Olympic National Forest
Native Plant Notebook

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Native Plant Notebook

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and

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Abstract

The purpose of this notebook is to provide Olympic National Forest staff with consistent, forest-wide standards, tools, and approaches for revegetation with native plants and/or non-invasive non-natives, tailored for individual projects and for plant communities of the Olympic Peninsula. Included is information on best plant materials and plant movement guidelines; road decommissioning and roadside treatments; and plants to use for wildlife forage, invasive plant treatments, mulch, and fertilizer. Appendices provide sample forms, contracts, survey results, recommendations from the Native Seed Network, and other supporting materials.

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Handful of seeds – Vicky Erickson, US Forest Service
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Table of Contents

List of Tables

List of Figures

Appendices

Introduction and a Little History

To meet a need for a handbook on restoration with native plants focused on western Washington, the first edition of the Mt. Baker-Snoqualmie Native Plant Notebook was produced in 1994 and updated in 1997 (Potash and Aubry 1997). Since that time, a wealth of additional information has become available, to the point where the myriad of options can feel overwhelming. In this era of "information overload," the purpose of this notebook is to provide Olympic National Forest (ONF) staff with a few consistent, forest-wide agreed-upon standards, tools, and approaches for revegetation with native plants (and/or non-invasive non-natives), tailored for your types of projects and for plant communities of the Olympic Peninsula.

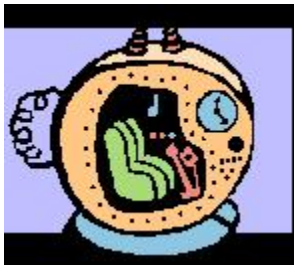
Region-wide contracts have already been prepared for your use so you don't have to re-invent the wheel. In addition, rather that expecting you to wade through 4,567,890 articles, bibliographies, and URLs, this document provides electronic links to critical sources of information. Finally, hard copies of a few select reference books will be purchased for each office.

Regional and National Native Plant Policy

In 1994, the Pacific Northwest Region (R6) led the way by adopting a native plant policy under Forest Service Manual 2600, *Regional Policy on Use of Native and Nonnative Plants on National Forests and Grasslands*. A national policy was later based on the R6 policy and is more explicit. The public comment period ended August 24, 2006; the final is expected early in 2007. The draft policy can be viewed by clicking *http://www.fs.fed.us/rangelands/whoweare/documents/FSM2070_Final_2_062905.pdf* .

Three key elements of the national policy are:

1. Native plants are defined as all indigenous terrestrial and aquatic plant species that evolved naturally in a defined native ecosystem.
2. Native plant materials will be the first choice in revegetation for restoration and rehabilitation of native ecosystems where timely natural regeneration of the native plant community will not occur.
3. Non-native, non-invasive plant species may be used when:
    a) Needed in emergency conditions to protect basic resource values, as an interim, non-persistent measure designed to aid in the re-establishment of native plants.
    b) When native plant materials are not available. [Ed. Note: This clause should not excuse us from the pre-planning that is necessary to ensure that native plant materials *are* available.]
    c) In permanently altered plant communities.



It's easy to visualize what this definition means for projects on the Olympic National Forest if you imagine that you stepped into a time machine that enabled you to stand at your project site about 300 or 400 years ago. What plants would you expect to see growing there? See "Definitions Referring to Plant Origin" on the next page.

Definitions Referring To Plant Origin

Native: Plant species present on the Olympic National Forest prior to European arrival, circa 1800.

Example: Pacific trillium (*Trillium ovatum*).

Local Native: A population of a native plant species that originated (that is, grew from seeds or cuttings) from genetically local sources. The geographic and altitudinal boundaries that define a species' genetically local source are determined by seed movement guidelines.

Example: Douglas-fir (*Pseudotuga menziesii*) seedlings grown from seed collected in the local seed zone.

Non-local Native: This term has two meanings: (1) a population of a native plant species that does not occur naturally in the plant community in which is it planted or (2) plant material of a native species that does not originate from genetically local sources. Non-local native plants can have detrimental effects on the composition of plant communities, plant-animal relationships and the local gene pool; they also can increase the risk of mortality and maladaptation.

Example: 1) black cottonwood (*Populus trichocarpa*) planted on an alpine ridge

2) Douglas-fir (*Pseudotuga menziesii*) seedlings originating from east of the Cascades planted on the Olympic National Forest

Desirable Non-Native: Annual or short-lived perennial that is not persistent or competitive with native vegetation. Used to decrease surface erosion or as noxious weed competitors.

Example: annual ryegrass (*Lolium perenne spp. multiflorum*)

Naturalized species: Non-native species that were introduced by humans to northwest Washington and have become a part of native plant communities.

Example: foxglove (*Digitalis purpurea*)

Exotic species: Non-native species that do not occur in northwest Washington except in landscape plantings or botanical gardens.

Example: southern magnolia (*Magnolia grandiflora*)

Undesirable Plant Species: Either one of the following:

1) Plant species on the Washington Department of Agriculture noxious weed list.

Example: hairy cats-ears (*Hypochaeris radicata*)

2) Horticultural varieties of native species

The Importance Of Using the Best Plant Materials and Plant Movement Guidelines[1]

When you collect seed or cuttings from one site and then plant them in your project area, the original plants from which you collected are your source plant materials. Consideration of the *origin* of these plants can be one of the most important decisions in a restoration project. In this context, origin can be thought of as the location where the source plant materials originally grew on the landscape.

If the source plant material is adapted to one set of environmental conditions, moving these plants to a project site with a very similar set of environmental conditions gives the best chances of success.

The "best" or "most appropriate" native plant materials are those which were originally collected from sites that are the most environmentally similar to your project area, because this increases the probability that they will actually survive in the project area itself. In other words, if the source plant material is *adapted* to one set of environmental conditions, moving these plants to a project site with a very similar set of environmental conditions gives the best chances of success.

Conversely, there are a couple of serious concerns if the source plant materials originated from a site very different from the project area. The first concern is that if the new plants are not well-adapted to environmental conditions found in the project area, they'll die[2], and there goes your hard-earned project funding. The second, bigger concern is that the plants introduced from the collection area would interbreed with the same species in the vicinity of the project area, introducing these maladaptations to plants in a broad area, with possible long-term ramifications in the watershed. Standards for how to ensure the origin of the collection area is appropriate for the project area on the Olympic National Forest are addressed in Plant Movement Guidelines, later in this section.

Choosing the "best" plant materials also entails consideration of the *genetic diversity* of the source plant material. Natural selection will favor some individual plants within the same species over others when they are planted in the project area. Therefore, overall percent chances of survival are higher if the source of the plant material was collected from a variety of individuals. Standards for how to ensure genetic diversity are addressed in Plant Movement Guidelines.

See http://frdev.ftcol.wo.fs.fed.us/wildflowers/nativeplantmaterials/rightmaterials.shtml for an outstanding, concise summary of this subject: *Selecting native plant materials for restoration projects—ensuring local adaptation and maintaining genetic diversity* (Withrow-Robinson and Johnson 2006).

[1] For definitions of key terms (identified in italics), see Definitions Related To Plant Movement Guidelines, later in this section.

[2] For example, thimbleberry (*Rubus parviflorus*) growing in Sequim might have a trait, such as timing of bud burst, that expresses a full month earlier than thimbleberry that has evolved to grow in avalanche chutes in the silver fir zone. If the Sequim thimbleberry seeds were used for a project 3,000 feet higher, they might die because the buds burst too early, while there are killing frosts.

Protecting Plant Genetic Resources

The protection of plant genetic resources is an important mission of the Forest Service. Safeguards for maintaining local adaptation and genetic diversity in native conifer species, for example, have long been the foundation of reforestation practices and nursery operations. These same considerations are now being applied to the development and use of plant materials for other types of native species, including hardwood trees and shrubs, grasses, and forbs.

The use of genetically inappropriate plant materials can have unanticipated and cascading negative effects throughout the ecosystem.

Plant materials that are not genetically suited to conditions of a planting site may cause the project to fail outright or not be sustainable over time. Poorly adapted plants may even negatively affect neighboring *populations* of the same species if they contribute pollen or seeds to them. Ensuring genetic diversity is also important because it can strongly influence the long-term viability of plant populations and their ability to adapt to changing climatic and environmental conditions. Plant materials that lack genetic diversity may be more susceptible to pathogens and other environmental stresses, and they may also be less competitive with exotic invasive species. Overall, the use of genetically inappropriate plant materials can have unanticipated and cascading negative effects throughout the ecosystem.[3]

How Far Can We Move Plants and Seed?

Plant and seed movement or seed transfer guidelines delineate the area over which seeds and cuttings can be collected and planted. The reason for setting plant movement guidelines is to increase the probability that the reproductive materials we use will survive, grow to maturity, and reproduce. The chance of success is much higher if we use locally collected material. The geographic limits of what constitutes a "local native" plant are called plant movement guidelines.

Before discussing the recommendations for plant movement on the Olympic, a brief introduction to the interactions between plants and their environments may be useful. The forces of natural selection result in the diversity of organisms by promoting adaptation to different ways of life (Ayala and Kiger 1980). Natural selection acts on the *genotype,* which is the genetic constitution the plant has inherited. The *phenotype* is the appearance of the plant—what we can see—including form, physiology, and behavior. The phenotype results from the interaction of the genotype and the environment.

Usually, most plants are precisely adapted to their immediate environments. Many widespread species adjust by breaking up into groups (ecotypes or subpopulations), each of which is adapted to the specifically defined ecological situation within one or more sub-areas of the species' range. Subpopulations are usually continuous but maintain their integrity through ecologically specified selection pressures despite *gene flow* from the other neighboring "ecological" races (Mettler and Gregg 1969). Moving plants outside

[3] Excerpt from Celebrating Wildflowers website, Native Plant Materials, http://frdev.ftcol.wo.fs.fed.us/wildflowers/index.shtml. Accessed 1/29/2007.

the sub-areas to which they are adapted can result in changes in a number of traits including plant size and shape, growth rate, seed production, and survival. The degree to which these changes occur depends on the difference between any two sub-areas. Planting climatic races in different environments illustrates these differences (Figure 1).

Three plants of the cinquefoil, *Potentilla glandulosa*, were collected in California—one on the coast about 100 feet above sea level (Stanford), the second at about 4,600 feet (Mather), and the third in the Alpine Zone of the Sierra Nevada at about 10,000 feet (Timberline). Each plant was cut into three parts and the parts were planted in three experimental gardens at different altitudes, the same garden for all three plants. The division of one plant insured that all three parts planted at different altitudes had the same genotype.

