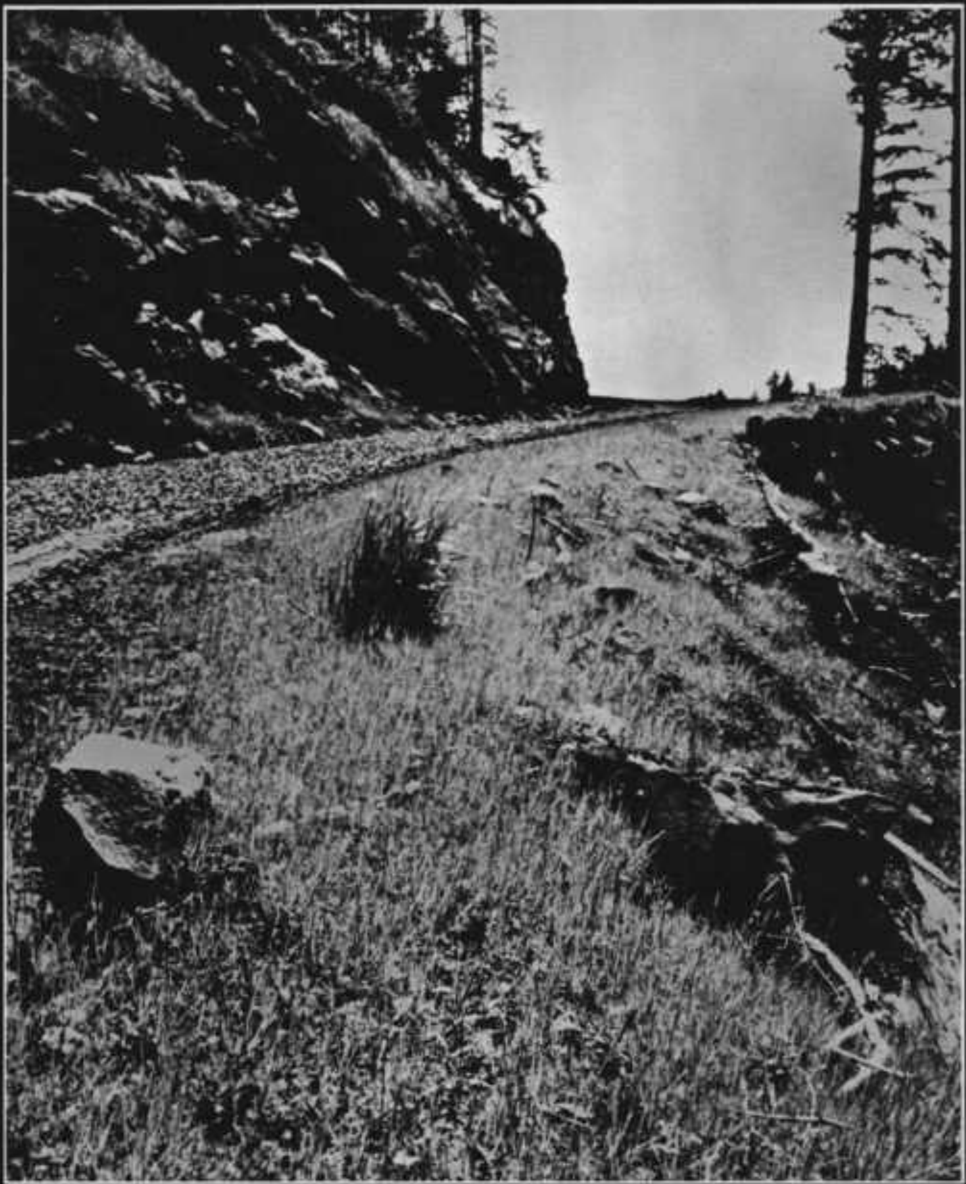
Seeding to Control Erosion Along Forest Roads



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Summary

Surface erosion from forest roads is a major management-related cause of forest stream turbidity and sedimentation in Oregon. Arresting energy expended by raindrops and flowing water and securing soil displaced by dry ravel erosion will curb surface erosion.

Grass and legume cover can solve surface erosion problems. Foliage protects the soil surface and reduces the impact of surface water movement. Dense root systems stabilize surface particles. Success can be had with a vegetative cover of 40 percent or more.

An erosion control program by revegetation requires that climate and soil characteristics and the physical features of plant materials must be considered in selecting species. Adaptability and specific characteristics of common species for erosion control are presented.

Seeding rates are computed on the basis of desired seed distribution after application.

Cutbanks and fillslopes roughened during construction are ideal seeding sites. Additional surface stabilization efforts may be necessary on critical fillslopes.

Fertilization is often essential for establishing adequate ground cover. Forty pounds of nitrogen per acre is usually adequate, though critical areas may benefit from 70 to 80 pounds per acre. Sulfur is a vital element—especially in eastern Oregon. Refertilization at three- to five-year intervals may be necessary if native vegetation does not occupy the sites.

Mulch is most important for curbing first-year soil losses. Excelsior, straw, and fiber materials are used commonly. Straw—an excellent, low-cost mulch—should be applied at two tons per acre. Wood fiber applications of 0.6 tons per acre are desirable.

Seeding, fertilizing, and mulching should be done in the fall or early spring. Favorable moisture and soil temperatures are needed for plant establishment. The seeding program culminates the road construction process.

Application techniques are varied. Equipment utilizes drill or broadcast methods.

