (sight distance) is necessary for the roadway, bridges, utilities and guardrail. Due to adjacent property constraints, careful plant selection is necessary to determine the right place for the right plant. Ideally, planting grass would be limited, and the majority of the impacted area be planted with a diverse set of native shrubs and trees common to the area⁸. Incorporate annual grass so it does not compete with the newly established plants if grass is necessary for preliminary or temporary erosion control.

Stream buffer design should also consider access for the duration of construction easements, which is required throughout all years of plant establishment, whether provided in contract or by State forces. Provide access for inspection and safe pull off for personnel. Maintenance practices may affect design strategy so know what the longer-term maintenance issues are prior to making design decisions. The engineer on the fish passage project will often use logs and rocks for bank stabilization. However, they are also valuable from a habitat restoration perspective: “logs and woody debris from headwaters forests are among the most ecologically important features supporting food chains and instream habitat structure in Pacific Northwest Rivers from the mountains to the sea (Maser and Sedell 1994).”⁹

Leave downed trees and plant as much as feasible around downed logs remaining in the floodplain to serve as habitat nurse logs. This will not only save on material hauling costs, but this effort will benefit the habitat in the area. Additionally, placing coir-wrapped soil lifts over the tops of the streambank logs allows for planting, as well as stabilizing the water edge during peak flows.

The surrounding stream corridor and landscape have a strong influence on the potential for success. Investigate the type of stream or channel to determine the appropriate plant community for the project. The plant community might very different from location to location due to soil types, flooding frequency, surrounding plant communities, and soil moisture conditions. Localized differences in erosion and deposition of sediment add complexity and diversity to the types of plant communities that naturally become established. Observe these typologies in the native landscape surrounding the project (reference site) to identify good examples to follow.

The Agricultural or residential development are often located near lower gradient, larger streams with less steep terrain. These land uses affect the typical plant communities in the middle and lower reaches of streams, while the upper reaches would require different plant communities due to gradient, size, and water flows. In the lower reaches with nearby human uses, pressure may exist to keep the vegetation clear to support those adjacent land uses, so it

⁸ Washington State Department of Ecology [Native Plant Selection Guide: http://www.ecy.wa.gov/programs/sea/pubs/93-30/table3.html](http://www.ecy.wa.gov/programs/sea/pubs/93-30/table3.html)

⁹ FISRWG 1998. [Federal Stream Corridor Restoration Handbook](#) (NEH-653). Stream Corridor Restoration: Principles, Processes, and Practices.

is important to communicate the need for and type of restoration with neighbors and get their buy-in to make the restoration sustainable.

Additionally, due to the higher human influence in highway roadsides, weed pressure is frequently high. This weed pressure may indicate a situation in which a sustainable vegetation restoration is difficult. Where plant communities are not reasonably sustainable, due to high weed pressure from aggressive weeds upstream of the project, planting only for the purpose of erosion control stabilization could be the most practical solution. As mentioned above, this should be discussed with the permit coordinator so that the agencies are brought into the decision making process and a sustainable solution is reached that meets environmental needs.

830.07(b) Planting Area Preparation and Weed Control

WSDOT standard specifications require preparation of all planting areas to ensure a weed free condition. For strategies regarding situations of weed infestation upstream or outside the project footprint, refer to the previous sections, “General Process for Restoration Design” and “Stream Buffer Design Requirements”. Many stream buffers have a proliferation of particularly difficult weeds such as knotweed, purple loosestrife, and reed canary grass. Prolific weeds at planting area locations may require Contract special provisions that call for specific control methods for weed control. The first step is to determine what species are present on site and decide what best management practices is the most effective. Best practices for these species require clearing and appropriate disposal to ensure limited dispersal and further spread of these very aggressive species.

The [Washington State Noxious Weed Control Board](#) includes information on weed laws, identification tools and resources on how to control noxious weeds. The local County Noxious Weed Control Board, local Conservation district or WSU extension office can provide technical assistance as well.

King County Noxious Weed Control Program¹⁰ Best Management Practices for knotweed:

1. If growing beside water (stream or ditch that frequently holds moving water), do not allow plant parts to enter water or beach. Plant parts move by water and will re-grow elsewhere.
2. Do not mow green canes in the fall; stem pieces can re-sprout and you will scatter seed.
3. Remove the entire plant including all roots and runners using a digging tool. Juvenile plants can be hand-pulled depending on soil conditions and root development. Remove dirt 15 feet around plants to prevent root spreading.
4. Double bag all plant parts, including dirt, and dispose of in the trash to prevent reestablishment and disposed of in an approved landfill.
5. Place tarps around the excavation area to capture plant material and root debris. Dispose in an approved landfill.

Best practices for reed canary grass include a cut/regrow/spray/regrow/spray protocol prior to excavation, where possible. However, where excavation is expected to remove the majority of

¹⁰ King County Noxious Weed Control Program Best Management Practices

<http://www.kingcounty.gov/services/environment/animals-and-plants/noxious-weeds/weed-control-practices/bmp.aspx>

the root mass, a single spray may achieve adequate control to prepare for planting. King County Noxious Weed Control BMPs can provide additional guidance on reed canary grass control. Recognize that the first year of plant establishment is the most critical time for achieving as close as possible to eradication of the invasive species, so extreme vigilance during construction is necessary.

As the project progresses, consider requirements for decontamination of equipment used for weed control to prevent spread of seeds and plant parts. The recommendation from WDFW includes:

Follow Level 1 Decontamination protocol for low risk locations. Thoroughly remove visible dirt and organic debris from all equipment and gear (including drive mechanisms, wheels, tires, tracks, buckets and undercarriage) before arriving and leaving the job site to prevent the transport and introduction of invasive species. Properly dispose of any water and chemicals used to clean gear and equipment. For contaminated or high risk sites please refer to the Level 2 Decontamination protocol. You can find this and additional information in the Washington Department of Fish and Wildlife's Invasive Species Management Protocols (November 2012), available online at <http://wdfw.wa.gov/publications/01490/>.

830.07(c) Planning for plant communities

Highly productive and diverse biological communities, such as bottomland hardwoods, establish themselves in the deep, rich alluvial soils of the floodplain. The slower flow in the channel also allows emergent marsh vegetation, rooted floating or free-floating plants, and submerged aquatic beds to thrive. The changing sequence of plant communities along streams from source to mouth is an important source of biodiversity and resiliency to change. Although many, or perhaps most, of a stream corridor's plant communities might be fragmented, a continuous corridor of native plant communities is desirable. Restoring vegetative connectivity in even a portion of a stream will usually improve conditions and increase beneficial buffer functions. Keep in mind that planting efforts may not be a direct translation of the desired end state. For example, establishment of floating plants such as pond lily is extremely difficult and time-consuming, and rarely successful. Assuming the seed source exists upstream, it may be sufficient to focus on the woody vegetation to create the conditions for the pond lily to naturally recruit. The purpose of the vegetation restoration is to set a trajectory for the site to continue to develop into the desired end-state. The designer may also adaptively manage the site to move it incrementally towards its desired end-state during plant establishment. See the Adaptive Management section for more information.

830.07(d) Biodiversity in restoration

Biodiversity is commonly identified at three levels. This has to do with the variety of ecosystems on Earth.

- **First**, genetic diversity is the diversity of genes within a species. There is a genetic variability among the populations and the individuals of the same species.
- **Secondly**, species diversity, which is diversity among species in an ecosystem. "Biodiversity hotspots" are excellent examples of species diversity.
- **Third**, ecosystem diversity is diversity at a higher level of organization, the ecosystem.¹¹

¹¹ The above text is excerpted from the Wikipedia article "[Biodiversity](#)", which has been released under the [GNU Free Documentation License](#).

Each location has a different regional biological structure, so to avoid adverse consequences, it is critical to understand the intended goals for the project. Some projects set a goal for genetic diversity, such as on National Forest Service land, while most WSDOT project goals outside of Federal lands are set at the species diversity level. Objectives for restoration should relate to the regional and landscape scale, providing the maximum biodiversity possible while incorporating targeted species as identified by the biological assessment. Generally, however, the goal should be to develop the restoration to support a diverse community based on the composition of an appropriate reference site.