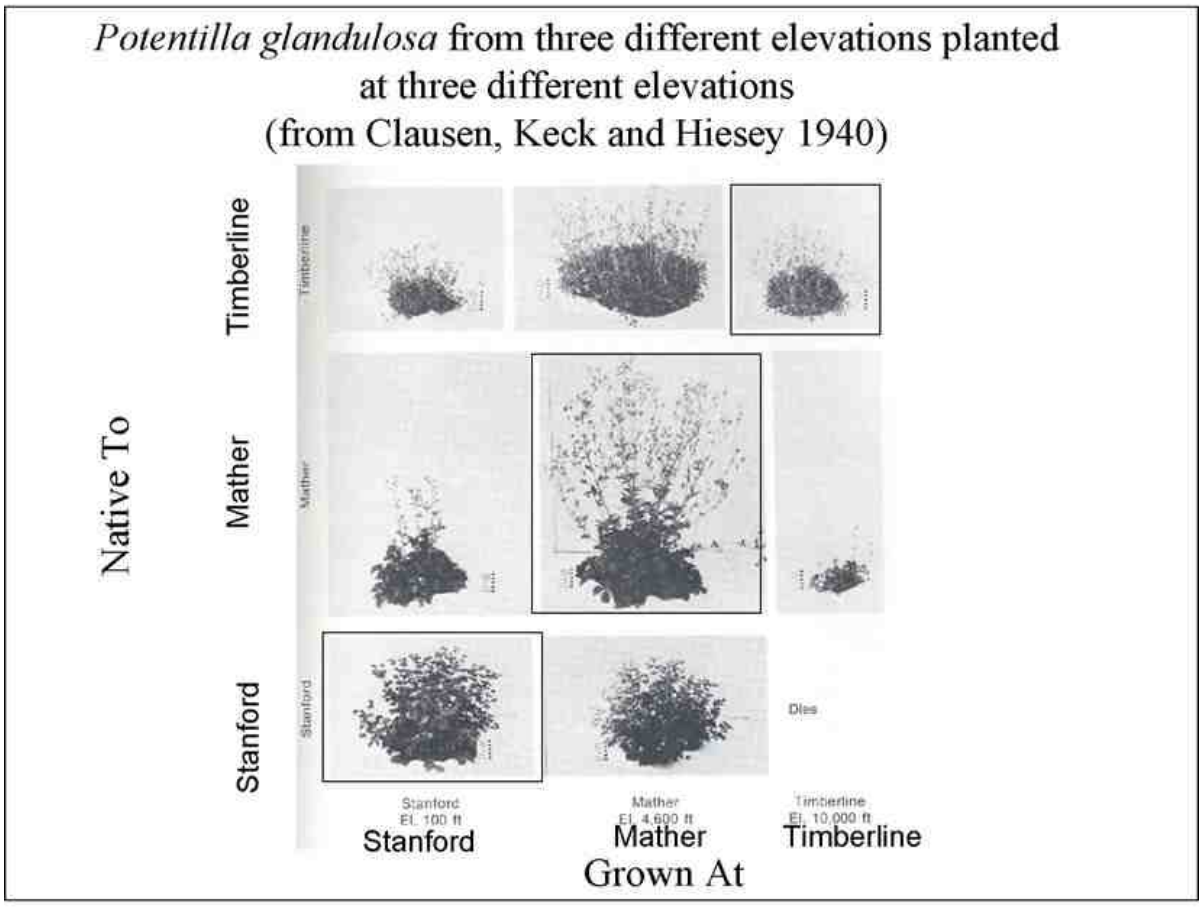


Figure 1. Effects of plant origin and the environment on plant growth. Photos courtesy of the Carnegie Institution of Washington, Palo Alto, California. Used by permission.

Each of the three sources grew differently across the three environments. Besides the obvious differences in appearance, there were differences in fertility, growth rates, and other traits. Plants in the same column in Figure 1 illustrate the effects of growing the three genotypes (sources) in one environment, such as the Timberline, Mather, and Stanford sources grown in the Stanford experimental garden (left-hand column). When the three sources were grown at Timberline (right-hand column), the Stanford source did

not survive; it was unable to adjust to, among other factors, the shorter growing season and harsher temperatures at 10,000 feet. Plants in the same row illustrate the effects of the three environments on a single source. For example, the cuttings from the Mather source (middle row) grew very differently in the three experimental gardens. Photos on the diagonal represent the three genotypes grown in their source environments; in each case, the plants from the source environment were the most vigorous.

Although we would never attempt testing across extreme elevational differences on an operational basis, such testing does show that a single species with a wide geographic range, like many of our forest species, varies in many important characteristics and this variation has a genetic basis. Studies similar to this one involving many more genotypes (chosen over many locations) have been used to develop plant movement guidelines for individual plant species. Few of these studies have been done on plant species native to our forest. The guidelines we will use are based on the our knowledge and experience, limited as it is, and are conservative in nature in order to reduce the risk of maladaptation.

Plant Movement Guidelines

As stated above, these guidelines are very conservative and can be adjusted depending on the species and project. Your friendly local area geneticist can help adjust these requirements based on your specific situation.

Plant Movement Guidelines For Upland Tree Species

Collect seeds or cuttings of upland tree species within seed (collection) zones. *Seed zones* are based on climatic and physiographic information and were developed in 1966 to reduce the risk of maladaptation of commercially planted conifers and to provide structure for the commercial seed trade. In addition to geographic boundaries each zone is divided into 500-foot elevation intervals. *Seed lots* are coded by both seed zone and elevation band.

Use the following elevation bands when building large seed lots: 0–500 feet, 500–1,000 feet, 1,000–1,500 feet, etc. When collecting seeds or cuttings for smaller projects (perhaps a one-time collection), a 500-foot elevation band would also be used (approximately 250 feet above and below the elevation of the project site).

Plant Movement Guidelines For Shrubs, Forbs, Grasses, and Riparian species

For shrubs, forbs, grasses, and riparian species, use 5th field watershed boundaries as seed/cutting collection zones. Within 5th field watersheds, make collections in 500- to 1,000-foot elevation intervals, depending on the project and plant species.

Gene Pool Conservation Guidelines

The genetic diversity of the seed or cuttings is just as important as the seed movement guidelines for successful revegetation and is critical for *gene pool* conservation. To prevent the loss of genes in the population, collect from a minimum of 30–50 unrelated *donor plants*. The desired result is 30–50 parent plants represented in surviving seedlings or cuttings. If mortality is expected in some stage of the process, collect from additional

donor plants. Collect relatively equal number of seeds/cuttings from each donor plant to ensure representation by as many parent plants as possible.

Donor plants should also be separated by sufficient distance to reduce the risk of relatedness—that is, originating from the same rhizome or root system or, for out-crossing plants, having one or both parents in common. The minimum distance between donor plants is determined by mating system and pollen flow and will vary by species. Use your best judgment and knowledge of the distribution of plant populations in the area.

Summary Of Guidelines For Native Plant Collection To Ensure Genetic Diversity and Adaptation To Planting Environment

- Collect from 30–50 **unrelated** plants.
- Collect an equal number of seeds or cuttings from each plant.
- For **upland tree species** collect seeds and cuttings within seed zones and 500-foot elevation bands or not more than 250 feet above and below the project site.
- For **shrubs, forbs, grasses, and riparian tree species** collect seeds and cuttings within watersheds and 500-foot elevation bands or not more than 250 feet above and below the project site.

Definitions Related To Plant Movement Guidelines

Adapted: How well plants are physiologically suited for high survival, good growth, and resistance to pests and diseases in a particular environment.

Donor or parent plants: The live plants from which seeds or cuttings are collected.

Gene flow: The exchange of genes between different but (usually) related *populations*.

Gene pool: The sum of all the genetic information carried by members of a *population*.

Genetic diversity: The property of a community of organisms of a certain species, in which members of the community have variations in their chromosomes due to a large number of slightly dissimilar ancestors; this property makes the community in general more resistant to diseases or to changing ecological conditions.

Genotype: The specific genes present in a cell or an individual.

Maladapted: Poorly adapted.

Phenotype: The observable characteristics of an individual, resulting from the interaction between the genotype and the environment in which the individual grows.

Population: A group of organisms of the same species relatively isolated from other groups of the same species.

Seed lot: An indefinite quantity of seed having uniform quality, produced at a specific location, or within a single seed collection zone and collected from a single annual crop.

Seed (collection) zone: An area having defined boundaries and altitudinal limits, within which soil and climate are sufficiently uniform that it is expected that seed can be freely moved without problems of maladaptation.

Get It Together: Native Seeds and Rooted Materials

Focus Species and Native Seed Mixes

In fiscal year 2007, we applied for and were awarded RAC Title II funds to hire the Native Seed Network (a division of the Institute for Applied Ecology) to develop a "focus list" of those native species best suited for seeding or planting for restoration projects on the ONF. The report will include species lists for various project types (wildlife forage, erosion control, etc.), sites (steep/flat, open/wooded), and environments (wet/dry, high/low elevation), as well as information about propagating and planting the focus list species. In addition, they will conduct a case study specifically for the Caraco elk forage units in the Dungeness River drainage. The final report from this effort will be posted later in FY07 on the ONF native plant website: http://fsweb/onpmp/index.html .

Five Steps for Acquiring Native Seed for Your Project

Step 1—Surveys

Project Area Surveys. The ideal way to determine what species would be most appropriate to seed at your site is to visit the area and make a species list of all the species that occur there. Other critical information to note is the elevation of your site, and if possible, the plant association according to the keys in *Forested Plant Associations of the Olympic National Forest* (Henderson et al. 1989).

Tip!
If the proposed project area has already been surveyed by an ONF botanist, you can get the complete species list, elevation, and plant association from them.

Next, cross-reference your comprehensive list with those species recommended in the "focus list" for the management objective you desire. The best chance of project success is to use those species that are included on the focus list *and* already occur naturally in the vicinity of your site.

Seed Reconnaissance Surveys. Once you know what species you want, you can hire someone to scope out the best places to collect your foundation seed (within the boundaries defined by the Plant Movement Guidelines). That way your seed collector doesn't waste a lot of time visiting areas that don't have the species they are hunting for. This process was completed for the Dungeness elk units; a summary is included in Appendix 1, and a prototype contract for this type of reconnaissance is included in Appendix 2.