Contents

The sections on legume inoculation and supplements A, B, and C were principally adapted from *The Oregon Interagency Guide for Conservation and Forage Plantings* [E. William Anderson (Chairman), USDA Soil Conservation Service, Portland]. The cooperative interagency effort involved the following: *State of Oregon*—Oregon State University, Oregon Wildlife Commission; *U.S. Department of Agriculture*—Forest Service (Pacific Northwest and Range Experiment Station and Pacific Northwest Region), Soil Conservative Service; *U.S. Department of Interior*—Bonneville Power Administration, Bureau of Land Management.

Seeding to Control Erosion Along Forest Roads

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The Columbia River discharges an average of 42,740 tons of sediment daily into the Pacific Ocean—enough to form a pile 3 feet x 3 feet x 17 miles. This sediment originates from soil erosion. Urban, agricultural, forested, and streambank areas continually lose soil to streams.

Some erosion is natural and some is due to man's activities. *Geological erosion* is a natural weathering process of the earth's surface. Geological erosion on forest lands would occur whether or not man existed. The process resupplies gravel to streambeds and alluvium to floodplain agriculture fields. *Accelerated erosion*—soil losses resulting from man's activities—is erosion from forest land in excess of geological erosion. This soil loss can impair forest productivity, stream productivity, and downstream water utilization.

Some accelerated erosion from forest land use is inevitable—but, considerable loss of soil can be curbed by controlling erosion along forest roadsides. One control technique is to seed grasses and legumes to revegetate bare soil surfaces resulting from road construction.

A revegetation erosion control program should address the following seven concerns:

1) Basic erosion control principles,
2) Seed selection and mixture formulation,
3) Site preparation,
4) Fertilization,
5) Mulching,
6) Time for application, and
7) Application techniques.

EROSION IN FORESTS

Forested areas contribute to geological and accelerated erosion. The latter is primarily associated with existing road and road construction activities. In general, timber harvesting is not directly the cause of erosion problems.

Basic processes

Two basic soil loss problems are commonly associated with forest roads in Oregon. First is mass soil movement—landslides or slumps. This is common in steep, unstable terrain. Tons of soil, trees, and debris can be deposited almost instantaneously from mountainsides to streams. Reducing or preventing this problem requires detailed geological and soils engineering.

The second type of soil loss is caused by surface erosion. It occurs from disturbed areas such as road surfaces, ditches, and cut and fill slopes. The principal agent for surface erosion is water.

Surface erosion from forest roads is a major cause of forest stream turbidity and sedimentation in Oregon. Often this erosion can be controlled.

Surface erosion processes

Waterborne and dry ravel surface erosion processes are two major problems in Pacific Northwest forests. Erosion control requires consideration and regulation of the primary causative agent—water. Water can cause problems from the time it strikes the soil surface until it stops flowing.

Raindrops expend tremendous amounts of energy upon striking a surface. (Rain falling at 0.1 inches per hour generates 100 horsepower per acre. This energy can keep a bare soil surface in constant motion during a storm.) Dislodged fine soil particles may be transported by flowing water. Furthermore, flowing water will exert buoyant and frictional forces that loosen and transport additional soil particles. The net result can be either a network of rills and gullies in the soil surface and/or the formation of the soil pedestals. Pedestals result when an object on the surface protects the soil immediately beneath it from raindrop impacts (Figure 1).

Figure 1. Surface debris protects soil from direct rainfall and soil pedestals form.

Dry ravel is the resulting, unprotected soil that rolls freely down steep roadsides. It is most common during the warm dry summers on road cutbanks and fillslopes (Figure 2). These soil losses can be as great as those of the waterborne erosion losses. Water between soil particles acts as glue. When the water evaporates the "glue" is no longer effective. Gravity causes free particles to move singly or domino-like downslope. Depositions in or near roadside ditches often are transported by water during the next storm period (Figure 3).

Establishing grass and/or legumes and applying mulches will, in most cases, check the surface erosional forces.

Vegetative control of the erosion process

Effective surface erosion control arrests the primary processes of both waterborne and dry ravel erosion. Effective control results if raindrops do not directly strike bare soil, if surface water movement is reduced, and if soil particles are fixed in position.

Plant and litter cover is the most important deterrent to surface erosion. Vegetation and mulch can control active erosion processes along roads on many sites.

Established vegetation along roads has the following important functions:

1) Vegetation protects the soil surface from direct impact of raindrops. Raindrop energy will be dissipated on the vegetation instead of the soil particles.

2) Grasses and legumes can alter the surface movement of water. Erect stems will reduce the velocity of surface runoff, provide more time for infiltration, and consequently lessen the volume of surface water. Stems may form a matting effect in a downslope direction. The matting—acting like a thatched roof—could increase the volume of surface runoff while protecting the soil surface.

3) Grass rapidly develops a fine, extensive root system that stabilizes soil particles. For example, a four-month-old cereal rye plant grown in one cubic foot of soil has been reported to have 387 miles of roots with a surface area of 2,554 square feet *plus* 6,604 miles of root hairs with a surface area of 4,321 square feet. (The author did not personally check these measurements.) Such root systems will resist forces that tend to move soil particles.

4) Established vegetation will trap and often prevent dry ravel from moving down the entire slope.

5) Organic matter produced by the vegetation not only covers the surface but becomes incorporated into the soil. This is important for soil formation and increased soil infiltration rates.

Required coverage

Seeding for erosion control along forest roads is intended for soil protection rather than forage

Figure 2. The dry ravel process undermines existing vegetation and results in soil deposition in ditches.

Figure 3. Dry ravel deposited in ditches is further eroded by water.

production. A plant and litter ground cover of 40 to 50 percent on a horizontal projection can significantly reduce erosion whereas a cover of 70 to 80 percent will effectively control erosion. A dense sod cover is not necessary.