The biological diversity of the plant communities on a site is important because plant ecosystems support animal ecosystems. While transportation projects cannot predict with accuracy which communities of animals will use a site, we can set the trajectory to support the types of native animal life usually found in the region. It would be virtually impossible to collect the empirical data for all species within a region, so the goal is to set the stage for natural processes to expand the diversity of the site.

830.07(e) Erosion control for bank slopes

In most cases, the construction of a new fish passable crossing under a highway will leave the stream banks vulnerable to erosion and bank surface failure unless specific efforts are undertaken to provide temporary stabilization. The objective of temporary erosion control is to arrest accelerated erosion until native vegetation becomes able to take over the function. Appropriate design solutions vary from simple sod cover for temporary erosion purposes along low intensity streams, to intensive bioengineering or potentially, rock and wood where stream flows are heavy or offsite development causes flashy high flows. Consult with the stream hydraulics engineers/hydrologists to identify the expected flows. The engineers are responsible for the design of the rock and heavy wood portions of the streambank stabilization. The landscape architect should examine the design to identify what other erosion control treatments are necessary. These may include:

- Streambank surface complexity: The purpose of surface complexity is to slow overbank water velocities and trap sediment and seed. Vegetation can be used for this purpose. On larger streams or streams with steeper profiles, larger diameter live stakes may provide surface complexity when planted in high density. Something as simple as compost socks with emergent plants can be sufficient to provide roughening along streambanks of low power, low-flow streams.



Exhibit 9: SR 18 stream restoration – use of woody material, coir lifts, and planting for bank protection.

- Turf reinforcement mat: The mat must have wide enough holes for seed or plants to be successful. It is only useful with seeding, since installation of container plants would require cutting the mats to install plants, which reduces their strength and defeats the purpose. Avoid designs that require cutting mats, where possible. Mats must be biodegradable for stream banks areas.
- An alternative for turf reinforcement mats on stream banks could be brush mattresses. The brush mattress consists of a lashed down six-inch to one-foot layer of native conifer branches over the surface of the stream bank. The mattress collects sediment during higher flows while it protects from erosion. Live stakes may be inserted within the brush mattress allowing for live growing material to become established in the bank areas. It is also possible to place brush mattress materials around planted conifers or other container-grown plants; the mattress protects the soil from eroding and helps hold the plant in place until its roots become established.
- If erosion control fabric is used, stake down the fabric and place above the OHWM to reduce the risk of it coming loose and washing downstream.
- Seeding vs sod for lining ditches: Sod is a very easy ditch liner that provides instant erosion control, so it is preferable to seeding, which will require delay of returning the stream to the channel, and therefore, contract completion, while waiting for the seed to germinate and establish.



Exhibit 10: Application of hydromulch for erosion control.

- Mulches:
 - Wood chip mulch yields better weed control, has more water holding capacity, and prevents seed germination better than bark mulch.
 - Bark mulch is used where it needs to be blown in.
 - Hog fuel is an unrefined mix of coarse chips of bark and wood fiber. Hog fuel is any type of wood byproduct or waste that can be burned for fuel but cannot be categorized as chips, shavings, bark, or sawdust. It is recommended for temporary use to protect soils in access road locations, but not as a planting area mulch.
 - Use compost socks, wattles, or coir logs to hold mulch in place.

All erosion control materials that will remain onsite must be composed of 100% biodegradable materials or materials made of natural plant fibers. In addition, straw used for erosion and sediment control, must be certified free of noxious weeds and their seeds per the standard specifications. Where appropriate, consider using wood straw, which appears to perform very well at these sites.

Avoid placing mulch below OHWM and within floodplain areas that are likely to be inundated in the near future. This reduces the risk of having mulch transported and deposited in locations where it is not desirable. An example would be spreading mulch over an entire floodplain and having mulch end up in the creek upon the first high water event. In smaller sites, mulch may be used if cover is provided as mentioned above.

830.07(f) Stream bank and site considerations for steeper slopes

Depending on the scope of work and condition of slopes above the ordinary high water level, utilize supplemental techniques to stabilize the stream bank in addition to conventional vegetative treatment and erosion control efforts. Soil bioengineering uses plant material, living or dead, to alleviate environmental problems such as shallow sliding soil, eroding slopes, and streambanks. Chapter 740 of the Roadside Manual further discusses soil bioengineering. Select the appropriate technique for the site to achieve successful restoration. At a minimum, consider climatic conditions, topography and aspect, soils, water (hydrology), erosion process and surrounding vegetation. Select the technique that matches the strength of protection against

the strength of attack that will perform most efficiently when tested by the strongest erosive process and the type of critical failure mechanism expected. The most commonly used bioengineering techniques include coir wrapped slopes or soil lifts, live fascines, coir logs and brush mattresses.



Exhibit 11: US 195 Cheney Spokane Interchange. The left photo shows coir wrapped layers prior to vegetation establishment. The photo on the right shows vegetation establishment after two years.

Key points about soil bioengineering techniques:

- Bioengineering is most useful for steeper slopes.
- Soil cohesiveness, gravel lenses present in the banks, surrounding land use and runoff, and potential for human or animal incursion could affect the type of bioengineering selected.
- Coir lifts, or coir wrapped layers, consist of biodegradable fabric around lifts of soil. Coir wrapped layers are suitable for high-energy areas needing a stronger level of bank protection. History has shown that coir lifts, live fascines, or other bioengineering efforts are more effective than erosion control mat placed on the soil surface. They should be used along the shoreline (above OHWM) above the rock or hard stabilization designed by the engineers, particularly where the erosive effects from the stream may back cut, undercut, or otherwise damage the newly constructed bank configuration and allow sediments into the stream.
- Secure the toe of slope on all stream projects. For lower energy systems, place compost socks to keep mulch out of stream gravel. Consider a more secure technique to secure the toe of slope for higher energy systems and steeper slopes (logs, rocks, etc.). Wherever new streambank is created with fill material, soil lifts and fascines can provide stability to the new edges.
- Fascines are suitable for lower energy systems. Place live fascines horizontally along the bank edge to curtail simple stream erosion. Install perpendicular to the channel to dissipate floodwater energy and encourage deposition. Place these with care, ensuring the potential deposition site is in an advantageous location.
- Brush mattresses are extremely effective at trapping sediments, preventing erosion, and stabilizing the bank while establishing planted vegetation.

- Consider planting sequence of work with regard to construction schedule. If planting within rock areas, soil is needed to provide the growing medium for the plants. Install plants (cuttings) together with rock placement to facilitate proper installation and decrease damage to plants. Filling voids in between rocks after rock placement is not successful, as it does not provide adequate soil for plants to grow, and the soil is not connected to ground water.
- When choosing vegetation for coir lifts, select plant materials (large live stake cuttings and perennials such as lady fern or some species of Carex) that withstand deposition for surface complexity.
- The simpler the stream edge plant mix, the better. However, to avoid having to remove established vegetation later, incorporate utility and roadway setbacks and height restrictions during design. For example, use shrubs under power lines and a consistent tree/shrub mix elsewhere.



Exhibit 12: Live Fascines ready for installation.

830.07(g) Installing plants within rock areas

The rock and gravel areas along the stream banks are high-risk highly dynamic zones. These zones have an increased risk of movement. Indicate in the plans or special provisions that adjustments will be required for planting locations based on the movement of gravel. Plantings may disappear or die because of the dynamic nature of the system. During the permitting process, consider what is appropriate and reasonable to guarantee.

Planting within streambed gravel must be planned well and is most successful in low-energy systems. In lower energy systems, planting can occur after the stream is released into the channel. If planted prior to the introduction of the stream, plant failure is highly likely due to lack of water availability. The permit coordinator should check to see if delayed planting requires permit language to allow personnel to access the near-bank edges for planting after the stream is opened to flows.