Step 2—Seed Collection

Seed collection will be most cost effective if you provide your contractor with the results of a preliminary reconnaissance survey, as mentioned above. Lacking that, you can give them a list of the desired species and have them search the project area. An example of a task order for seed collection is shown in Appendix 3. The entire contract is available on the ONF native plant website: http://fsweb/onpmp/index.html .

Tip!

Given the wild storms of FY2007, remember to provide your collector with local district updates about washed-out roads. Also remember to coordinate with the wildlife biologist for keys to gates locked for wildlife closures.

Step 3—Seed Cleaning and Testing

Seed collected (by either you or a contractor) is roughly cleaned to remove obvious debris and then shipped to the Forest Service's Bend Seed Extraction Facility. The Bend Seed Extractory will expect you to include, along with your shipment of rough cleaned seed, their seed collection form #158, which you can download from their website http://fsweb-ochdes.r6.fs.fed.us/seedextractory/extractory.shtml. If you have any questions, they're happy to help you—just call 541-383-5481.

The Bend Seed Extractory cleans your seed thoroughly until it meets the industry standard and then sends it to Oregon State University for testing. On form #158 you checkmark which of the following tests you want:

- ❑ **Germination** (the predicted percentage of the seed that will actually sprout vs. duds). The industry norm for commercial crop seed is $\geq$ 80 percent.
- ❑ **Noxious weeds** (sometimes called the "all states noxious weed test"). Ask them to use the Washington state noxious weed list. They will list any species they find.
- ❑ **Purity** (how much of the seed is actually the species you want, including noxious weeds, any other species, or inert materials like chaff and straw). Industry norm for commercial crop seed is $\geq$ 90 percent.
- ❑ **Percent pure live seed (PLS)**. This is a calculated number based on multiplying the (percent purity) by the (percent germination). For example, your batch of blue wildrye has (90%)(80%) = 72% pure live seed. That means that 72 percent of the stuff you sow from that batch is more or less "guaranteed" to germinate.

It's important to understand that the pounds of seed needed from the field collections ("rough cleaned") will be greater than pounds of properly cleaned, pure live seed needed to start a seed increase project. Some species, such as oceanspray, have a high proportion of unviable seed; others have thick seed coats, so the amounts vary by species. For example, you'd need to collect between 1 ½ to 3 pounds of broadleaf lupine seeds to yield 1 pound of clean seed, and between 1.5 and 1.8 pounds of sedge seeds to yield 1 pound of clean seed (estimates for other species are available from Bend Pine Nursery).

Step 4—Seed Increase

Tip! *A seed increase program can get you the bulk quantities you need and save you money in the long run!*

Native seed is usually difficult to collect in large quantities because the plants may be sparsely distributed or difficult to get to, or the seed itself may have low viability. Restoration workers have helped resolve this problem by establishing seed increase programs.

After your seed is cleaned and tested and meets a standard that is specified in the contract, it is sent to J. Herbert Stone nursery for storage—this is called the "foundation seed." The foundation seed is then sent to one of the pre-approved a nurseries in our R6 contract, where it is planted in a nursery bed, babied, and grows up to produce a large quantity of seed that can be readily harvested. Sometimes the same crop can produce even more seed the 2nd or 3rd year. See great diagrams and photos of the seed increase process at http://frdev.ftcol.wo.fs.fed.us/wildflowers/nativeplantmaterials/stock.shtml. The nursery needs a minimum amount of foundation seed (meeting certain purity and germination requirements) to establish a 1-acre "production field." Table 1 shows three examples just to give you an idea.

Table 1—Pounds of foundation seed needed to start a 1-acre production field, three examples

Species	Amount of clean foundation seed needed (lbs)	Germination/pure live seed (percent)	Average yield 1st year harvest (lbs)	Average yield 2nd year harvest (lbs)
Blue wildrye	8	75/95	300	300
Common yarrow	2	85/98	165	165
Tufted hairgrass	2	75/90	110	510

Source: Umatilla National Forest, from regional seed increase contracts

Seed increase on the ONF will be a coordinated effort at the forest level and not a project-by-project affair. If you have a project where you'd like to use native seed, discuss it with the coordinator of the ONF Native Plant Materials Program. An example of an R6 task order for seed increase is in Appendix 3. The entire contract is available on the ONF native plant website: http://fsweb/onpmp/index.html .

Seed increase is an excellent investment. Figures 2 and 3 provide some examples of seed increase yields from Region 6.

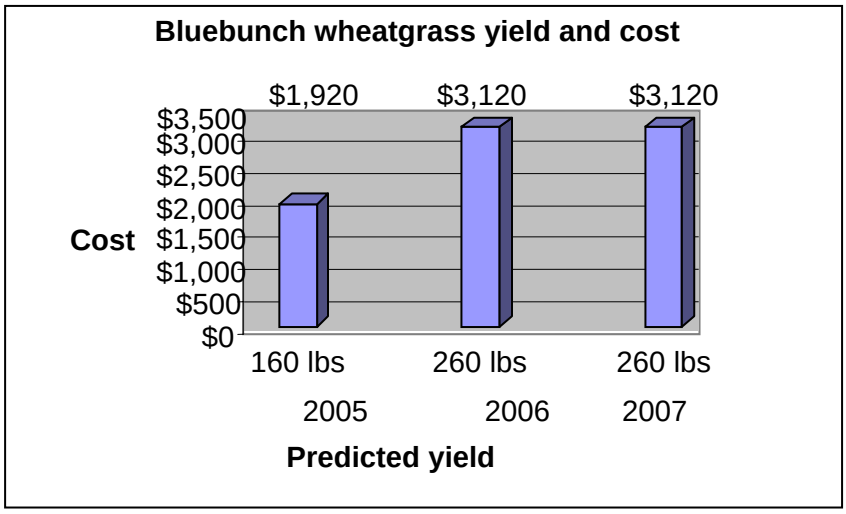


Figure 2—Bluebunch wheatgrass seed yield and cost. In this example, 4 pounds of seed were collected from the Wenatchee River Ranger District to establish 1 acre of bluebunch wheatgrass for seed increase. From this 1-acre stand, seed will be purchased for revegetation work. The predicted yields and associated purchase prices are shown graphically here. Yield predictions are based on past experience with the species being grown. At the end of 3 years, 680 pounds of bluebunch wheatgrass will be produced from the original 4 pounds of foundation seed, at a cost of about $12/pound.

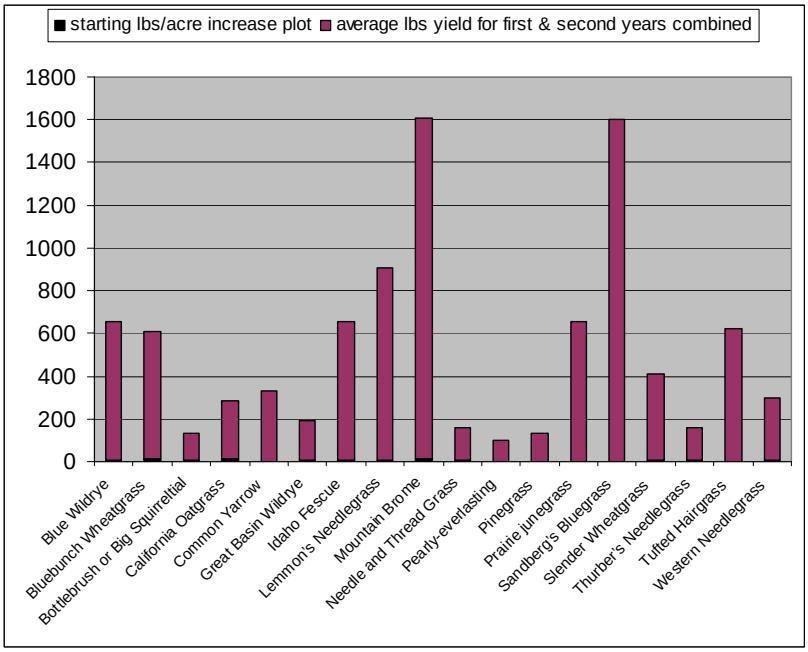


Figure 3—Proportion of seed increased compared to foundation seed. This graph, based on Regional Seed Increase Contracts, shows the number of pounds of foundation seed compared to what can be harvested after 2 years (the little black bars at the base of the colored bars represent starting pounds per acre and are barely visible because of the disproportionate scales). For example, only 8 pounds of blue wildrye were collected, but they yielded 650 pounds after the 2nd year—an 81-fold increase.

Step 5—Storage

If the seed isn't stored properly before it is sowed, there's a good chance it's useless. Rose et al. (1998) (Appendix 4) sums up the issue very well: "Successful storage requires knowledge of the seed characteristics of different species as well as the quality of the seed before storage, its moisture content, and the storage temperature and method."

Obviously this kind of treatment requires the knowledge of a plant materials specialist, and we're fortunate to be able to rely on the expertise of the J. Herbert Stone Nursery. All native seed collected for project use on the ONF (whether it is for simple broadcast at a later time in the project area, or destined for a seed increase program) should be sent to this nursery where it will be properly cared for until it is ready for use (Figure 4).

Seed-bearing material was lightly cleaned and packaged in plastic bags for shipment to the Forest Service's J. Herbert Stone Nursery for storage.

Figure 4—Seeds ready for shipment to J.Herbert Stone Nursery. This seed was one of seven native species collected on the Okanogan-Wenatchee National Forest. There is a nice Powerpoint presentation developed by Robin Shoal that describes their program; it can be viewed by visiting the ONF native plant website: http://fsweb/onpmp/index.html .

Rooted Plant Materials

If your project objectives determine that woody plants/shrubs are needed, it is generally not practical to collect and sow their seeds in the project area because they'll take too long to grow. In this case, the contractor usually collects stem cuttings or, depending on the species, root segments. These are delivered to a nursery, where they are grown into entire plants with roots, which are then planted back out on the project site.

Stock Types

Rooted plant materials are available from nurseries in a variety of forms, each with distinct advantages and disadvantages (Dorner 2002)[4]. The following is a list of commonly available nursery stock types:

- BALLED-IN-BURLAP or "B&B". The plant is grown in the nursery, dug up with its roots and surrounding soil, and wrapped in a protective material such as burlap.
- BARE-ROOT. The plant is sold without any soil around its roots.
- CONTAINERS. The plant is sold in a container of soil with drainage holes. Sizes and shapes of containers vary, but they usually are plastic. Examples of common sizes are: 4-inch pots, 6-inch pots, and 1-, 2- or 5-gallon containers.
- CUTTINGS or WHIPS. A piece of branch, root, or leaf that is separated from a host plant and is used to create a new plant. These may be placed in a rooting medium or stuck directly into the ground for planting.
- LINERS. A small grafted plant, rooted cutting, or seedling that is ready for transplanting. They are often used for herbaceous plants and grasses.
- PLUGS or TUBELINGS. These are similar to liners, but they are individual cylindrical or square planting containers that are longer than they are wide. The longer shape provides room for a plant to build root mass for transplanting.