Critical, first-year mulch applications provide the necessary ground cover to curb erosion and aid plant establishment. Plant coverage should be satisfactory by the time the mulch decomposes.

SEED SELECTION CRITERIA

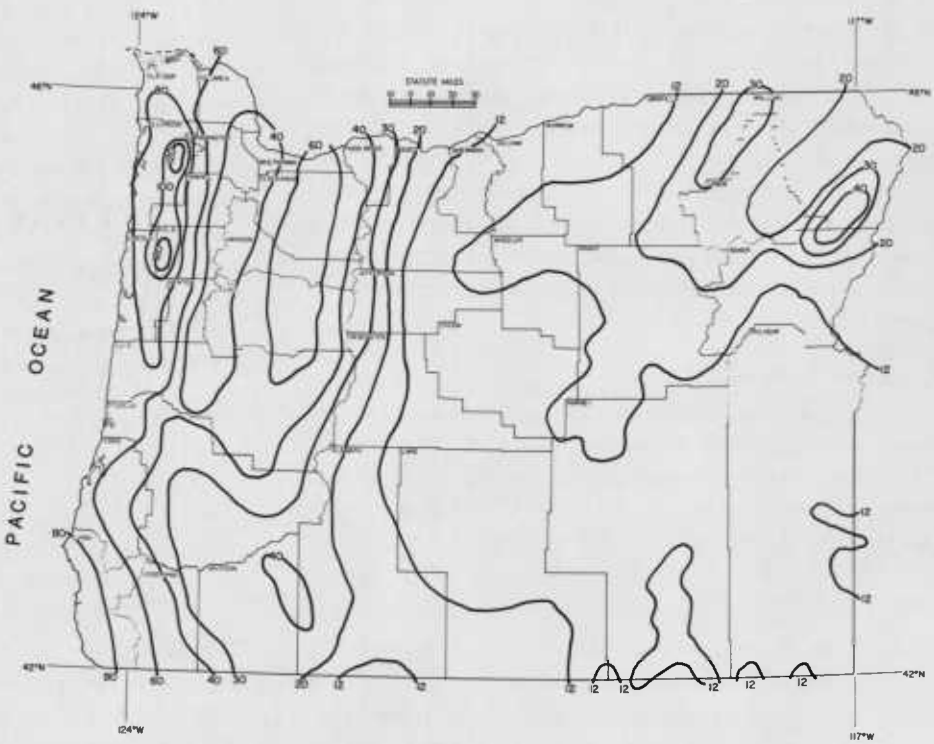
Selection of appropriate grasses and legumes is important for stand establishment. Grasses vary as to climatic adaptability, soil chemistry, and plant growth characteristics.

Climatic adaptability is crucial. The most important climatic element is moisture availability for plant growth. Precipitation in Oregon is variable (Figure 4). Soils differ in their ability to retain water but, in general, more moisture is available at the higher forested elevations that at lower elevations. North aspects generally have more favorable soil moisture conditions than south aspects and eastern aspects more so than western aspects. Consequently, species selection depends upon specific sites and one broadscale seed mixture is not feasible. The "environmental adaptability" of various plant materials is presented in Supplement A.

Climates of high elevations require additional attention. Short growing seasons, frost heaving, high solar radiation levels, and low air and soil temperatures may inhibit the development of some plants.

Soil variation throughout Oregon is complex. Soils in coniferous forests are generally acidic, with zones of higher precipitation generally being more acidic. The pH values range from approximately 4.0 to 6.5. Many grasses are most productive when

Figure 4. Mean annual precipitation in Oregon (inches).



soil pH range is 6.0 to 7.0. Red fescue, however, is more productive as soil acidity increases.

Physical and growth characteristics differ for various plants. For example, root system development differs between grasses and legumes. Bentgrasses and bromes develop dense, fibrous, but shallow root systems that effectively stabilize surface soils. Trefoils develop deep tap-roots that will sustain the plant throughout summer drought periods. Stem orientation differences may determine the suitability of a plant for erosion control. For example, chewings and creeping red fescue are virtually identical, but chewings fescue has tufted, vertical stem development whereas creeping red fescue has lateral stem development. Thus greater soil coverage may be achieved by using creeping red fescue.

Rapid establishment of vegetative cover is desirable. Rapidly developing plants will offer slope protection sooner than slower developing plants. One of the fastest developing plants is annual ryegrass.

Notes on various grasses and legumes are listed in Supplement B.

Species selection

A mixture of grass and legume species is normally used along forest roads. No clear, concise rule exists for selecting specific plants. It would be unwieldly and wasteful to include all species in one mixture.

Species selection guidelines have been developed for forested areas throughout Oregon (Supplement C). However, these guidelines should not curtail interest in establishing tests of different species and mixtures.

Up to five plant species usually are included in a seed mixture. Inclusion of legumes often is desirable for nitrogen fixation in the soil. Adjacent grass species benefit from the nitrogen. Legumes are attractive to wildlife.