For requests to plant within the stabilization rock, carefully analyze the necessary conditions before committing to the regulatory agencies for standards of success. Sometimes, agreement to plant without a guarantee of success is the most prudent route in attempting restoration within rock areas that would become inaccessible for plant establishment activities once the engineer removes construction access. Plants require soil and water to establish and thrive, so work with engineers to ensure the correct conditions are in place to be able to plant within the rock areas.

Consult the hydraulics engineer during discussions about incorporating logs, anchoring needs, and rock placement. The landscape plans will either reference or include these features, so close coordination with the engineer is crucial to clearly communicate material selection and placement. For example, the engineer determines the streambed gravel limits, rock size and type, and the decision to locate log structures downstream of high-energy systems. The landscape designer should understand the limits and intent of these engineering decisions in relation to the revegetation efforts (including supplemental erosion control needs) to provide a balanced design approach to the natural system.

830.08 Construction

Early and close coordination with the Construction project is key to maximizing efficiency in site preparation efforts (early weed control) and to ensure that during clearing and grading, the Contractor saves existing vegetation to the greatest extent feasible. Vegetation to be saved must be indicated on the plan sheets during design. Understand the schedule laid out for the project and identify key times to attend Contractor's weekly meetings. Engage in discussions that involve any work on weed control, moving the soil, placement of materials (gravel, rock, logs) and planting.

If using State forces to perform any pre-project work such as weed control ensure the right of entry is in place for construction easement areas prior to scheduling Maintenance to be on the site. This may take coordination with Real Estate Services to ensure the proper length of time and appropriate windows of work are available. While coordinating for pre-construction easements, be sure to coordinate the length of access needed to cover plant establishment.

Soil compaction from the use of heavy equipment affects success of plant establishment. For areas used as staging or not otherwise identified in the plan sheets, identify highly compacted areas prior to planting and develop a strategy with the construction office to remedy the compacted soils.



Exhibit 13: SR 92 Pilchuck River Chronic Environmental Deficiency Repair – constructing bank protection and bank protection during first storm.

It is important to consider the project needs not only during construction (when weather is likely to be good) but also how the site will perform under extreme conditions. If bank work is done well and the

calculations are good at predicting actual conditions, the project holds together as shown above. However, the project cannot fully hold the Contractor responsible since planted areas within these zones have an increased risk of movement. The contract should specify that adjustments be required to respond to the movement of gravel. Plantings may disappear or die because of the dynamic nature of the system. Replanting may be required in subsequent years but might change from the original planned configuration. Place plants closer to the wetted channel wherever possible.

The engineer generally identifies project timeline based on the expected time that the contractor will be using the site to install the culvert. To meet the five-year monitoring of the permit requirements, the crews maintaining the area will need access for the full five years.

830.09 Maintenance (Plant Establishment)

Plant establishment¹² begins when the Contractor installs all plants and the construction office grants acceptance to the contractor for planting areas. Total years of plant establishment varies depending on permit requirements and can range from three to five years for stream restoration projects. Standard plant establishment activities include, but are not limited to: weed control for target weeds within planting areas (chemical applications, hand weeding and removal), fertilizing, watering, litter and debris removal, pruning, insect and disease control, erosion control methods and procedures, plant replacement and irrigation system management (if applicable).

Plant establishment activities for stream restoration projects tie to monitoring and performance criteria set forth by the permit obligations. For monitoring and performance criteria, link performance of planting areas to goals set for the site. Make goals as simple and unambiguous as possible. Many permits require five years of monitoring, though some require as few as three. Typical standards for vegetation include qualitative assessment of percent vegetative cover, species density, size distribution, plant survival, bird and wildlife use, and aerial photography documentation to support the data provided.

During the first year of plant establishment, the landscape architect meets regularly with the Contractor, documents observations for the project inspector and makes recommendations to ensure Contract conditions are on track at the end of each plant establishment year. Documentation includes photos, observation of weeds, erosion issues and plant health. It is the Contractor's responsibility to resolve the issues identified by the project inspector. Second year plant establishment will not begin until first year plant establishment obligations are met (for example, 100% plant survival and weed free planting areas).

¹² WAC: 220-660-120(13)(k) Complete replanting during the first dormant season (late fall through late winter) after project completion. Maintain plantings for at least three years to ensure at least eighty percent of the plantings survive. Failure to achieve the eighty percent survival in year three will require that a person submit a plan with follow-up measures to achieve requirements or reasons to modify requirements.

WAC: 220-660-120(13)(l) The department may waive the requirement to plant vegetation where the potential for natural revegetation is adequate or where other factors preclude it.

For second year and beyond (typically up to year five), the plant establishment efforts may remain with the contractor or they may turn over to the plant establishment crew. The crew or contractor performs work on the site as often as needed to address site issues. For example, expect to meet the crew on site four to five times a year to address high weed pressure (reed canary grass or knotweed control). Under good conditions and low weed pressure, expect to meet the contractor or crew on site a minimum of two to three times a year. Establish tolerances or triggers with the Contractor or the restoration crew to proactively manage and prevent recolonization of invasive species. For example, setting percent cover of invasive species close to zero at years two and three is advantageous to allow new plantings a chance to establish.

830.09(1) Alternative Actions

Because restoration involves natural systems, unexpected consequences of restoration activities can occur. The four basic options available are as follows:

_ **No action.** If the restoration is generally progressing slower than or at the expected rate, but will probably meet restoration goals within a reasonable amount of time, no action is appropriate.

_ **Maintenance.** Physical actions might be required to keep restoration development on course toward its goals.

_ **Adding, abandoning, or decommissioning plan elements.** The project requires significant changes in parts of the implemented restoration plan that entail revisiting the overall plan, as well as considering changes in the design of individual elements.

_ **Modification of restoration goals.** Monitoring might indicate that the restoration is not progressing toward the original goals, but is progressing toward a system that has other highly desirable functions. In this case, the participants might decide that the most cost-effective action would be to modify the restoration goals rather than to make extensive physical changes to meet the original goals for the restoration. This is adaptive management.

830.09(2) Adaptive Management

The first fundamental rule during design is to set proper expectations for the restoration effort. Be clear about expectations versus experimental techniques. When including experimental techniques, accommodate some risk of failure or be flexible to make midcourse corrections. One effective way to set reasonable expectations from the beginning is to acknowledge uncertainty, evaluate performance, and make adjustments as part of the game plan.



Exhibit 14: Phases of Adaptive management. (Conservation Measures Partnership - Open Standards for the Practice of Conservation, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=6925415>)



Exhibit 15: ***Plant protection may become necessary during plant establishment.***

Adaptive management involves adjusting management direction as new information becomes available. It requires willingness to experiment scientifically and prudently, and to accept occasional failures (Interagency Ecosystem Management Task Force 1995). Since restoration is a new science with substantial uncertainty, expect adaptive management to incorporate new midcourse information. Moreover, adaptive management has capacity to focus on and correct specific problems. Restoration is uncertain. Therefore, allow contingencies to address problems during or after restoration implementation. Assess the progress of the system annually, document the changes, and keep the permitting agencies informed.