Calculating Quantity Needed for Different Planting Densities

To plan your budget, you'll need to know how many plants to order. Once you know the pros and cons and decide what stock type you want (see link in footnote), talk to a Forest Service landscape architect and/or your nursery grower to get advice about typical spacing for that species and that stock type. Then use Table 2 to calculate how many plants you'll need. Visit http://parks.state.co.us/NR/rdonlyres/00A97125-2219-4E68-A28F-6CC62300D43A/0/revegetation.pdf to see the entire document, which is chock full of useful information.

Table 2—Calculation of the required number of plants to achieve desired density

If the distance on center* is…	Then the number of plants you need is…
0.5 ft	(Area in Square Feet) x 4
1 ft	Area in Square Feet
1.5 ft	(Area in Square Feet) x 0.444
2 ft	(Area in Square Feet) x 0.25
3 ft	(Area in Square Feet) x 0.11
4 ft	(Area in Square Feet) x 0.625
5 ft	(Area in Square Feet) x 0.04
6 ft	(Area in Square Feet) x 0.028

*The "distance on center" is an expression to describe how many feet apart the plants are spaced, if spaced evenly in a grid-like pattern.
Source: Colorado Natural Areas Program 1998

[4] An excellent table comparing the advantages and disadvantages of each stock type is on page 30 of the document by Dorner (2002). A hard copy will be provided to you (Appendix 8), or visit http://www.nps.gov/plants/restore/pubs/intronatplant/toc.htm to see it now.

Costs For Acquiring Native Seed Or Rooted Plants

Costs for using native species in restoration projects will vary based on a multitude of factors, but here are a few examples to give you a rough idea.

Cost For Step 1, Surveys

Project Area Surveys. The easiest and most effective way to have these surveys done is to allot days in WorkPlan to have an ONF botanist complete the job. Calculate their cost-to-government at about 1 field day per 20 acres + an office day to ID grass species you may want to collect and/or or weed species you may want to control. If the survey is also clearance for rare plants, more time will be required. Alternatively, you may be able to use a volunteer from your local chapter of the Washington Native Plant Society (www.wnps.org). If you go this route, it is critical that the volunteer is experienced enough to distinguish native from non-native species in "difficult" families like graminoids (grasses, sedges, rushes) and composites (plants in the sunflower family, such as hawkweeds and thistles).

Seed Reconnaissance Surveys. Once you know what species you want, you can hire someone to map the seed collection sites. In 2006, the elk forage seed inventory in the Dungeness and Gray Wolf watersheds cost $2,400, which allowed us to pay with a government check and didn't require routing though the formal contracting process. Average cost of mapping collection sites in eastern Oregon, based on data compiled by the Umatilla National Forest, ran between $300 and $350 per species within a 5th field watershed.

Cost For Step 2, Seed Collection.

Tip!
Ask the contractor to bid on the entire job, not on cost-per-pound of clean seed.

Cost will vary based on the number of pounds needed, species desired, and accessibility of collection sites. A recommendation from both the Umatilla and Okanogan-Wenatchee is that you ask the contractor to bid on the entire job (Table 3), rather than a bid based on cost per pound per of clean seed. Contractors like this better because they don't have a good feel for how many pounds of "rough cleaned" seed will be needed to reach your desired pounds of clean seed. Of course their bid will be lower if you're able to provide them with good reconnaissance information (mapped collection sites).

Table 3—Partial Government cost estimates for task order for seed collection for Mission Ridge Highway project, based on experience and costs on other native projects on the Umatilla National Forest

Item No.	Sub-item No.	Description	Quantity order	Unit	Unit price ($)
2.A	1	Collect bluebunch wheatgrass from approved collection areas (minimum 20 lbs rough cleaned weight)	1	Job	1,800
	2	Collect Sandberg's bluegrass from approved collection areas (minimum 6 lbs rough cleaned weight)	1	Job	900

Item No.	Sub-item No.	Description	Quantity order	Unit	Unit price ($)
	3	Collect common yarrow from approved collection areas (minimum 10 lbs rough cleaned weight)	1	Job	1,000
	4	Collect silverleaf Phacelia (*Phacelia hastata*) seed from approved collection areas (minimum 5 lbs rough cleaned weight).	1	Job	1,500

Cost For Step 3, Seed Cleaning and Testing

Bend Seed Extractory charges:

$43.50 flat fee to clean less than 1 pound of seed

$65 flat fee to clean between 1 and 25 pounds (that is, 25 pounds costs the same as one pound).

Then they send it to Oregon State University for the whatever tests you requested on form #158. OSU charges:

$37–$45 per seed lot for "all states noxious weed" test

$30 per seed lot for germination

$72–$92 per seed lot for purity (which includes noxious weeds and any other species)

Cost For Step 4, Seed Increase

Costs vary widely depending on the grower, the species (some species are harder to grow than others), and the quantity (cost per pound generally goes down the larger the quantity). For example, the Siuslaw contracted a local grower to produce 1,500 pounds of blue wildrye for $4.84 per pound. The cost to produce 680 pounds of bluebunch wheatgrass (as shown earlier in Figure 2) was $12/pound.

Cost For Step 5, Storage.

J. Herbert Stone Nursery charges $1.00 per pound per year to store seeds under refrigeration, and $1.50 per pound per year to store seeds in their freezer. They can advise you as to which is most appropriate.

Cost To Produce Rooted Plants Materials

Cost will vary depending on what size stock type you want. Three bids received on the Okanogan-Wenatchee National Forest ranged from $2.25 to $3 each for "D-40 plugs" and from $4 to $5 each for "long tubes." A nursery in Olympia estimated $2.75 each for 1-gallon container plants.

Road Decommissioning and Roadside Treatments

The purpose of this chapter is to address the need for immediate erosion control. The ONF aquatics program manager, forest hydrologist, hydrologist technician, and engineers indicated that they want seed mixes that will persist longer than 2 years, can grow rapidly in poor soils, and will stabilize slopes until trees are established. Our approach is to use "non-invasive non-natives" and mulch, with the assumption that if the species recommended are not overly persistent, native species will eventually become established at these sites.

The Revegetation Project Form (Appendix 6) is intended to meet a need to provide a consistent framework for all resource areas to use whenever immediate erosion control is required.

Engineering Contract Specifications (Appendix 7) are intended to meet a need to have consistent language, forest wide, regarding revegetation for erosion control that can be inserted into contracts. There are four different versions, depending on the elevation and soil moisture.

Non-invasive, Non-native Seed Mixes For Road Decommissioning

This section is based on a manuscript by Laura Potash, Marty Chaney, and Carol Aubry (Potash et al. 2007). It addresses those times when we need a seed mix of non-native plant species for road decommissioning. A number of characteristics for the "perfect non-native seed mix" are summarized below:

Objectives

- ❑ 80 percent cover in first through third season
- ❑ Cover rapidly reduces in fourth year and is nearly gone in fifth year
- ❑ Provide environment for natives to seed in
- ❑ Exclude or out compete noxious and obnoxious weeds
- ❑ Prevent erosion

Characteristics

- ❑ Inexpensive
- ❑ Readily available from seed companies
- ❑ Free of noxious weeds
- ❑ Will not hybridize with local native species
- ❑ Noninvasive
- ❑ Provide a variety of stand characteristics
    - Tall or short
    - Deep-rooted or shallow-rooted
    - Vary in level of winter cover
    - Bunchy or mat-like
    - Include at least one nitrogen-fixing species
- ❑ Non-toxic to wildlife

Four seed mixes have been developed for high and low elevations (above and below 2,500 feet) and on dry and wet sites (Table 4). Each mix includes the following:

1. A short-lived (3–5 years) perennial bunchgrass (perennial rye)
2. A non-persistent annual grass (annual rye)
3. One or more annual grain or cereal (oats, wheat, winter triticale, barley)
4. One or more short-lived (3–5 years) perennial nitrogen-fixer (peas, clovers)

Plant characteristics for each of these species is given in Table 5.

Table 4—Non-native seed mixes for road decommissioning[a] on the Olympic National Forest[b]

≤ 2500' Elevation						**> 2500' Elevation[c]**					
Soil droughty to somewhat moist, but not saturated to the surface in mid-summer ↓ **Olympic Mix 1**			Soil saturated to the surface in mid-summer ↓ **Olympic Mix 2**			Soil droughty to somewhat moist, but not saturated to the surface in mid-summer ↓ **Olympic Mix 3**			Soil saturated to the surface in mid-summer ↓ **Olympic Mix 4**		
	Lbs/ ac	*pct by wt*		Lbs/ ac	*pct by wt*		Lbs/ ac	*pct by wt*		Lbs/ ac	*pct by wt*
Annual ryegrass	40	*40%*	Annual ryegrass	40	*44%*	Annual ryegrass	40	*42%*	Annual ryegrass	40	*44%*
Oats	30	*30%*	Oats	30	*33%*	Winter triticale	40	*42%*	Oats	30	*33%*
Perennial ryegrass[d]	10	*10%*	Barley	15	*17%*	Perennial ryegrass[d]	10	*11%*	Barley	15	*17%*
Red clover[e] (inoculated)	5	*5%*	Alsike clover (inoculated)	5	*6%*	Red clover[e] (inoculated)	5	*5%*	Alsike clover[e] (inoculated)	5	*6%*
Austrian winter peas (inoculated)	15	*15%*									

INSPECT YOUR SEED TAGS when you receive shipment from your supplier! The rates above assume **≤ 90%** PLS (pure live seed). Seed tags should be inspected for "other seed" as well as for noxious weed seed, because "other seed" can include many common grasses and weeds.

[a] Assumptions:
- ✓ The site has nutrient poor, highly disturbed soil that may be lacking a natural A horizon
- ✓ The site is not intended for continuous disturbance (e.g. mowed ski area); the goal is eventual re-establishment of native species
- ✓ The site is not intended to be retreated in subsequent years

[b] Source: Potash et al. 2007. Table draft, last revised 12/20/2006.