Legume inoculation

Legume inoculation is important so as to introduce nitrogen fixing bacteria to the plant roots. The inoculant, a dry powder-like material, is mixed with a liquid so that it sticks to the legume seed. Thus, new seedlings are immediately exposed to appropriate, beneficial bacteria. A general guideline is as follows:

1. Use inoculants labelled for the specific legume. This is important!
2. Purchase fresh, dated inoculant from seed dealers using cool, dark storage facilities. The storage temperature should be just above freezing.
3. Mix the inoculant with a liquid. Milk—whole, condensed, or skim—serves as an effective adhesive to stick inoculant to the seed. About one pint of milk per 100 pounds of seed is needed. Use plenty of inoculant as it is inexpensive.
4. Add the inoculant/milk mixture to the seed. Dampen all seed but avoid too much liquid because seed will stick together and cause application problems. Note: If you add too much liquid, try adding fine, dry soil to absorb the excess liquid.
5. Avoid letting inoculated seed come in direct contact with fertilizer because the bacteria may be killed.
6. Apply the seed immediately. Seeding on moist soil or before light rain is best. Avoid exposing the seed to severe hot, dry conditions, as the inoculant may become ineffective. Reinoculate the seed if it is not planted within 24 hours.

Seeding rates

Careful attention to seeding rates will provide soil protection without wasteful overseeding and may save you money. Selecting the seeding rate involves figuring the amount of live seed needed. Live, germinable seed is termed Live Pure Seed (LPS). LPS is a product of seed lot purity and germination percentage. In general, LPS ranges from 68 to 88 percent of the purchased seed. Seed suppliers should be able to specify the LPS percentage.

Seeding rates depend upon the number of live, germinant seeds per unit weight and not simply seed weight (Table 1). An example comparing subterranean clover and timothy seed illustrates this difference.

> One pound of subterranean clover seed contains about 75,000 seeds whereas, one pound of timothy has 1,300,000 seeds—a 17.3 fold difference. Consequently, for a given area to receive an equal number of subterranean clover and timothy seeds, the weight of subterranean clover in the seed mixture must be 17.3 times greater than that of timothy; or, the seed density of one pound of subterranean clover on one acre would equal that of 0.9 ounces of timothy on the same acre. A given weight of applied seed has no bearing on the number of applied seeds.

Normally 100 to 150 LPS per square foot are sufficient seed densities for roadsides. A general rule-of-thumb is 144 LPS per square foot, or 1 LPS per square inch. It may be desirable to in-

Table 1. Seed Quantity Data for Grasses and Legumes Commonly Seeded in Oregon's Forested Regions. Species are arranged from drier site adaptability (cereal rye) to moist site adaptability (big trefoil). Species in bold face are legumes.

Species	Variety	(1) Thousands of seeds/lb.	(2) Seeds/sq. ft. at 1 lb./acre	(3) Seeding rate to yield 144 LPS/sq. ft.
				pounds/acre
Cereal rye	———	18	0.4	356.0
Crested wheatgrass	Nordan	175	4.0	44.6
Big bluegrass	Sherman	917	21	10.9
Streambank wheatgrass	Sodar	170	3.9	51.3
Bulbous bluegrass	———	450	10	17.8
Pubescent wheatgrass	Topar, Luna	91	2.0	94.1
Hard fescue	Durar	565	13.0	13.7
Tall wheatgrass	Alkar, Largo	79	1.8	99.1
Annual ryegrass	———	217	5.0	33.7
Alfalfa	———	225	5.2	32.9
Smooth bromegrass	Manchar	125	2.9	63.5
Intermediate wheatgrass	Greenar	100	2.4	74.3
Yellow sweetclover	———	259	5.9	30.8
Perennial ryegrass	———	247	5.7	28.6
Rose clover	———	164	3.8	45.0
Kentucky bluegrass	———	2,156	50	4.3
Birdsfoot trefoil	Cascade	470	11	15.7
Creeping red fescue	———	615	14	13.1
Chewings fescue	———	615	14	13.1
Tall fescue	Alta	230	5.3	32.6
Orchardgrass	Latar, Pomar	540	12	16.7
Timothy	Drummond, Climax	1,300	30	6.2
Hardinggrass	———	347	8.0	25.0
White clover	New Zealand	800	18	9.5
Subterranean clover	Mt. Barker	75	1.7	95
Alsike clover	———	682	16	10.4
Field bromegrass	———	330	6.9	30.7
Canada bluegrass	———	2,500	57	3.7
Redtop bentgrass	———	5,000	120	1.6
Meadow foxtail	———	900	21	10.7
Colonial bentgrass	Astoria, Highland	8,500	195	0.9
Mountain bromegrass	Bromar	90	1.6	117.6
Reed canarygrass	———	506	12	15.6
Big trefoil	Beaver	1,000	23	7.5

crease a seeding rate in critical areas—culvert and bridge installations and road fillslopes—and decrease it in less critical or arid areas. Seeding rates in drier climates may be as low as 15 to 40 LPS per square foot. General seeding rates per species are specified in Supplement C.

Developing a seed mixture consists of four steps. The following example illustrates the development of a 144 LPS per square foot seeding rate.

1. Select desirable species. Table 2 lists three species commonly used for roadside soil stabilization in western Oregon (see the 41- to 60-inch effective precipitation zone in Supplement C).
2. Decide upon the desired proportion of each species to provide adequate stands and soil coverage. The proportions are somewhat arbitrary—but, because annual ryegrass is competitive with other grasses, its proportion should be lessened. A 2:2:1 mixture would be suitable in this example (Table 2, column 1).
3. Select from Table 1, column 3, the respec-

tive pure seeding rates of pounds per acre to yield 144 LPS per square foot. Record in Table 2, column 2.

4. Compute the final seeding rate in Table 2 by multiplying the respective values in column 1 by those in column 2. Summation of column 3 is the mixture's application rate per acre (15.7 pounds per acre).

Existing seed mixtures may be evaluated by a similar procedure. A hypothetical mixture is presented in Table 3. In total, 20 pounds of seed per acre are being applied (column 1). Select respective values for column 2 from Table 1, column 2. Multiplication of columns one and two in Table 3 reveals a total current seeding density of 266 seeds per square foot. Critical areas may require such application rates, whereas other sites may require half of that or less. Two pounds of timothy and three pounds of perennial ryegrass would be desirable for this example.