830.10 Additional Sources of Information

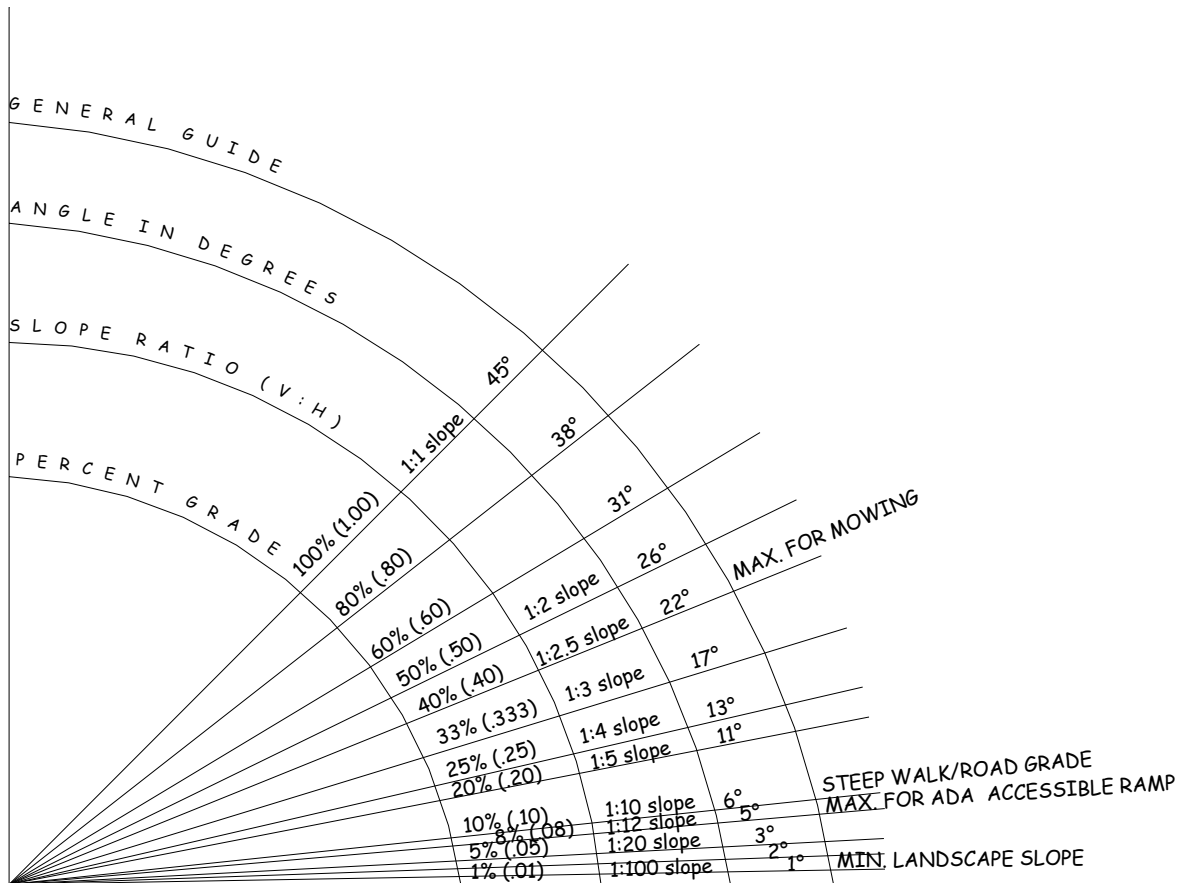
- In-stream flow workshop: University of WA
- Streams and hydrology: training offered by tribal entities
- Geomorphology of stream channels: University of WA extension courses

Landscape Architects

- Roadside Restoration Plans
- Wetland Mitigation Plans
- Contour Grading Plans
- Planting Plans
- Site Development Plans
- Irrigation Plans
- Co-signatory on Soil Bioengineering Plans, with Geotechnical Engineer or Engineering Geologist

Appendix B

Slope Visualization Diagram



Notes:

- Maximum slopes for cut and fill depend upon the materials involved. Refer to the Region Materials Engineer and the [Standard Specifications for Road, Bridge and Municipal Construction](#) 2-03.3(14) for guidance.
- The preferred slope for mowing is 1V:3H or flatter. Refer to the [Maintenance Manual](#) for more specific information.

Appendix C

Sun Angles and Solar Exposure

Exhibit C-1 shows hourly sun angles for December 21 on a highway with a southwest– northeast road alignment, with a tree canopy height that might be typical for forested areas where shading is a concern. The drawing shows that for this road alignment, shading is caused by vegetation far outside the average right of way dimensions. For example, at 11:00 AM trees that shade the roadway are a minimum of 300 to 400 feet beyond the roadway centerline.

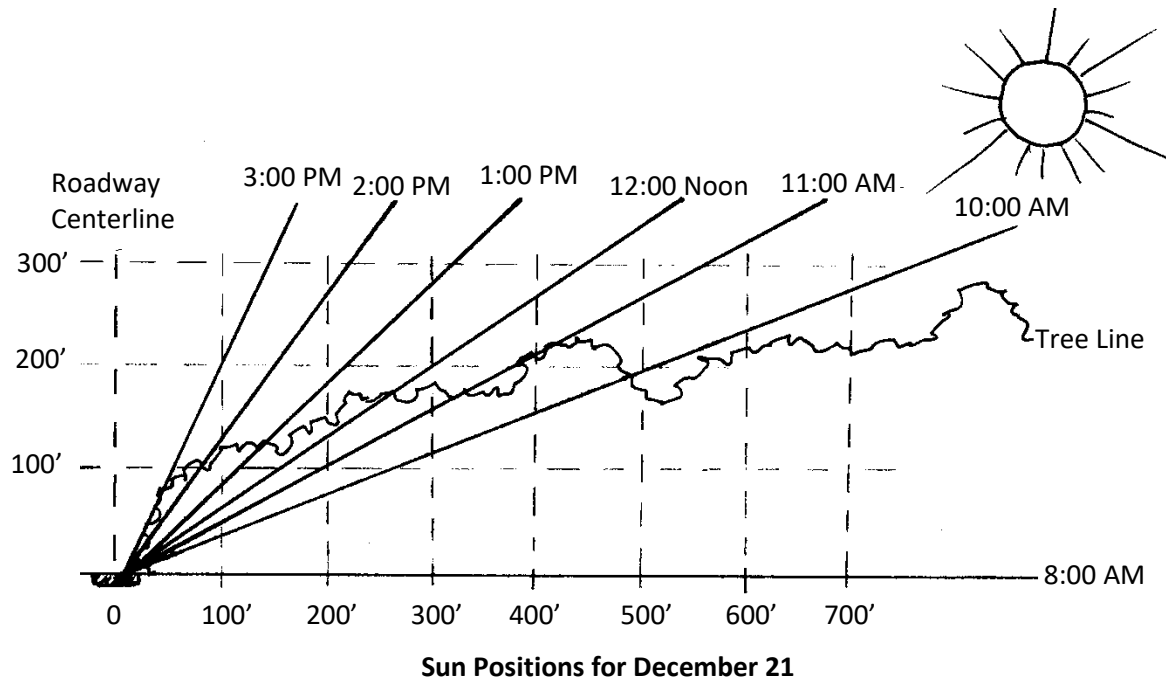


Exhibit C-1 Southwest to Northeast Road Alignment

Exhibit C-2 shows hourly sun angles for November 21 and January 21 on a road having an East–West alignment. It also depicts a tree canopy height that might be typical for forested areas where shading is a concern. The drawing shows that for this road alignment, shading is caused by vegetation far outside the average right of way dimensions. For example, at this time of year, for this road alignment, shading at 12:00 noon is caused by vegetation 500' to 600' beyond the roadway centerline. At no time during the day, for this example, does the sun reach an angle where it could reach the roadway.