[c] Higher elevations are less likely to have historical introductions of non-native species. To avoid setting this precedent, the use of local native seed mixes is a high priority here. Excellent species for revegetation on the Olympic National Forest include blue wildrye (*Elymus glaucus*) , slender wheatgrass (*Elymus trachycaulus*), and tufted hairgrass (*Deschampsia caespitosa*). Conversely, **cultivars of native species should be avoided** on the Olympic.

[d] Although persistent to invasive under many circumstances, perennial rye will drop out if soil fertility is low.

[e] Red clover (*T. pratense*) and Alsike clover (*T. hybridum*) are not extremely short-lived but are both less persistent than white clover (*T. repens*). Red is better for dry sites, Alsike for wet.

Table 5—Characteristics of the non-native species in Olympic National Forest Seed Mixes

Characteristic	Plant Species—Common Name, Scientific Name, and NRCS Code							
	Annual ryegrass *Lolium multiflorum* LOMU*	**Perennial ryegrass** *Lolium perenne* LOPE	**Oats** *Avena sativa* AVSA	**Austrian winter peas** *Pisum sativum* spp. *arvense* PISAA8	**Red clover** *Trifolium pratense* TRPR2	**Common barley** *Hordeum vulgare* HOVU	**Alsike clover** *Trifolium hybridum* TRHY	**Winter triticale** *Triticosecale* spp TRITI2
Longevity	Annual or biennial	Annual or perennial	Annual	Annual	Perennial (acts as biennial) (2–3 years)	Annual	Perennial (acts as biennial)	Annual
Height (inches)	24–36	12–24	24	24–48	12–36	30	12–36	42
Leaves	Sheath round, smooth, open; blade rolled in bud, flat, 1/8-in. wide; ligule small, membran-ous; auricles small	Sparse leaves on clums; underside glossy; auricles present; ligule difficult to see; x-section of leaf blade v-shaped	Sheath round, short, hairy, split with overlapping margins; blade rolled in bud shoot, ¼- to ½-in. wide, margins short, hairy; ligule prominent, membranous, rounded, toothed; auricles absent	Opposite, pale green with whitish watermark	palmately trifoliolate; leaflets not serrated; inverted v-shaped water mark usually present; large stipules; stems, leaves, and petioles pubescent	Alternate, linear lanceolate, 10 in. long.	palmately trifoliolate; finely serrated; large, pointed stipules; glabrous	Similar in appearance to wheat: flat; glabrous or pubescent; internodes usually hollow except for immediately below spike
Inflorescence	4–16 in. long spike; spikelets arranged edgewise, alternately up the stem	Spike; 35 spikelets per spike; 6–10 florets per spikelet	Panicle large, open, pyramid shaped; spikelets 2–3 flowered, drooping	Raceme arising from leaf axil; flowers range from white to pink or purple	Heads consisting of up to 125 flowers; rose-purple or deep purplish-red; heads nested in 2–3 leaves	Spikelets sessile, arranged in 3s on 2 sides of flattened rachis; densely flowered	Seed head consisting of 17–91 florets supported by petiole from leaf axil; flowers white to pink	Seed head is a spike, with 30–40 awned spikelets arranged alternately ontwo sides of the rachis
Optimal soil drainage	Does well on heavy, waterlogged soils	Somewhat poorly drained	Grows in everything from well-drained to saturated, heavy soils	Well-drained to moist	Well-drained	Prefers well-drained but can tolerate water-logging	Poorly drained	Tolerates drought better than most cereals
Optimal soil fertility	High	Medium high	Moderate	Moderate	Low to moderate	Prefers calcareous soils	Medium	Prefers more nitrogen than wheat

Characteristic	Plant Species—Common Name, Scientific Name, and NRCS Code							
	Annual ryegrass *Lolium multiflorum* LOMU*	**Perennial ryegrass** *Lolium perenne* LOPE	**Oats** *Avena sativa* AVSA	**Austrian winter peas** *Pisum sativum* spp. *arvense* PISAA8	**Red clover** *Trifolium pratense* TRPR2	**Common barley** *Hordeum vulgare* HOVU	**Alsike clover** *Trifolium hybridum* TRHY	**Winter triticale** *Triticosecale* spp TRITI2
Optimal soil pH	5.0–7.9	5.6–6.2	5.3–8.5	5.5–6.5	Prefers above 5.0	6.5–8.5	6.0–6.5	Alkaline to acid, no numbers
Palatability (for livestock)	Low	Very high	Medium	High	High (bloat hazard)	Medium	High (bloat hazard)	High
Winter hardiness	Will not withstand severe winters	Better than annual rye	Least hardy compared to other PNW cereals	Good	Good	Excellent	Good	Well-drained to moist
Drought tolerance	Low	Low	Low	Intolerant of waterlogged or very droughty soils	Intolerant of lengthy periods of drought	Low	Moderate	Moderate
Shade tolerance	Intermediate	Intolerant	Intolerant	Low tolerance	Moderately intermediate	Intolerant	Intolerant to moderately intolerant	Prefers full sun
Nitrogen fixation	No	No	No	Yes	Yes	No	Yes	No
Seed description	Awns present	Tan; oblong; rachilla flat and wedge-shaped, not knobbed; awns usually absent	Light tan; long, narrow	Round; various colors depending on variety	Small, kidney-shaped; varies in color from yellow to deep violet	Light brown; oblong	Apple-green to greenish-black, browning with age; nearly heart-shaped except notch slightly off center	Larger than wheat, slightly smaller than rye cereal
Seeds per pound	190,510	227,000	19,400	1,800–3,000	281,000	13,600	700,000	12,000
When to sow	Mid August to early September	Mid August to early September	Spring or fall	Late fall	Sow winter varieties in fall	Fall	Early spring or late summer	Sow winter varieties in fall
Emergence time (days)	6–10	14	Unknown	Rapid	Unknown	Unknown	7	Rapid
Optimum germ temp. (^{o}F)	50–87	60–75	Unknown	55–65	Unknown	Unknown	70	Unknown

* Also known as LOPEM2, *Lolium perenne* ssp. *multiflorum*

Pictures and Drawings

Photos of perennial ryegrass, red clover, oats, alsike clover, annual ryegrass, and their seeds are included as a separate document obtained from NRCS and will be given to each recipient of this notebook (Appendix 8). The document can also be viewed on line at:

www.plantmaterials.nrcs.usda.gov/technical/plantid/herbaceous/ConservationPlants.html.

Three species (barley, Austrian winter peas, and winter triticale), which are not included in the NRCS document, are shown below.

Figure 5—Common barley (*Hordeum vulgare*)
Illustration and photo of seeds courtesy of NRCS PLANTS database.

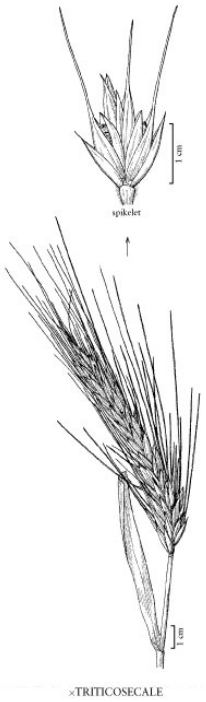


Figure 6—Austrian winter peas (*Pisum sativum* spp. *arvense*) on left. Copyright permission for this notebook obtained from Sustainable Agriculture Network (1998).

Figure 7—Winter triticale (*Triticosecale* spp.) on right. Note the very long awns. Illustration by Cindy Roché; copyright permission for this notebook obtained from Utah State University (Barkworth et al. 2007)

Ordering Information

Non-native Seed Suppliers

The Olympic National Forest is so lucky to have the expertise of folks from the Natural Resource Conservation Service right in the Supervisor's Office. The following local suppliers were recommended by Jeff Swotek, Resource Conservationist with NRCS (jeff.swotek@wa.usda.gov).

- Wilco (formerly Cenex), Centralia, WA. Phone 360-748-9277. FAX 360-748-7204, attention Troy or George.
- Dairygold Feed and Farm Supply, Chehalis, WA. Phone 360-748-3368. FAX 360-748-4363, attention Vern.
- Del's Farm Supply, Yelm, WA. Phone 360-458-5737. FAX 360-458-7753, attention Johnny.
- Kiperts Korner Feed, Olympia, WA. Phone 360-352-3309. FAX 360-352-1739.

If these suppliers can't help you, some larger suppliers the Mt. Baker-Snoqualmie has successfully worked with include:

- Rainier Seeds, Inc. Phone 800-828-8873, x 224. FAX 509-725-7015, attention Harold Wood. [Ed. Note- Harold is very knowledgeable and helpful for all kinds of questions hwood@rainierseeds.com].
- Barenburg Seed Company. Phone 800-547-4101. FAX 541-926-9435, attention Sam Cable, Sales Manager.
- Granite Seed Company. Phone 801-531-1456. FAX 801-768-3967, attention Bill Agnew.

How To Order Commercial Seed.

The best way to get bids is to FAX the supplier your species list (Olympic Mix 1, 2, 3, or 4) and ask them to send you back a bid for the number of pounds you want (see Figure 8 for an example). Multiply the amount in the mix by the number of acres to get total amounts. For example, if your site is 10 acres and you want Olympic Mix #2, multiply all quantities by 10. When you order seed from a commercial supplier, note on your FAX that you would like to receive a copy of the lab report in addition to the seed tag. This will list the names of any species occurring in the mix so you can decide if it's a real problem or something you can live with. For example, if your product is impure because of 2 percent rice seed you may not care but if it's 2 percent knapweed you don't want it!

OLYMPIC NATIONAL FOREST

U S D A - FOREST SERVICE

Supervisor's Office
1835 Black Lake Blvd. SW, Suite A
Olympia, WA 98512-5623
PHONE # (360) 956-2402 Front Desk
FAX # (360) 956-2330 Mail Room

Telecommunication Cover Sheet
☎

Date: _____ Time: _____

Number of pages being faxed: _____

Fax to: _____

Fax from: _____

Message:
We need _____ lbs of a mix of the following proportions (please label and refer to it as "Olympic Seedmix #2"). Please send a bid, including cost for delivery for a mix comprised of:

Annual ryegrass	44 % by weight
Oats	33 % by weight
Barley	17 % by weight
Alsike clover (inoculated)	6 % by weight

When we order the seedmix, we will also need to request the following from you:

1) Provide the complete lab report, including results of a crop and weed test.
2) Please divide the shipment up so that each individual sack weighs $\leq$ 50 pounds.

Thank you very much,

USDA Forest Service, Pacific Northwest Region, Olympic National Forest

Figure 8. Sample FAX for requesting bids for commercial seed.