Table 2. An Example of Seed Mixture Development for Roadside Stabilization in Western Oregon—40- to 60-inch effective precipitation zone.

Selected species	(1) Desired proportions (% ÷ 100)	(2) Lbs./acre to yield 144 LPS/ sq. ft.	(3) Computed final seeding rate (lbs./acre) (1) x (2)
New Zealand white clover	0.40	9.5	3.8
Creeping red fescue	0.40	13.1	5.2
Annual ryegrass	0.20	33.7	6.7
TOTAL	1.00	-----	15.7

Table 3. Evaluation of an Existing Seed Mixture

Species	(1) Current application rate	(2) Seeds/sq. ft. at 1 lb./acre	(3) Current seeding density (Seeds/ sq. ft.) (1) x (2)
	(lbs./acre)		
Orchardgrass	5	12	60
Perennial ryegrass	5	5.7	29
Timothy	5	30	150
Tall fescue	5	5.3	27
TOTALS	20		266

SITE PREPARATION

Cutbanks and fillslopes along forest roads often are difficult to revegetate. Seeding, fertilizing, and mulching should be planned and specified as the road construction is planned. More favorable seedbed conditions result from nonvertical, roughened soil surfaces.

Slopes of 1:1 (45°) or less provide a good seeding surfaces. Such slopes permit surface applications with simple seed sowing devices. Steep banks often require techniques that "plaster" seed, fertilizer, and mulch to the soil surface or else the materials may fall to the ditchline.

Construction efforts should leave the surface roughened. Rough soil surfaces provide niches for seed to lodge and germinate and will reduce the movement of seed and fertilizer to ditchlines. Smoothing cutbanks with a grader blade may produce a geometrically pleasing surface, but it also produces a poor seedbed.

Site preparation efforts on shallow soils may permanently damage the seeding site. The small volume of soil interlacing rocks may fall in the ditchline and be lost.

Loose soil sidecast on fillslopes is extremely vulnerable to erosion. Such soils may benefit from light compactive efforts. One pass with a sheepsfoot roller will lightly compact the soil and maintain a roughened surface.

FERTILIZATION

Fertilization often is necessary for successful grass establishment. Forest road construction commonly results in fertile topsoil being removed or buried. The residual subsoil is infertile. Fertilizers are needed to provide young plants with sufficient nutrients.

Proper fertilizer selection and adequate application rates are important. The major elements most frequently deficient in forest soils are nitrogen (N) and phosphorous (P). A common assumption is that potassium (K) is not deficient in most forest areas. Consequently, ammonium phosphate, 16-20-0 (the percentage ratio of N-P-K), often is used. A balanced fertilizer such as 10-16-8 should be used in known K-deficient areas. In addition to nitrogen, phosphorous, and potassium, studies show sulfur (S) to be deficient in some Oregon forests. Plant responses to N, P, and K may be greatly lessened if S (as sulfate) is not present in adequate amounts—particularly in eastern Oregon. It may pay to add the sulfur with the fertilizer mix. Sulfur is especially important when legumes are seeded.

Key areas of questionable fertility should be tested. A soil test program is conducted by Oregon State University through its local county Extension agents. Call your Extension office for instructions and assistance in getting your soil tested.

The following rule-of-thumb has been developed from various seeding trials, using the amount of nitrogen as the key. If total nitrogen is greater than 0.2 percent, no fertilizer is needed. If total nitrogen is less than 0.1 percent, fertilizer is needed. Between 0.1 and 0.2 percent, addition of fertilizer will depend on the nature and importance of the erosion hazard.

Recommended fertilization rates will vary according to the level of nutrients needed for establishing the new seedings. On most forest soils sufficient fertilizer to provide an added 40 pounds of actual N per acre will help establish a new grass planting. An example would be 250 pounds of 16-20-0 fertilizer per acre. Critical areas may benefit from application rates of 70 to 80 pounds N per acre. The common 16-20-0 fertilizer also has about 15 percent S present. This provides an ample application of S.

Fertilizer application usually is done along with seeding in the fall—before the fall precipitation—or in early spring. Split applications—one in the fall and one the following spring—are effective. Seedlings become established rapidly in the fall and attain vigorous spring and summer growth. Application of fertilizer—not seed—to the snowpack when several inches of water remain may result in the fertilizer incorporation in the soil. Precautions must be taken in areas with frozen soil, distinct layering in the snowpack, and critical water resources.

A refertilization schedule is also important. Several years after plant establishment the vigor may decline because nutrients are not held by coarse subsoil material. Reduced vigor will increase potential erosion unless native plants satisfactorily dominate the site. Small rills and gullies may become evident. Refertilization every three to five years will help maintain a quality erosion control program.

Fertilizer costs are increasing and supplies are limited. If sufficient quantities of fertilizer at a reasonable cost are not obtainable, you may wish to concentrate the limited supply of fertilizer on such key areas as large fills and culvert and bridge emplacements.

MULCH

Mulch is non-living material offering instantaneous protection to the soil surface. Soil erosion is reduced because raindrop energy expended on mulch reduces detachment and transport of soil particles and seed from the surface. Mulch may provide more favorable temperature and moisture conditions for seed germination. Lower soil surface temperatures and more uniform moisture conditions created by mulches can improve the percent germination and seedling growth rates.