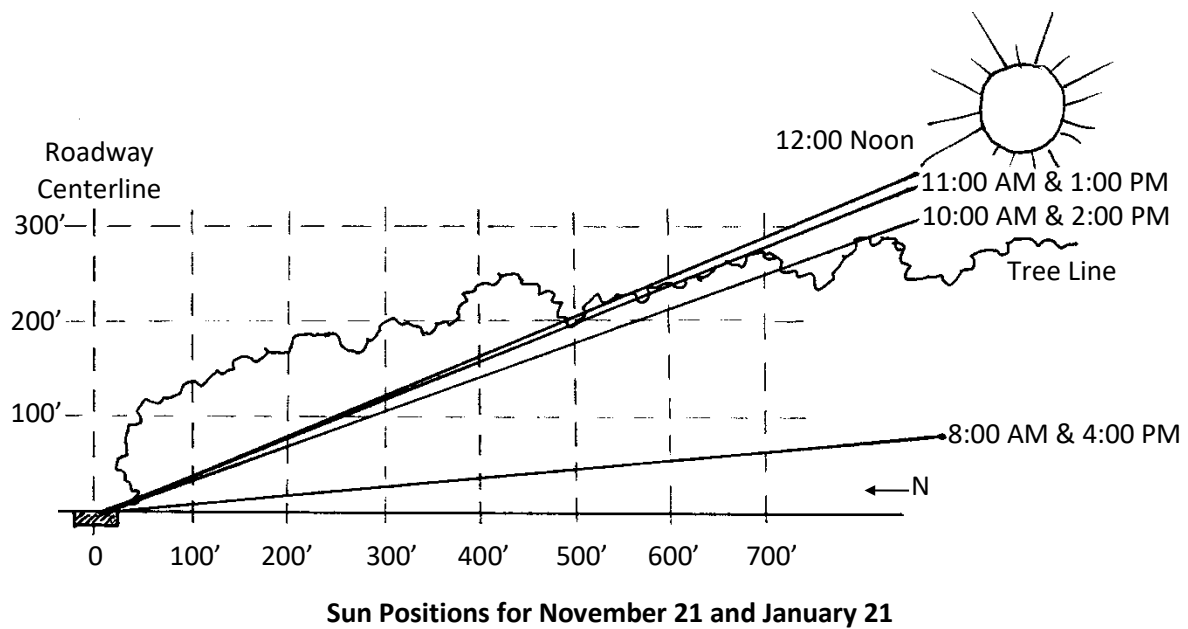
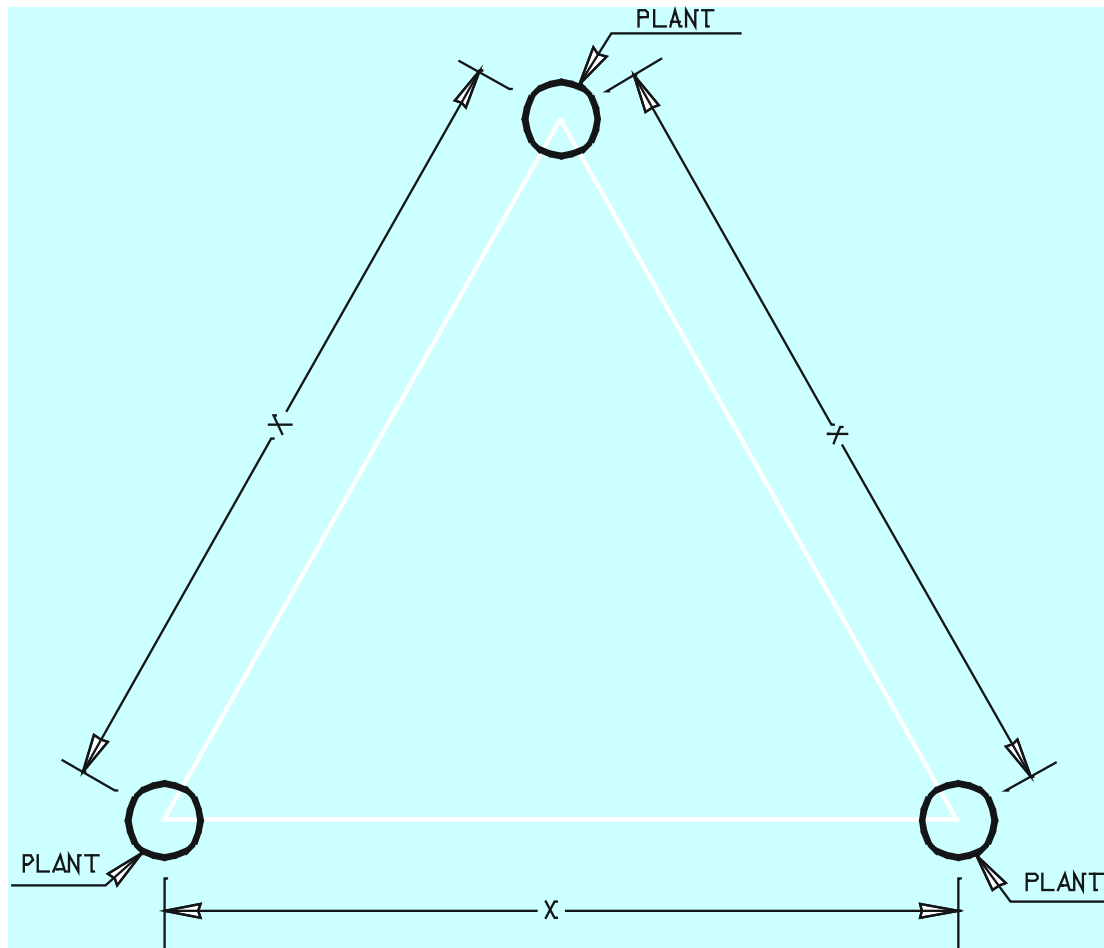


Exhibit C-1 East–West Road Alignment

Assumed geometric pattern for plant spacing



If this is the geometric shape in which plants will be spaced, the area of the equilateral triangle is:

$$\text{Area} = 2 * X / 2 * \sqrt{(X^2 - X^2 / 4)} = X^2 / 2 * \sqrt{3}$$

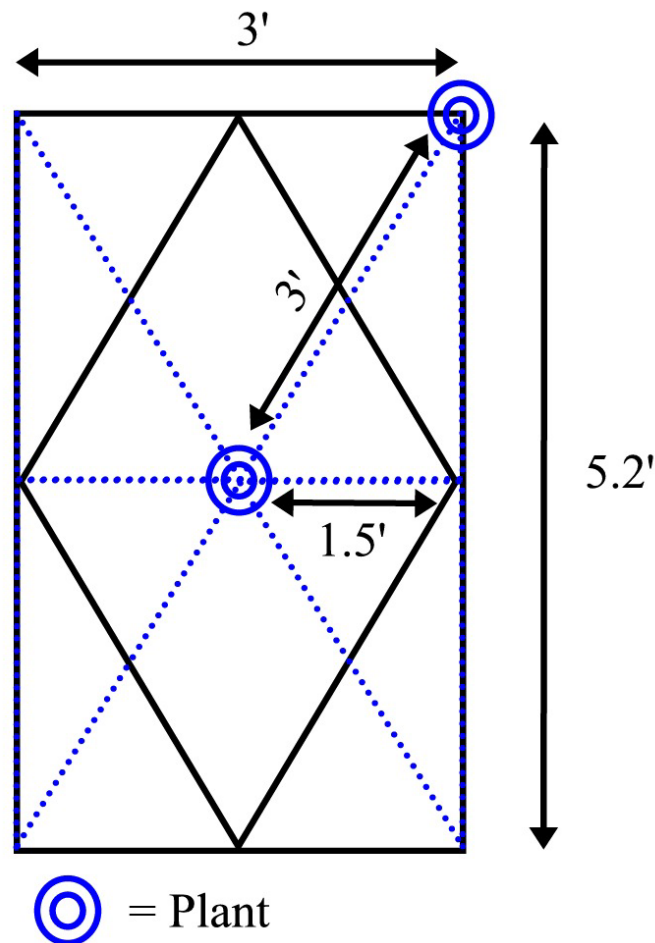
There will be one plant for each equilateral triangle shaped area throughout the area to be planted, plus two extra plants.

Therefore, the number of plants that will be needed for an area in acreage is:

$$\text{No. of plants} = \text{acreage to be planted} * 43560 \text{ sq. ft. per acre} / X^2 / 2 * \sqrt{3} \text{ (where X is the plant spacing in ft.)} + 2 \text{ more plants}$$

(Formula first developed by Julie Nelson, P.E. for the SCR WSDOT Environmental Office.)

DRAFT Plant Spacing Formula for Vegetation Mitigation Projects



Assuming a 3' on-center planting requirement, the following applies:

- A. Total Area of Above: $3' \times 5.2' = 15.6$ sq. ft.
- B. Two (2) plants per 15.6 sq. ft. or one plant per 7.8 sq. ft.
- C. If at first you don't think it will work, try stacking the rectangles side by side and top to bottom and you will start to see how it works.
- D. The only possible flaw would be around the edges of a large area to cover, where it may come up a little short.
- E. When used in the Selah project, the planting numbers came out just right.
- F. In the field, construction of the formula is not expected to be exactly 3' on-center for each plant. Some variation will occur.
- G. There may be room for improvement so if you have suggestions, please forward them to the SCR WSDOT Environmental Office (your comments are greatly appreciated).
- H. Formula easily changed for 2', 4', 5', 8', or 10' on-center calculations.