You'll want to check the seed tag that comes with each sack of seed to make sure you're getting a quality product (Figure 9). Definitions and examples of the following terms are in the section on seed cleaning and testing, (see Step 3, earlier in this document):

- Germination rate. (industry norm is $\geq$ 80 percent);
- Noxious weeds. Ask them to use the Washington state noxious weed list; the lab report will list any species they find. It is illegal to sell seeds with > 2 percent noxious weeds;

or ask them to conduct a

- Crop and Weed Test (lab report will list both weeds and crop plants by species);
- Purity; industry norm is $\geq$ 90 percent.
- Percent pure live seed (PLS); industry norm is $\geq$ 72 percent.

Safety tip!

If you're the one who's going to be hauling around the bags, you might want to remind the supplier (on your fax, see Figure 9 above) to package up the product in sacks lighter than 100 pounds each

Regarding Potential Chemical Residues In Seed

In some circumstances, if a grower recently treated his or her fields with certain chemicals for weed control, there may be some risk to aquatic environments if the crop is immediately harvested and the stems are used for mulch, but this is not a concern for seed (Bautista, personal communication, 2007). See Cautions and Considerations in the section on mulch, later in this document, for more information.

Inland Northwest Dryland Mix — NET WT 25 lbs

Lot: 0309-903-17091

# IN MIX	SPECIES	%BY WEIGHT	PURITY	GERM	ORIGIN	TEST
2,400	Paiute Orchardgrass	27.78	92.60	85.00	OR	05/06
2,400	Manchar Smooth Brome	29.43	98.09	85.00	WA	05/06
2,400	Oahe Intermediate Wheatgrass	29.60	98.66	85.00	MT	06/06
800	Dahurian Wildrye	9.95	99.56	85.00	CN	07/06

Rainier Seeds, Inc.
1404 4th St.
Davenport, WA 99122

CROP:	0.07	INERT:	3.09	AMS730
WEED:	0.08	NOXIOUS:	None Found	

Figure 9—Sample commercial seed tag. Each company's tag will look a little different. Note that the purity and germination (GERM) rate are above the industry norm, and there are no noxious weeds so basically it looks fine.

Plants To Use For Wildlife Forage

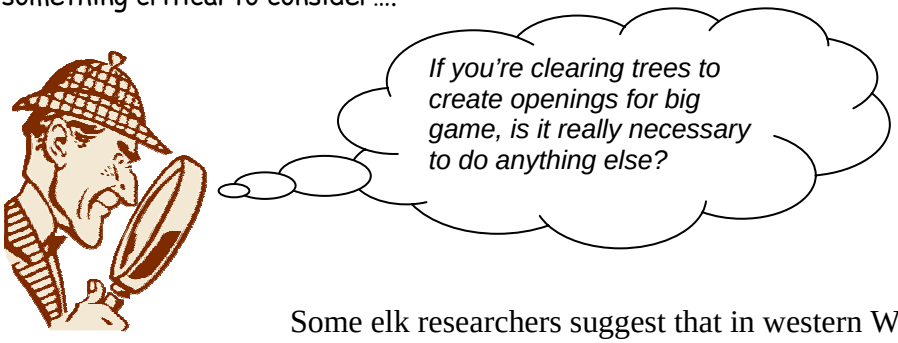
Traditional wildlife managers often use non-native grasses and non-native legumes to enhance wildlife forage. Many of these species (such as orchard grass and white clover) have proven to be persistent to the point of excluding native species. The purpose of this chapter is to provide suggestions for enhancing forage for wildlife with native plants.

Ideal native plants for this purpose have the following characteristics:

- Already occur naturally in the vicinity of your project area
- High caloric content/ nutritional value
- Desired by the animals (selected over other species)
- Easy to propagate
- Herbaceous species are fine for summer forage, but shrubs are best if winter forage is limiting, since the herbaceous species would be buried under snow.

Tip!

Before you invest money in surveys, collection, and propagation of native plants, here's something critical to consider….



Some elk researchers suggest that in western Washington if openings are created, natural regeneration of native herbs and shrubs will provide everything the animals need (Davis, personal communication, 2006). Silvicultural prescriptions only need to take measures to prevent doghair regeneration from occurring in the opening (such as removal of western hemlock seed source around the circumference of the opening). More important than the individual species composition, Cook and others (Puget Sound Energy 2003) found that the driving factor in weight gain of lactating cows and calves was canopy closure.

Findings From Research In the Pacific Northwest

Research Findings From Puget Sound Energy Report

Innovative research in the Nooksack River watershed on the Mt. Baker-Snoqualmie National Forest can be highly instructive for elk management on the Olympic National Forest (Puget Sound Energy 2003). In deciding which species to use for enhancement efforts, this research is recommended here over the standard text usually cited (Toweill and Thomas 2002) for three reasons:

- The herds studied occurred in western Washington, as opposed to the Rocky Mountains.
- Forage value was determined in controlled studies that considered elk preference for certain plant species relative to other plant species growing on the same site. Most other studies show what the elk ate, but not in comparison to what was available. This study ranked plant species preference into three categories: "selected," "neutral," and "avoided."
- Forage value was determined based on nutritional value in terms of digestibility. Most published research is based on studies that only analyze what plant species are present in the scat. The problem with this approach is that what's leftover in the scat are the food products that are least digestible. The Nooksack elk were temporarily trapped in enclosures so the researchers could accurately record what plant species were eaten (selected) and compare that to weight gain of lactating cows and calves.

Table 6 is a condensed subset of the results of the PSE study, listing the native species that were selected by the elk and occur on the ONF. You may also want to consider using species they listed as neutral, since for many species (such as *Epilobium*, or *Vaccinium*), the difference between selected and neutral had more to do with a marginally positive p-value (statistical issues) than a strong indication of preference. The complete report is available on line at http://www.pse.com/energyEnvironment/hydroPDFs/baker/studies/t21studyreport.pdf.

One of the take-home messages from this list and the discussion above should be to not confine elk forage enhancement efforts to one or two plant species in only one type of growing situation. In fact, in an analysis of food habits Jenkins and Starkey (1991) found that "Roosevelt elk consumed a wide variety of forage species across their range, demonstrating a high degree of dietary plasticity and generalist foraging strategies."

Findings From Happe et al. (1990) and Happe (1993) Studies

Happe et al. (1990) evaluated nutritional quality of *Rubus spectabilis*, *Vaccinium parvifolium*, *Acer circinatum*, and *Polystichum munitum* growing in clear-cuts and old-growth forest on the Olympic Peninsula. Levels of astringent tannins were higher in clear-cuts than in old-growth. The high tannin levels led to reductions in digestible proteins, thus affecting nutritional value. This was especially true for *R. spectabilis*, *A circinatum*, and *P. munitum*. However, *V. parvifolium* still contained adequate levels of crude protein.

In general, their findings suggest that browse grown under partial canopy will have higher quality than browse grown under more open canopy conditions, although the ability for the greater quantity of browse and presence of herbaceous forage in clear-cuts to compensate for these differences was not examined. The trade-off however, is that forage under canopy will generally provide less total digestible energy than types and abundance of forage grown in open areas (Happe, personal communication, 2007). This suggested the importance of managing for forested foraging areas in combination with created openings to providing nutritionally and energetically balanced feeding areas for elk. Forested foraging areas have the added benefit of intercepting snow and making forage available when forage in adjacent open areas is buried.

In her doctorate on the ecological relationships between cervid herbivory and understory vegetation in old-growth spruce/hemlock forests in Olympic National Park, ONP Head Wildlife Biologist Patti Happe found that diets of deer (Figure 10) and elk (Figure 11) varied depending on the season (Happe 1993). Therefore, when planning a big game forage enhancement project it's important to consider what part of the diet may be limiting, and whether that involves winter forage or summer forage.

Table 6—Selected native elk forage species that occur on the Olympic National Forest

Plants selected	
Scientific name	**Common name**
Acer circinatum	Vine maple
Acer macrophylum	Big leaf maple
Agrostis spp.	Bentgrass
Anaphalis margaritacea	Pearly everlasting
Carex spp.	Sedge
Clintonia uniflora	Queen's cup, Beadlily
Lonicera ciliosa	Orange honeysuckle
Maianthemum dilatatum	False lily-of-the-valley
Oplopanax horridus	Devil's club
Rhamnus purshiana	Cascara
Rubus parviflorus	Salmonberry
Salix spp.	Willow
Smilacena spp.	False Solomon's seal
Sorbus sitchensis	Mountain ash
Spiraea douglasii	Rose spirea, Hardhack spirea
Stellaria calycantha	Northern starwort
Symphoricarpos spp.	Snowberry
Trientalis latifolia	Starflower
Valeriana sitchensis	Sitka valerian

Source: Puget Sound Energy 2003

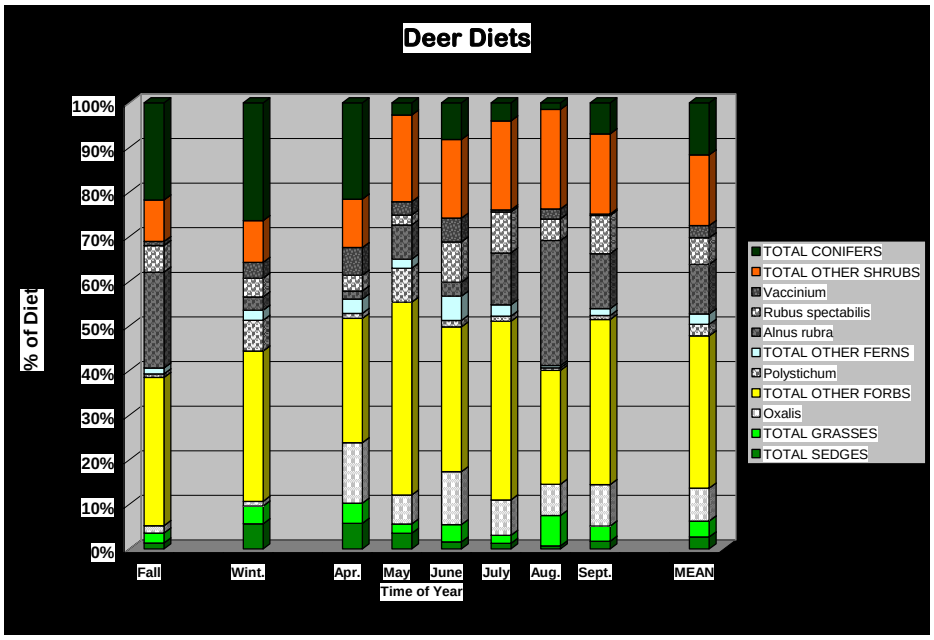


Figure 10—Diets of deer in Olympic National Park. Source: Happe 1993.