Greatest surface erosion rates from newly constructed roads occur within the first two years. Fall seeding and fertilizing may result in a lush growth of grass and legumes the following spring—*but* soil losses may still have been substantial during the previous winter months. Mulch will minimize soil losses until vegetation becomes well-established.

Common mulches include excelsior, straw, and slurried wood or ground-paper fibers. Their order of performance is generally the same with excelsior being superior. The intertwining of excelsior provides sufficient tensile strength to resist surface soil movement. Straw is excellent if held in place by chemical tackifiers (liquid adhesives). Without tackifier applications straw is somewhat less effective but often least expensive. Slurried wood fiber, commonly used in the Pacific Northwest because of ease of application, may have insufficient damming ability or tensile strength to prevent erosion on long slopes. Sawdust and bark dust are not normally used in roadside erosion control.

Application rates depend upon the kind of mulch used. Straw mulch is effective when applied at two tons per acre. Wood fiber should be applied at 0.5 to 0.6 tons per acre. Wood fiber application rates of one or more tons per acre will improve erosion control but reduce plant establishment.

Mulch applied after seed and fertilizer applications results in the seed being in contact with mineral soil for more favorable plant establishment. Hydroseeding a fiber-seed-water slurry can entrap 60-70 percent of the seed in the mulch layer. The probability that such seed will germinate and establish primary roots in mineral soil is lessened.

When using straw for mulch, use only clean straw. Other materials may spread or introduce noxious plants such as tansy ragwort and Canada thistle.

TIME OF SEEDING

Apply seed, fertilizer, and mulch to disturbed soil just before the winter rains or snow. This completes the road construction process. Mulch and rapidly developing plant species—such as annual ryegrass—will protect the loose porous soil during the first fall and winter, providing time for other species to get established. If seeding cannot be completed in the fall, finish the job in early spring when moisture and soil temperatures are favorable for germination and growth.

Summer seeding may be successful at higher elevations if summer moisture is enough to sustain plant growth. Summer seedings at lower elevations may require irrigation. Summer dry ravel may deposit seed and fertilizer into ditches, leaving slopes unprotected the following fall.

Winter seedings are not advisable for most areas. Climate discourages plant development and the probability of seed loss from slopes is greater. Broadcast seeding on snow is not recommended and results in poor seedling emergence the following spring.

APPLICATION METHODS

Drill and broadcast seeding are the two primary methods for applying seed and fertilizer. Drilling is best, but may not be possible on steep cutbanks and fillslopes. Manufacturers of seeding equipment are listed in Supplement D.

Drilling places the seed in the soil at a controlled depth and seeding rate. Drilling, as compared to other methods of seeding, may require only half as much seed to establish a satisfactory stand. Fertilizer can be applied with seed. Some skid roads are presently seeded with rangeland drills in Oregon.

Broadcast methods apply seed and fertilizer only to the soil surface, but may be the only choice on steep slopes. Some beneficial effects of covering the seed can be obtained by applying mulch to the seeded surface—but, it is still inferior to direct soil coverage. In general, broadcasting requires heavier seeding rates than drilling due to lack of a soil cover for the seed, uneven distribution of seed, greater seed loss to rodents, and poorer plant establishment.

Broadcast seeding methods consist of three basic techniques:

Water slurry applicators—commonly called hydroseeders—maintain a constantly churning slurry of seed, fertilizer, and fiber mulch in a truck-mounted tank. These tanks vary in size from 300 to 3,000 gallons or more. This technique is most suitable to large areas and to steep slopes where plastering of materials is necessary. It is a one-step process. Drawbacks include poor seed contact with soil and the use of less effective mulches.

Blower methods use an air stream to apply seed and fertilizer. Materials can be applied simultaneously from separate supply bins. Minimal seed damage and fertilizer pulverization occurs when materials are fed directly into the airstream instead of through the blades of a fan. This technique is less expensive than water slurry applications, is effective under normal conditions, and applies seed to the bare soil. Drawbacks include mulching as a separate operation and vibrations that can stratify the mixture of seed in bins and result in a poor distribution. Seeding distance depends on seed size and density. A blower technique also is used to apply straw mulches.

Rotary disk broadcast seeders are most easily adapted to aerial, all-terrain-vehicle, or hand-held techniques. Seed and fertilizer are fed onto a ribbed rotating disk and are spread by centrifugal force. This technique is often the least expensive, due to manpower and machine costs. It is effective under normal conditions, suitable for small areas, and applies materials to the bare soil. Drawbacks are the same as those of blowers, plus less control on precise direction of application.

SUPPLEMENT A

Environmental Adaptability of Species

Careful evaluation of the site will save money. An ecological approach to site evaluation and selection of adapted plants is basic. Factors of climate, soil, slope, and exposure, and the native plant community of the site interact with each other to create a net environment to which the seeded plants respond.

Precipitation zones are an index for selecting species to seed, but they can be misleading. Under a precipitation of 13 inches, a north-facing slope may have the capability of producing plants as if it were receiving 15 inches of precipitation. A south-facing slope in the same area may perform as if it were receiving 10 inches of precipitation. Other factors, such as clayey subsoils, gravelly substrata, restricting layers, and timeliness of the precipitation in relation to the growing season, commonly change the net environment from that

normally typical of the precipitation that falls on the land.