Appendix E

Native Plant List - Eastern

For more information and other region native plant lists, please refer to the Native Plant List website at: <http://plantnative.org/rpl-imw.htm>



[home](#) | [plants](#) | [how-to](#) | [nursery](#) | [community](#) | [professional](#)

NATIVE PLANT LIST

Idaho, Eastern Oregon, and Eastern Washington



This is a "starter" list of native plants for Idaho, eastern Oregon and eastern Washington. It is intended for residential or commercial landscapers who want to create attractive and varied native landscapes.

Find another Native Plant List!

Select a Region

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Trees

Common Name	Scientific Name	Sun	Soil Moist.	Height	Comments
Big-tooth Maple	<i>Acer grandidentatum</i>	F-P	A-W	8-40'	Fall foliage varies from orange to yellow.
Water Birch	<i>Betula occidentalis</i>	F	A-W	15-25'	An excellent choice for Rocky Mtn. states.
Netleaf Hackberry	<i>Celtis reticulata</i>	F	D	10-30'	Reddish orange berries in the fall.
Western Juniper	<i>Juniperus occidentalis</i>	F	D	20-30'	Blue-green cones appear in the spring.
Western Larch	<i>Larix occidentalis</i>	F	A	150'	This deciduous conifer turns golden in fall.
Blue Spruce	<i>Picea pungens</i>	F-P	A	30'	Large evergreen with a silver-blue color.
Pinyon Pine	<i>Pinus edulis</i>	F	D	10-20'	Requires full sun and good drainage.
Western White Pine	<i>Pinus monticola</i>	F-P	A	150'+	Grows best in sun with moist, well-drained soil.
Ponderosa Pine	<i>Pinus ponderosa</i>	F	D	130'	Yellow brown, sweet-scented bark on old trees.
Quaking Aspen	<i>Populus tremuloides</i>	F	W	50'	Leaves turn gold in fall, shimmer in wind.
Black Cottonwood	<i>Populus trichocarpa</i>	F	W	100'	Oval leaves are glossy dark green.
Douglas Fir	<i>Pseudotsuga menziesii</i>	F-P	A	200'	Best in full sun with well-drained soil.
Rocky Mountain Ash	<i>Sorbus scopulina</i>	F-P	W	13'	Bet in moist, well-drained acidic soil.

For more info, enter a plant name

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Sun Exposure	Soil Moisture
F = Full Sun	W = Wet
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Shrubs

Common Name	Scientific Name	Sun	Moist.	Height	Comments
Rocky Mountain Maple	<i>Acer glabrum</i>	F-P	A-W	8-25'	Showy fall foliage is red, orange, and yellow.
Saskatoon Serviceber.	<i>Amerlanchier alnifolia</i>	P	A	5-20'	White flowers April-May become purple fruit.
Kinnikinnick	<i>Arctostaphylos uva-ursi</i>	P	A	6"	Mat-forming shrub has pink flowers Mar-Apr.
Silver Sagebrush	<i>Artemisia cana</i>	F	D-A	3-5'	Semi-evergreen shrub with silver foliage.

Fringed Sagebrush	<i>Artemisia frigida</i>	F	A	8-18"	Foliage is metallic silver.
Louisiana Sage	<i>Artemisia ludoviciana</i>	F	A	12-18"	Smells strongly of sagebrush.
Big Sagebrush	<i>Artemisia tridentata</i>	F	D-A	3-12'	Yellow inconspicuous flowers in the fall
Four-wing Saltbush	<i>Atriplex canescens</i>	F	D-A	4-5'	Yellow inconspicuous flowers mid-spring
Curl-leaf Mtn. Mahog.	<i>Cercocarpus ledifolius</i>	F	D-A	8-15'	Evergreen; dark green leaves, gray bark
Mountain Mahogany	<i>Cercocarpus montanus</i>	F-P	A	5-10'	White flowers Apr-May, Plumes persist into fall
Fern Bush	<i>Chamaeb. millefolium</i>	F	A	6-8'	White flowers in summer
Rubber Rabbitbrush	<i>Chrysoth. nauseosus</i>	F	D-A	2-7'	Dark yellow flowers late summer into fall
Green Rabbitbrush	<i>Chrysoth. viscidiflorus</i>	F	D-A	3'	Leaves green, shiny, and sticky
Red-osier Dogwood	<i>Cornus stolonifera</i>	F-S	A	3-9'	White flowers May-Jun, berries attract birds
Douglas Hawthorn	<i>Crataegus douglasii</i>	F-P	A	8-20'	Showy clusters of white flowers mid spring
Mormon Tea	<i>Ephedra viridis</i>	F	D	2-5'	Yellow flower-like cones and berry-like fruits.
Apache Plume	<i>Fallugia paradoxa</i>	F	D-A	4-6'	White to rose flowers late spring-early summer
Winterfat	<i>Kraschen. lanata</i>	F	D	1-3'	Tolerates highly alkaline soil, needs drainage
Creeping Oregon Grape	<i>Mahonia repens</i>	P-S	D-A	1'	Holly-like leaves; drought and shade tolerant
Mockorange, Syringa	<i>Philadelphus lewisii</i>	F-P	D-A	4-10'	Incredibly fragrant flowers begin late spring
Ninebark	<i>Physocarp. malvaceus</i>	F-S	A	3-6'	White flowers (spring); red fall color
Shrubby Cinquefoil	<i>Potentilla fruticosa</i>	P	A	3'	Yellow flowers early summer- mid fall
Bitter Cherry	<i>Prunus emarginata</i>	F-P	A	6-8'	Fragrant white flowers become red cherries
Chokecherry	<i>Prunus virginiana</i>	F-P	A	10-20'	White flowers in spring become red-purple fruit
Antelope Bitterbush	<i>Purshia tridentata</i>	F	D	5-8'	Yellow highly fragrant flowers Apr-May.
Smooth Sumac	<i>Rhus glabra</i>	F-P	A	4-20'	Compound, blue-green leaves turn red in fall.
Oakleaf Sumac	<i>Rhus trilobata</i>	F-P	D-A	3-6'	Leaves turn a bright red to orange color in fall.
Golden Currant	<i>Ribes aureum</i>	F-P	A	3-6'	Bright yellow flowers in early spring.
Red-flowering Currant	<i>Ribes sanguineum</i>	P	A	3-5'	Pale to dark pink flower spikes in early spring.
Woods' Rose	<i>Rosa woodsii</i>	F-S	D-A	3-4'	Pale to dark pink flowers bloom in late May.
Blue Elderberry	<i>Sambucus cerulea</i>	F-P	W	8-12'	Small white flowers in late spring; attracts birds
Silver Buffaloberry	<i>Shepherdia argentea</i>	P	W-A	10-15'	Dense form of silver foliage, good bird habitat
Russet Buffaloberry	<i>Shepherdia canadensis</i>	F-P	D-A	3-12'	Leaves are blue-green, often with rusty dots
Common Snowberry	<i>Symphoricarpos albus</i>	P-S	A	4-6'	Pink to white flowers bloom in May or June

For more info, enter a plant name

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Flowering Perennials (Wildflowers)

Common Name	Scientific Name	Sun	Moist.	Height	Comments
Western Yarrow	<i>Achillea millefolium</i>	F	D	1-3.5'	White flowers fading to cream from spring-fall
Parry's Agave	<i>Agave parryi</i>	F	D	24"	Light gray to green foliage is broad and flat
Pearly Everlasting	<i>Anaphalis margaritacea</i>	F-P	A	6-18"	White flowers bloom prolifically Jun-Sep
Rosy Pussytoes	<i>Antennaria spp.</i>	F-P	A	4-8"	Pink and white flowers Jun-Jul; drought tolerant
CO Blue Columbine	<i>Aquilegia caerulea</i>	P	A	12-30"	Blue and white unique blooms Jun-Aug