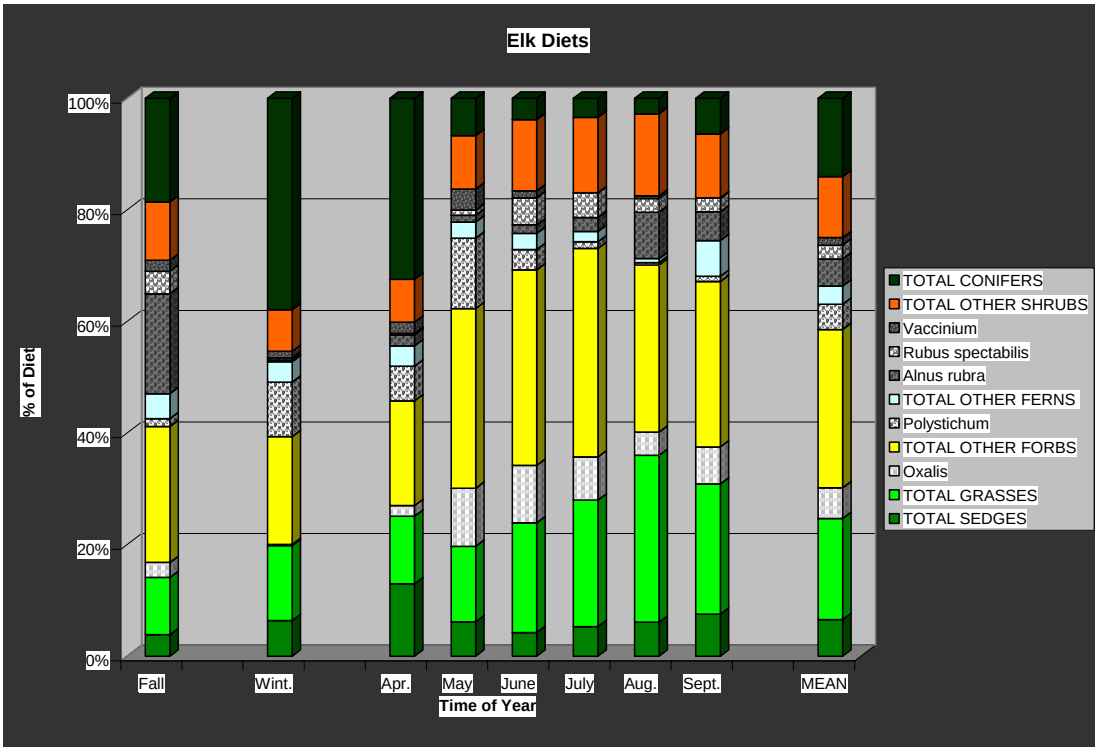


Figure 11—Diets of elk in Olympic National Park. Source: Happe 1993.

Results Of Dungeness Elk Forage Survey

In 2006, the ONF hired a contractor to conduct a survey in the Dungeness and Gray Wolf River drainages to scope out potential collection sites native species suitable for propagation as elk forage. Appendix 1 is a condensed version of the results, showing the species for 11 different sites and their availability at each site. Appendix 2 explains the contracts used for this work.

Recommendations By the Native Seed Network

In 2006, the ONF applied for and was awarded funding through Title II, Resource Advisory Committee, to work with the Native Seed Network, a branch of the Institute for Applied Ecology. The purpose of the project was to "determine which native species are best suited for revegetation activities on the Olympic Peninsula, meet stewardship objectives of enhancing forest ecosystems, restore and improve land health and water quality". As part of this project, a species list will be developed especially for elk habitat enhancement on the ONF. Appendix 9 summarizes the report, which will be included in the ONF native plant website: http://fsweb/onpmp/index.html.

As part of this project, a species list will be developed especially for elk habitat enhancement on the ONF.

Food For Thought

Here are some general considerations influencing the value, availability, and abundance of elk or deer forage.

Overstory

Canopy closure influences abundance and diversity of species or types of forage, energetic content, and even nutritional quality as mentioned above. For example, forage species adapted to under-canopy conditions may be better suited to re-vegetation efforts in commercial thins, or in sections of road decommissioning projects that pass through dense old-growth forest, whereas higher energy forbs and grasses may be more appropriate in more open settings. Canopy cover can also influence the availability of forage during snow-events.

Elevation

Forage species intended for use in a specific season won't be of much use if the animals aren't there or if the species isn't available or nutritionally useful during that time. For example, Taber and Raedeke (1980) found the upper elevational extent of elk winter range on the Olympic National Forest to be from 1,500 to 2,000 feet depending on the location on the forest, and to be influenced by snow fall patterns. Elevation also influences the phenology of the plants in terms of when new growth is available and the value of the portions consumed. Browse species intended for winter use won't be of much use if planted at high elevations.

Migratory and Non-migratory Elk

In some areas of the Olympic National Forest, elk migrate from winter to summer ranges whereas some elk remain in the same general area year round. Understanding the seasonal patterns of elk habitat use is important to maximize the success of elk forage enhancement efforts. Contact your local Washington Department of Fish and Wildlife biologist about information on specific elk herds.

Aspect

The aspect of the project site influences plant phenology, which in turn can influence availability and nutritional value. Consider elk forage availability in a range of aspects, especially at lower elevations.

Roads and Other Forms Of Human Disturbance

Elk may tolerate human disturbance to access high quality forage (as anyone who lives in Sequim can attest), but as a general rule elk forage enhancement efforts will be more successful if insulated from human disturbance. All other things being equal, forage enhancement efforts a quarter-mile or more behind a decommissioned or gated road will probably have more value than one along a well-traveled road. However, a trade-off to this approach is the logistics and effort needed to initially treat the area, and any subsequent efforts.

Juxtaposition

The pattern and placement of food in relation to other elements of functional elk habitat on the landscape (thermal and security cover, water, etc.) is an important consideration that pulls together all of the above information when planning elk forage enhancement efforts. For example, placing forested foraging areas adjacent to non-forest foraging areas offers a suite of food available under a variety of conditions. Proximity to water and high energy food supplies is particularly important if elk are known to calve in a particular area. Hutchins (2006) found that heterogeneous landscapes with patches of good nutritional forage resulted in increased reproductive success in elk in managed forests on the Olympic Peninsula.

Invasive Plant Treatments

The R6 EIS for Preventing and Managing Invasive Plants (USDA Forest Service 2005) emphasizes prevention in every aspect of our management activities. One of the best ways to prevent invasion (or re-invasion) of noxious weeds is to revegetate disturbed bare ground with more desirable species. But revegetation in areas that have recently been dominated by weeds, especially aggressive state-listed noxious weeds[5], poses some challenging issues.

The first consideration is whether or not to revegetate at all and if so, when and how. Table 7 provides an approach for appropriate follow-up after weed treatment for different scenarios.

Deciding what kind of mulch to use is important for follow-up treatments at weed sites. See the next chapter on mulch for information on the pros, cons, and other consideration of various mulches.

Table 7—Decision matrix for follow-up actions following weed treatments*

Scenario	Follow-up management action with respect to revegetation.
1. Weeds were treated on river gravel bar, stockpile, rock pit, or other area normally unvegetated.	No mulch, no revegetation.
2. Weeds were treated in parking lot, immediate road shoulder next to fog line, chain-up zone, or other area that is regularly plowed, sanded, or graded.	No mulch, no revegetation.
3. Weeds were treated in walkway, around picnic tables, or other area where vegetation is not desired but is not expected to be regularly plowed, sanded, or graded.	Consider heavy mulch of raw wood chips.
4. First year of weed treatment completed but the infestation will require 3–4 years of subsequent follow-up treatments because the weed species is aggressively rhizomatous, or the soil contains a large quantity of weed seeds; infestation is larger than 1/10th acre.	**Option 1**: If weeds are fairly dense, and you're using a non-selective herbicide such as glyphosate, then no seed or mulch until the infestation is significantly reduced (e.g. probably no reveg the first 3 years of treatment). When infestation is reduced to small patches (hopefully by year 4), seed with non-invasive non-natives (Table 4) covered with 2-inch mulch in between the patches. **Option 2:** If the target weed is not a grass, and you're treating with broadleaf selective herbicide (or hand pulling), then apply non-invasive non-native grass seedmix and cover with 2 inches of mulch the same season.

[5] To see the definition of a "noxious weed", and the most recent Washington State Noxious Weed List, visit http://www.nwcb.wa.gov/.

Scenario	Follow-up management action with respect to revegetation.
5. Weed infestation is small (under 1/10th acre), no re-treatments expected, and the site is surrounded by native species that will provide a seed source.	No additional revegetation needed. May apply light cover of mulch if needed for soil erosion considerations. Allow natural revegetation to occur.
6. Weed infestation is small, no re-treatments expected, but *not* surrounded by native species.	Seed with non-invasive non-natives covered with 2-inch mulch *or* revegetate with local native species.
7. Weed infestation is larger than 1/10th acre, no retreatments expected.	Seed with non-invasive non-natives covered with 2-inch mulch.

* All other weed prevention measures (such as use of clean equipment) will continue to be implemented regardless of scenario.

Figure 12. Scot's broom hand-pulling weed treatment on the 2870-059 road on the Hood Canal Ranger District in 2005. (This is the access road to the Cranberry Bog Botanical Area.) Upper photo is before treatment, lower photo is after treatment. This site would likely fall under scenario 4, option 2—first year of hand-pulling, with follow-up treatments required because of accumulated weed seeds in the soil. Disturbed soil could be sown with the appropriate non-native seed mix and covered with mulch.

Photos by Carol Dargatz, Clallam County Noxious Weed Control Board

Mulch: What and How Much

Benefits

The virtues of mulch in restoration work are succinctly summarized by Hanbey (1992): “Properly applied mulches can inhibit erosion, retain moisture, protect plants and seeds, ameliorate surface temperatures, reduce frost action, and provide some organic matter for soil build-up.”

Cautions and Considerations

Be an informed decision maker! Here’s some lessons learned the hard way…

- When mulching around planted stock, Hanbey (1992) advises spreading the mulch 2–4 inches deep around the base and in between the plantings, but do *not* push it up around the crown or stem base of the plants—air circulation is needed in this area to prevent fungus damage.
- Research has demonstrated that woody mulch high in raw cellulose can leach nitrogen from the soil (Banke 1980). This phenomenon has pros and cons—see Wood Chips below.
- Avoid the use of hay since it may contain undesirable species. Use approved weed-free straw instead—see Weed Free Straw below.
- Depth of Mulch—see discussion under Weed Free Straw below.