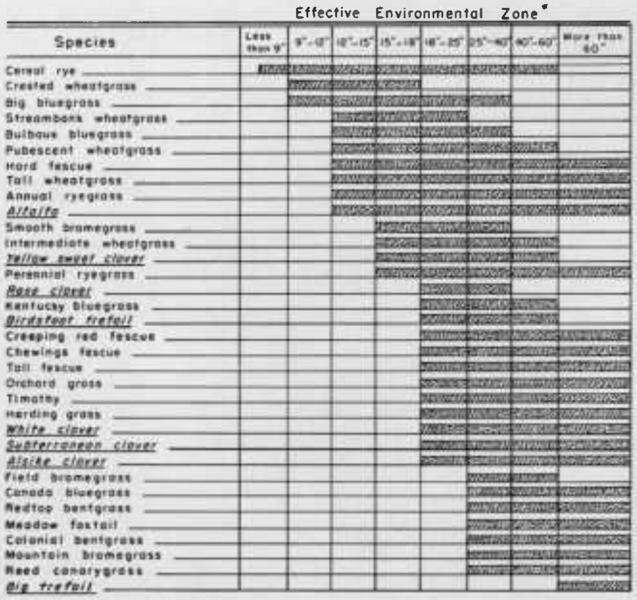
The concept of "net environment" or "effective environment" thus is important.

Generalized native characteristics of various effective environmental zones include:

Effective Environment	*Native Vegetation*
Under 9 inches	Needlegrasses, ricegrass, Sandberg bluegrass, big sage brush.
9 to 11 inches	Bluebunch wheatgrass, Sandberg bluegrass, needlegrasses, big sagebrush.
12 to 14 inches	Bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, bitterbrush. Droughty bottomland soils may have this rating.
15 to 17 inches	Idaho fescue, bluebunch wheatgrass, basin wildrye, snowberry, ponderosa pine. Semi-moist bottomland that naturally produces a sparse stand of basin wildrye have this rating.
18 to 25 inches	Idaho fescue, Columbia needlegrass, elk sedge, pinegrass, slender wheatgrass, tall shrubs, Douglas-fir, ponderosa pine. Moist bottomland that produces a dense stand of basin wildrye have this rating.
26 to 40 inches	Tufted hairgrass, timber oatgrass, redtop, twinflower, meadowrue, grand fir, Douglas-fir, larch. Semi-wet bottomland that produced moist-land vegetation such as redtop, have this rating.
41 to 60 inches	Douglas-fir, bigleaf maple, western redcedar, alder, western white pine. Wet bottomland that produces wet-land vegetation such as tufted hairgrass and Nebraska sedge, has this rating.
More than 60 inches	True firs, western hemlock, sitka spruce, beargrass, rhododendron.

Ranges of effective environmental adaptability for plants seeded for soil conservation efforts in Oregon's forested regions.

Species in *italics* are legumes.



* Expressed in inches of average annual precipitation, adjusted by environmental site concerns.

How To Use the Table, "Ranges of Effective Environmental Adaptability for Plants Seeded for Soil Conservation Efforts in Oregon's Forested Regions."

Determine the average annual precipitation for the site to be seeded. Next, study the factors of the site that could make it produce plants as if it were actually receiving more (or less) precipitation than it actually does. These factors include soil, slope, exposure, run-on, run-off, timeliness of precipitation, elevation, etc.

If nothing about the site logically could increase or decrease the effectiveness of the precipitation that falls on the land, use the column representing the average annual precipitation that falls on the site.

If site factors logically increase the effectiveness of the precipitation that actually falls on the site so as to make it perform as if it were in a higher precipitation zone, use the column representing the higher zone.

If site factors lower the effectiveness one zone, use the column representing the lower zone.

SUPPLEMENT B

Notes on Species Seeded in Oregon's Forested Regions

(Species in **bold face** are legumes)

Alfalfa (*Medicago sativa*)

Perennial legume with numerous varieties having different characteristics. Adopted where the moisture equivalent is comparable to 12 inches or more precipitation. Eastern Oregon varieties should be winter-hardy and resistant to bacterial wilt. Moderately winter-hardy varieties are suited for Western Oregon. Stem nematode resistance is necessary in many areas.

Bentgrass, colonial (*Agrostis tenuis*)

Long-lived, creeping turfgrass, adapted to a wide variety of soil conditions. Provides good erosion control on road cuts and fills. Well adapted to acid soils. Is difficult to eradicate once established. Not compatible with legumes. The 'Highland' variety is more tolerant of droughty, low-fertility sites.

Bentgrass, redtop (*Agrostis alba*)

Widely adapted to wet, acid to neutral, low-fertility soils. It can withstand short summer droughts. Provides a low-growing dense cover. Is excellent for irrigation ditch banks.

Bluegrass, big (*Poa ampla*)

A long-lived, improved, native bunchgrass. Adapted where the moisture equivalent is comparable to 9 to 15 inches precipitation. Its loosely constructed bunch can be broken apart and pulled up easily. Need shallow, late fall or early spring seeding.

Bluegrass, bulbous (*Poa bulbosa*)

A small, spring-active bunchgrass. Plants reproduce by bulblets in the head instead of seeds. Stem base also has a bulbous area for reproduction which can live for several years. It is considered a weed in wheat fields.

Bluegrass, Canada (*Poa compressa*)

A low-growing perennial with aggressive rhizomes. It is suited to low-fertility soils and able to survive long-duration flooding.

Bluegrass, Kentucky (*Poa pratensis*)

A low-growing perennial for turf uses, best suited to well-drained, neutral soils. It is only moderately shade tolerant. Stays green in summer if irrigated regularly.

Bromegrass, field (*Bromus arvensis*)

A low-growing, winter active, annual grass that produces a massive fibrous root system. Seed either quickly germinates or deteriorates in moist soils. Has a high degree of winter-hardiness and drought tolerance, and matures seed much later than other annual bromes.