Western Columbine	<i>Aquilegia formosa</i>	P	A-W	2-3'	Unique red and yellow flowers spring-summer
Wild Aster	<i>Aster spp.</i>	F	A	12-36"	Purple, light blue to cream flowers
Arrowleaf Balsamroot	<i>Balsamorhiza sagittata</i>	F	A	12-24"	Plants don't flower until they are five years old
Blue Camas	<i>Camassia quamash</i>	F	W	1-2'	Blue petals and yellow stamen blooms May-Jun
Purple Coneflower	<i>Echinacea purpurea</i>	F-P	A	2-3'	Continuously blooms (purple) summer-fall
Cut-leaf Daisy	<i>Erigeron compositus</i>	F	D	6"	Numerous white to lavender flowers in spring
Wyeth Buckwheat	<i>Eriogon. heracleoides</i>	F	A	6-16"	Creamy white flowers; drought tolerant
Snow Buckwheat	<i>Eriogonum niveum</i>	F	A	6-18"	White flowers in the summer and fall
Sulfur Buckwheat	<i>Eriogonum umbellatum</i>	F	A	1'	Yellow flowers with hints of reddish orange
Woolly Sunflower	<i>Eriophyllum lanatum</i>	F	A	6-12"	Yellow flowers in the spring; drought tolerant
Blanket Flower	<i>Gaillardia aristata</i>	F-P	A	24"	Flower rays a mix of red, yellow or orange
Sticky Geranium	<i>Gerani. viscosissimum</i>	F-P	A	12-30"	Pink to lavender flowers with red veins May-Sep
Prairie Smoke	<i>Geum triflorum</i>	F-P	A	18"	Reddish to purplish flowers
Texas Red Yucca	<i>Hesperaloe parviflora</i>	F	D	4'	Red blooms in summer reach 5'; slow-growing
Scarlet Gilia	<i>Ipomopsis aggregata</i>	F-P	A	12-24"	Red flowers (Jun) attract hummingbirds
Wild Blue Flax	<i>Linum perenne</i>	F-P	A	8-24"	Blue flowers all spring and summer; drought tol
Silver Lupine	<i>Lupinus argenteus</i>	F-P	A	8-24"	Blue to white flowers; nitrogen fixing
MO Evening Primrose	<i>Oenoth. missouriensis</i>	F	D	6-12"	Yellow flowers Jun-Sep; slightly fragrant
Prickly Pear Cactus	<i>Opuntia spp.</i>	F	D	12"	Flowers of yellow, pink, or red bloom Jun-Jul
Pagoda Penstemon	<i>Penstemon angustifolius</i>	F	A	1'	Comes in various shades of blue to lavender
Scarlet Bugler	<i>Penstemon barbatus</i>	F	A	2-3'	Distinctly bright red corolla, flowers Jun-Sep
Dark Blue Penstemon	<i>Penstemon cyaneus</i>	F	A	12-28"	Dark blue to violet flowers May-Aug
Hot Rock Penstemon	<i>Penstemon deustus</i>	F	A	8-18"	Small creamy white flowers May-Jun
Firecracker Penstemon	<i>Penstemon eatonii</i>	F	A	3'	Flower stalks lined with bright red flowers
Shrubby Penstemon	<i>Penstemon fruticosus</i>	F	A	18"	Blue/lavender to light purplish flowers May-Jun
Palmer Penstemon	<i>Penstemon palmeri</i>	F	D-A	2-4'	Large pink fragrant flowers attract hummingbird
Pine-Leaf Penstemon	<i>Penstemon pinifolius</i>	F	A	6-18"	Red flowers attract hummingbirds
Rydberg's Penstemon	<i>Penstemon rydbergii</i>	F-P	A	8-28"	Bluish-purple flowers in whorls around stem
Showy Penstemon	<i>Penstemon speciosus</i>	F-P	A	2-6"	Bright purple to violet flowers May-Jun
Rocky Mtn. Penstemon	<i>Penstemon strictus</i>	F	A	1-3'	Blue to violet blooms Jun-Jul
Lovely Penstemon	<i>Penstemon venustus</i>	F	A	36"	Stunning flowers lavender-purple May-Jun
Whipple's Penstemon	<i>Penstemon whippleanus</i>	P	A	8-24"	Flowers usually creamy white-green Jul-Aug
Prairie Clover	<i>Petalostem. purpureum</i>	F	D	1-2.5'	Pinkish purple flowers May-Sep; fixes nitrogen
Goldenrod	<i>Solidago spp.</i>	F	A	2-5'	Yellow flowers cover plant late summer-fall
Desert Globemallow	<i>Sphaeralcea ambigua</i>	F	A	20-40"	Orange to brick red flowers Mar-Jun
Gooseberry-leaf Globe.	<i>Sphaera. grossulariifolia</i>	F	D-A	12-24"	Salmon colored flowers in the summer
Orange Globemallow	<i>Sphaeralcea munroana</i>	F	D-A	12-24"	Apricot-pink to reddish-orange flowers
Prince's Plume	<i>Stanleya pinnata</i>	F	D	3-4'	Spikes of lacy yellow flowers spring-summer
Narrowleaf Yucca	<i>Yucca glauca</i>	F	A	3-6'	Creamy white bell shaped flowers in July

For more info, enter a plant name

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Grasses

Common Name	Scientific Name	Sun	Moist.	Height	Comments
Indian Ricegrass	<i>Achnather. hymenoides</i>	F	D	12-16"	Beautiful inflorescence when it goes to seed
Little Bluestem	<i>Andropogon scoparium</i>	F	A	12-36"	Blue-green warm season grass; reddish in fall
Blue Grama	<i>Bouteloua gracilis</i>	F	D	4-12"	Mat forming warm season grass
Buffalograss	<i>Buchloe dactyloides</i>	F	D	3-5"	Long blue-gray to green blades; reddish in fall
Bottlebrush Squirreltail	<i>Elymus elymoides</i>	F	D	13-24"	Unique tufted seed head in mid-spring
Idaho Fescue	<i>Festuca idahoensis</i>	F-P	A	18"	Gray-blue blades in early summer
Sheep Fescue	<i>Festuca ovina</i>	F-P	D-A	18"	Does not do well in continuously wet sites
Great Basin Wildrye	<i>Leymus cinereus</i>	F	D	4-6'	Bluish tan blades with wheatlike seed heads
Bluebunch Wheatgrass	<i>Pseudo. spicata</i>	F	D	13-24"	Bluish cast, decorative inflorescence
Sand Dropseed	<i>Sporobolus cryptandrus</i>	F	D	8-16"	Stays green in heat of summer; resists fire if mowed annually

TREES SHRUBS FLOWERING PERENNIALS GRASSES

IMPORTANT CONSIDERATION:

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2. While a plant is native to a region, that does not mean that it will grow everywhere in that region. The characteristics of any site will typically vary from place to place and some plants may do better than others at various places within a site. In other words, a little experimentation might be required.
3. The above list is a starter list. Though adequate for most residential and commercial landscapes, there are many more native plants and should you want to consider them, please inquire at a [listed nursery](#), [community service organization](#), [reference book](#) or other resources.

CREDITS:

1. Landscaping with Native Plants of the Intermountain Region

US Department of the Interior Bureau of Land Management in cooperation with Boise State University and the Pahove Chapter of the Idaho Native Plant Society
www.id.blm.gov/publications/TR1730-3/cover_p7.pdf.

2. Idaho Native Plant Society.

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Appendix F

Native Plant List - Western

For more information and other region native plant lists, please refer to the Native Plant List website at: <http://www.plantnative.org/rpl-orwa.htm>



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NATIVE PLANT LIST - Western Oregon and Western Washington



This is a "starter" list of native plants for western Oregon and western Washington. It is intended for residential or commercial landscapers who want to create attractive and varied native landscapes.