Potential Chemical Residues In Mulch

Concern has been raised that certain chemicals, specifically picloram and clopyralid, may harm fish if the grower used these to control weeds. Shawna Bautista (personal communication, 2007), who wrote the toxicology portion of the Region 6 Invasive Plant EIS (USDA Forest Service 2005), does not claim to be an expert but at least offers us an educated opinion. For clopyralid, the risk to fish is very low and would not be a concern. If however, you were trying to grow native composites (such as pearly everlasting), clopyralid contaminated mulch would be a bad idea. Also, if picloram had been applied to the mulch the same year the material was harvested, it would not be recommended for use on stream crossings. All this said, the risk of contamination should be very low because product labels warn growers not to use these products if their crop is intended to be immediately used for mulch.

Four Common Types Of Mulch; Suppliers; Cost Estimates

Wood Chips

Wood chips have the advantage of being very cheap. A logging mill near the Mt. Baker-Snoqualmie National Forest donated large quantities of wood chips for a high profile restoration project. Chippers have also been brought on site to create wood chips from slash during road decommissioning projects.

As mentioned above, fresh wood chips can result in nitrogen deficiency. This can play in your *favor* if you have treated noxious weeds in an area that you prefer to remain

unvegetated (e.g. walkways at district offices, high-use picnic table areas), because noxious weeds generally prefer more nitrogen than our native plants.

The following information is from Dr. Richard Miller (personal communication). To use wood chips as a mulch for desirable species, add nitrogen (N) to meet the requirements of decomposing bacteria so the plants are not adversely affected. Wood chips have a carbon/nitrogen ratio of about 100:1 and you want about 50:1. So in general, for a wood chip mulch 1–2 inches thick, apply 50–100 lbs of nitrogen per acre.

Fresh wood chips can result in nitrogen deficiency. In general, for a wood chip mulch 1–2 inches thick, apply 50–100 pounds of nitrogen per acre. Urea is the cheapest N available.

Time-release pellet fertilizers are expensive; use urea because it's the cheapest N available. If your N is in the form of urea, apply 100–200 lbs of urea per acre, *but only when it is wet and rainy*. If urea is applied in warm weather you could lose over 50% of the N to volatilization (lost to the atmosphere as nitrogen gasses). Also, if the weather is too dry, you could get concentrations of ammonium and ammonia in the soil that would be toxic to the plants.

For supplies of wood chips, try:

- Willis Enterprises, Hoquiam 360-249-5244. Prices vary depending on species of tree used to make the chips and the quality. "Hogfuel", which is mostly bark, runs about $100/truckload. Actual wood chips run about $2,500/truckload (32 tons).
- North Mason Fiber, Bob Dressel 360-275-0228

For urea, try any of the suppliers of non-native seed listed previously, such as:

- Wilco (formerly Cenex), Centralia, WA. Phone 360-748-9277. FAX 360-748-7204, attention Troy or George. 200 lbs of urea costs about $46.

WoodStraw™ Wood-strand Erosion Control Material

This is a relatively new product produced by ELWd Systems, a division of Forest Concepts LLC. Its sounds like a miracle cure according to the manufacturer: a high sediment storage blend of sliced wood strands for steep slopes and highly erosive soils, weed-free, lasts much longer than straw, and stays put much better than straw in high winds.

Cost. A truckload (20 tons) normally costs $8,500 + shipping and delivery. It comes in 50 pound bales @ 11.95 each (price maybe negotiated down for large quantities). They recommend about 3–4 tons per acre. About 70 percent cover of WoodStraw™ = 2 inches deep of regular straw.

Contact. ELWd Systems, 1911 SW Campus Dr. #655, Federal Way, WA 98023; (253) 838-4579 Fax (253) 815-9000. www.elwdsystems.com.

Weed Free Straw

Depth Of Straw. The "ideal straw depth" is 2–4 inches depending on whom you talk to. For example, engineers on the Mt. Baker-Snoqualmie National Forest found that seed (sown along the same stretch of road) germinated when covered with very light mulch of straw, but did not germinate under 3–4 inches of mulch (Martinez and Hamilton, personal

communication, 2006). To determine the optimum straw depth for road decommissioning, the ONF will be conducting a study in 2007 using varying application rates of straw with the non-native seed mix. The results of this study will be posted on the ONF website in 2008.

Quantity To Order To Achieve Desired Depth.

- Mt. Rainier NP Restoration Handbook (Rochefort 1990), cites an application rate of 4,000 pounds (2 tons) per acre for a 4-inch thick mat of straw, so 2 inches thick = 2,000 lbs per acre.
- The Washington State Department of Ecology recommends 2 to 3 inches of mulch, equating to 2 to 3 tons per acre (Washington State Department of Ecology Water Quality Program 2001, p. 4-21)

Standards, Guidelines, Contract Specifications. Standard #3 in the R6 EIS for Preventing and Managing Invasive Plants (USDA Forest Service 2005) specifies that:

> "If State certified straw and/or mulch is not available, individual Forests should require sources certified to be weed free using the North American Weed Free Forage Program standards … or a similar certification process."

Washington State does not have a certification process in place at this time[6]. Since 1999, in lieu of "State Certified" weed-free straw, the MBS National Forest has included the following specifications in contracts, per the concurrence of Bill Whitson, which could be modified for the ONF as follows:

> "Erosion control material (such as commercial erosion control mat or straw) for this project shall be weed free. Straw shall be obtained from a grower whose fields have been annually inspected by the county coordinator for the Washington State Noxious Weed Control Board. The Olympic National Forest Supervisor's Office has inspection letters on file—contact the contracting officer if you want access to the letters.
>
> If a contractor wants to buy straw from a source that is not already approved, the local county weed coordinators may be able to inspect that grower's fields. The current list of coordinators can be found on their website at *www.wa.gov./agr/weedboard*. A signed letter from the county weed coordinator (or other qualified botanist) must be provided to the USFS to serve as documentation that the grower's fields were inspected. Enough lead-time must be allowed since inspections have to occur before the straw is baled."

Remember—you need to make sure the inspection letters are recent! Straw sitting around uncovered for 2 or 3 years could be contaminated with noxious weeds.

Growers Of Weed Free Straw. You can buy directly from the grower; some growers of weed free straw that have been approved in the past include:

- Richard Jones, Douglas County (509) 745-8351

[6] Washington State Department of Agriculture is hoping to have a certification process in place by summer 2007 (Nancy Phelps, personal communication, 2007). When available, details will be added to this notebook and posted on the ONF native plant website http://fsweb/onpmp/index.html.

- Kurt Isaak, Douglas County (509) 632-5712
- Steve Koelzer Farms, Franklin County (509) 543-3772
- Jerry Heilig, Grant County (509) 765-5023
- Elwin Crutcher, Stanwood, WA (Snohomish County) 360-939-2334

Distributors Of Weed Free Straw. You can buy from a distributor:

- S-K Environmental, Okanogan WA. Sheilah Kennedy 509-322-6909, shekennedy@hotmail.com
- King Feed, Enumclaw WA 360-825-6554. Straw buyer is Mike Hamlin (253-261-1001). He buys from farmers in eastern Washington whose fields have been inspected by Dean Alverson (Coordinator for Intercounty Weed District #52). Mr. Alverson provides a letter for the farmers.

  Price per bale: $4.75 per bale (Average weight per bale: 60–70 lbs)

  $4.25 for 10+ bales

  $4.15 for 350 bales

Erosion Control Blankets Or Erosion Control Matting

In general, the advantage of using a blanket or mat is that it is more long lasting than straw, readily available, easy to transport, and guaranteed weed free. The disadvantage is that it is more expensive, and requires labor intensive pinning to hold it in place. There are literally dozens of types and manufacturers so for the sake of simplicity, a “favorite” is described here.

Subalpine restoration workers on the Leavenworth Ranger District (Therrell, personal communication, 2007) and Olympic National Park (Albright, personal communication, 2007) have both favored “Curlex® blankets” by American Excelsior Company for many years. For more information visit http://www.curlex.com/pro_blankets.php. Albright now has concerns because of changes in the plastic net backing that make it much more difficult to remove, and they are trying WoodStraw™ in 2007. NPS removes the backing because they have found that it traps and kills wildlife.

To Fertilize or Not to Fertilize

Native plants in the Pacific Northwest have adapted to low nutrient levels in the soil, so in general, fertilizer is not recommended for native seeds or plants. In addition, noxious weeds thrive on high nitrogen levels and will get the competitive advantage if you use fertilizer and there are sources of weeds in the vicinity. However, if you are trying to restore an area that has been stripped down to the C horizon and contains only sterile sub-soils, you will want to provide some sort of organic matter, after making sure (through ripping or other means) that the substrate has been de-compacted.

Biosolids have been used successfully in restoration projects to increase native plant biomass and total vegetative cover on the MBS National Forest (Bergeron 2003). However, there is controversy regarding the potential risk of contamination from heavy metals (Mortvedt 1995, Paré et al.1999, Sloan et al. 1997)

Compost can be purchased commercially and used to both improve texture and nutrient levels of sterile soils. For more information contact Cedar Grove Compost at 1-877-SOILS-4U (1-877-764-5748), write to them at infocg@cedar-grove.com , or visit their website at http://www.cedar-grove.com.

Lastly, as discussed in detail in the chapter on Mulch above, if you are using wood chips as a mulch for desirable species, add nitrogen in the form of urea because it's the cheapest N available.

Monitoring

Finally, in order to assess the effectiveness of any revegetation or restoration effort, it is important to incorporate several years of post-treatment monitoring into the project plan. Monitoring is defined as "the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective" (Elzinga et al. 1998, p.1). Monitoring should be conducted one year after the revegetation treatment, again the second or third year after treatment, and at five and ten years after treatment (DiGregoria et al. 1995). Aubry and Potash (1998) developed a revegetation effectiveness monitoring protocol for decommissioned roads that is included with this Notebook as Appendix 10. This is a straightforward monitoring technique that requires some botanical expertise for plant identification. The document includes all the forms, codes, and instructions needed to conduct the monitoring, and to visually document changes on the site using permanent photo points.

Monitoring provides an excellent opportunity for volunteers to become involved with revegetation and restoration projects. Groups such as the Washington Native Plant Society have the knowledge and skills to conduct the monitoring, and are generally enthusiastic about these monitoring opportunities.

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