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Trees

Common Name	Scientific Name	Sun	Soil Moist.	Height	Comments
Deciduous:					
Vine Maple	<i>Acer circinatum</i>	F-S	A-W	25'	Attractive fall colors. Shade, ornmtl, undrstry.
Big Leaf Maple	<i>Acer macrophyllum</i>	F-P	A	30-100'	Yellow fall color. Excellent shade.
Alder (Red)	<i>Alnus rubra</i>	F	W	40-100'	Good along streams for erosion control, shade.
Pacific Madrone	<i>Arbutus menziesii</i>	F	A	40-80'	Reddish bark, shiny leaves, white flowers.
Paper Birch	<i>Betula papyrifera</i>	F-S	A	80'	Peeling white bark. Yellow fall color.
Black Hawthorne	<i>C. douglasii</i>	F	W	20-30'	Low-growing. Berries for birds. Erosion control.
Pacific Dogwood	<i>Cornus nuttallii</i>	F-P	A	30-50'	White flowers, pink-red berries.
Oregon Ash	<i>Fraxinus latifolia</i>	F	W	40-75'	Gray/brown bark, olive green leaves.
Crab Apple	<i>Malus spp.</i>	F-P	A-W	15-35'	Small green to red fruit, yellow/red fall color.
Indian Plum	<i>Oemleria cerasiformis</i>	F-P	D-A	16'	Blooms Jan, Feb. White flowers, purple plums.
Aspen (Quaking)	<i>Populus tremuloides</i>	F	A-W	40-80'	Food source for deer & other mammals.
Black Cottonwood	<i>Populus trichocarpa</i>	F	W	70-100'	Nesting for large birds. Fast-growing.
Bitter Cherry	<i>Prunus emarginata</i>	F-P	A	20-60'	White flowers, conspicuous red seeds.
Oregon White Oak	<i>Quercus garryana</i>	F	D-A	30-100'	Only native OR oak. Wide spreading branches.
Cascara	<i>Rhamnus purshiana</i>	F-P	A	30'	Silver grey bark. Berries attract birds.
Pacific Willow	<i>Salix lasiandra</i>	F	W	20'	Yellow bark, good along streams and ponds.
Evergreen:					
Grand Fir	<i>A. grandis</i>	F-P	D-A	100-200'	Tall, straight, stately, gray-brown bark.
Noble Fir	<i>A. procera</i>	F			Symmetrical, conical, smooth. Good Xmas tree.
Sitka Spruce	<i>Picea sitchensis</i>			100-150'	
Ponderosa Pine	<i>Pinus ponderosa</i>	F	D-W	60-130'	Scaled, colored bark. Vanilla fragrance.
Douglas Fir	<i>Pseudotsuga menzies</i>	F	D-W	75-200'	OR state tree. Can live over 1000 years.
Giant Sequoia	<i>Sequoiadendron giganteum</i>	F	A	200	Gray-green foliage and reddish brown bark.
Western Redcedar	<i>Thuja plicata</i>	P	A-W	100-175'	Great for wildlife cover, restoration, ornamental.
Western Hemlock	<i>Tsuga hereophylla</i>			125-200'	

For more info, enter a plant name <input type="text"/>	Find a Nursery in: OR WA	<table border="1"> <tr> <th>Sun Exposure</th> <th>Soil Moisture</th> </tr> <tr> <td>F = Full Sun</td> <td>W = Wet</td> </tr> <tr> <td>P = Part Sun</td> <td>A = Average</td> </tr> <tr> <td>S = Shade</td> <td>D = Dry</td> </tr> </table>	Sun Exposure	Soil Moisture	F = Full Sun	W = Wet	P = Part Sun	A = Average	S = Shade	D = Dry
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Shrubs

Common Name	Scientific Name	Sun	Moist.	Height	
Vine Maple	Acer circinatum			5-35'	hjhghvg
Serviceberry	Amelanchier alnifolia	F	A	4-15'	Red fruit attracts birds. Imprtn browse for deer.
Hairy Manzanita	Arctostaphylos columbiana			10-15'	
Kinnikinnick	Arctostaphylos uva-ursi	F-P	A	12"	Dark green leaves, red edible berries.
Tall Oregon Grape	Berberis aquifolium			8-10'	
Snowbrush	Ceanothus velutinus			9'	
Red-osier dogwood	Cornus stolonifera	F-S	W	15'	Red stem, white flowers, white berries.
Western Hazelnut	Corylus cornuta var. cal.			5-12'	
Salal	Gaultheria shallon	F-S	A	6'	Lustrous leaves. Spreads where other shrbs fail.
Ocean Spray	Holodiscus discolor	P-S	D-W	3-20'	Creamy white flowers. Riparian restoration.
Western Honeysuckle	Lonicera ciliosa			vine	
Twinberry	Lonicera invlucrata			4-8'	
Creeping Oregon Grape	Mahonia nervosa	F-S	D-W	12"	Holly-like leaves, dark blue edible berries.
Indian Plum	Osmaronia cerasiformis			15-20'	
Mock Orange	Philadelphus lewisii	F-P	D-A	4-10'	Aromatic white flowers attract bees & butterflies.
Pacific Ninebark	Physocarpus capitatus	F-S	W	10'	Clusters of white flowers, maple-like leaves.
Bald-hip rose	R. gymnocarpa	F	D	5'	
Wood rose	R. woodsii			1-8'	Large, pink flowers. Attracts birds, mammals.
Cascara buckthorn	Rhamnus purshiana			1-8'	
Red Flowering Currant	Ribes sanguineum	F-P	A	10-35'	Beautiful. Attracts butterflies, hummingbirds.
Nootka rose	Rosa nutkana			8-10'	
Salmonberry	Rubus spectabilis	F-P	A-W	12'	Forms dense thickets. Yellow/red edible fruits.
Red Elderberry	S. racemosa	F-S	A	1-8'	Fast-growing. White flowers, red berries.
Western Spirea	Spiraea douglasii	F-P	A-W	3-6'	Leggy. Pink/purple flowers in July. Ornamental.
Snowberry	Symphoricarpos spp.	F-P	D-W	8-20'	Attractive foliage. Waxy berries through winter.
Black Huckleberry	Vaccinium membranaceum			2-6'	
Evergreen Huckleberry	Vaccinium ovatum			4'	
Red Huckleberry	Vaccinium parvifolium			2-8'	
				3-12'	

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Perennials - Sun

Common Name	Scientific Name	Sun	Moist.	Height	
Red Columbine	Aquilegia formosa	F-P	A-W	to 3'	Soft foliage, drooping red to yellow flowers.
Shooting Star	Dodecatheon hendersonii	F	A-W		Magenta to lavender flowers on singular stalk.
White Fawn Lily	Erythronium oregonum	F-S	A		Lance-shaped leaves, white nodding flower.
Tiger Lily	Lilium columbianum	F			Bright orange flowers with red or purple spots.
Big Leaf Lupine	Lupinus polyphyllus	F	A-W	3-4'	Nitrogen fixer. Blue to violet pea-like flowers.
Oregon Stonecrop	Sedum oregonum	F-P	A-W		Yellow to pink flowers. Good for rock gardens.
Yellow-Eyed Grass	Sysyrinchium californicum	F-P	W		Yellow flowers on short stalks. Spreads easily.

For more info, enter a plant name

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Perennials - Shade

Common Name	Scientific Name	Sun	Moist.	Height	Comments
Dwarf Dogwood	Cornus canadensis	S	W		Low, trailing. White flwrs, red berry-like drupes.
Bleeding Heart	Decentra formosa	S	W	1-2'	Fern-like. Pink/purple heart-shaped flowers.
Early Blue Violet	Viola adunca	S	W	to 4"	Heart-shaped leaves, yellow flwrs, purple lines.

TREES

SHRUBS

PERENNIALS-SUN

PERENNIALS-SHADE

IMPORTANT CONSIDERATION:

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CREDITS:

1. East Multnomah SWCD 2006 Native Plant Descriptions

East Multnomah Soil and Water Conservation District
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