Bromegrass, mountain (*Bromus marginatus*)

A rapid-developing, short-lived, generally winter-active, upright, perennial bunchgrass. It is a rapidly developing cover for high elevations.

Bromegrass, smooth (*Bromus inermis*)

A long-lived sod-former. Suitable for extremely wet land or where prolonged inundation occurs. Responds to high rates of nitrogen fertilization. Suited for conservation plantings. Can be serious weed in irrigated areas and along drainage ditches.

Clover, Alsike (*Trifolium hydridum*)

Short-lived perennial legume. Used where the moisture equivalent is comparable to 18 inches or more precipitation. Adapted for use on poorly drained, acid soils, especially in cool areas. Tolerant of moderately alkaline conditions. No improved varieties available.

Clover, rose (*Trifolium hirtum*)

A densely hairy, winter-annual legume varying from 3 to 18 inches tall. Adapted to thin dry soils and mild climates. It is outperformed in most areas by other species.

Clover, subterranean (*Trifolium subterraneum*)

A winter-annual legume. Suited for Western Oregon where the moisture equivalent is comparable to 18 inches or more precipitation. Requires well-drained soils. Good for fall-seeded erosion control plantings. Will volunteer freely for many years if managed properly or it will leave an ungrazed grass stand.

Clover, white (*Trifolium repens*)

Long-lived, perennial legume. Can be grown where the moisture equivalent is comparable to 18 inches or more precipitation. Requires medium to high fertility and adequate moisture for optimum production. Tolerates poor drainage but not strongly acid or strongly alkaline conditions. Is a good erosion control plant on streambanks and roadsides.

Fescue, chewings (*Festuca rubra commutata*)

A long-lived, turf-type bunchgrass. Adapted

where the moisture equivalent is comparable to 18 inches or more precipitation. Does well on acid soils of low fertility. Requires well-drained soil. Is shade tolerant. Used primarily as a turf and conservation grass.

Fescue, creeping red (*Festuca rubra*)

Similar to chewings fescue but it has weak rhizomes. Performs best on acid soils and increases productivity with increasing acidity.

Fescue, hard (*Festuca duriuscula*)

A low-growing bunchgrass with a dense and voluminous root system. Adapted where the moisture equivalent is comparable to 12 to 60 inches of precipitation. Gives excellent erosion control but is slow in becoming established.

Fescue, tall (*Festuca arundinacea*)

A long-lived, high-producing bunchgrass. Adapted to a wide range of soil and climatic conditions. Suited to moderately wet conditions and areas where the moisture equivalent is comparable to over 18 inches of precipitation. Tolerant of strongly acid to strongly alkaline conditions.

Foxtail, meadow (*Alopecurus pratensis*)

A long-lived, weak sod-former. Adapted to wet soils, winter and spring flooding, and high altitudes. Tolerant of frost, prolonged snow cover, and strongly sodic conditions. Responds to high fertility. It is difficult to seed—requires carrier for the seed if seeded through standard drill or requires special seeding equipment. Spreads well into native meadow sod.

Hardinggrass (*Phalaris tuberosa* var. *stenoptera*)

A drought-resistant, winter-active, long-lived perennial. Adapted only to western Oregon on moderately deep to deep soils (40 inches or more) that are fine- to medium-textured, and imperfectly to moderately well-drained. Spring seeding is recommended because seedlings are not winter-hardy. Entire stands of hardinggrass seedlings have been killed when temperatures dropped to 10°F.

Orchardgrass (*Dactylis glomerata*)

A long-lived, high-producing bunchgrass. Adapted where the moisture equivalent is comparable to 18 inches or more precipitation. Adapted to well-drained soils. Is shade tolerant. Varieties are early-, mid-, and late-season in maturity.

Orchardgrass, dwarf (*Dactylis glomerata*)

A late maturing, low-growing grass. Its tolerance to shade, drought, frost, and insects is similar to standard orchardgrass. It is more shade tolerant than creeping red fescue or Kentucky bluegrass. The clippings decompose rapidly after clipping. 'Pomar' is a common variety.

Rye, cereal (*Secale cereale*)

Extremely winter hardy, annual cereal grain used for conservation plantings in Oregon. Demonstrated effectiveness at elevations of near 7,000 feet. Effective preventative to wind erosion. It is tolerant to drought and saline and alkaline soils. Cereal rye is a serious, persistent weed in dryland wheat cropping systems.

Ryegrass, annual (*Lolium multiflorum*)

A vigorous, winter-active annual. Adapted west of the Cascades to a wide variety of soil conditions. Used where the moisture equivalent is comparable to 12 inches or more precipitation. Makes a good winter cover crop or temporary seeding on disturbed areas. Established rapidly, is strongly competitive and may retard establishment of perennial grasses and legumes if it is seeded too heavily in a mixture.

Ryegrass, perennial (*Lolium perenne*)

Long-lived, vigorous perennial. Adapted west of the Cascades to a wide variety of soil conditions. Used where the moisture equivalent is comparable to 15 inches or more precipitation. Well adapted to short rotations with clover. May retard establishment of other perennials if it is seeded too heavily in a mixture. Tends to go dormant in summer.

Sweetclover, yellow (***Mililotus officinalis***)

A tall, stemmy, annual or biennial legume. Only biennial forms of yellow sweetclover are commonly used. Suited on dryland where the moisture equivalent is comparable to 15 inches or more precipitation. 'Madrid' is yellow-flowered. It is earlier maturing, less productive under optimum growing conditions, and more suited for use on sandy soils or in drier conditions than is white-flowered sweetclovers.

Timothy (*Phleum pratense*)

Perennial adapted to high elevations and where moisture equivalent is comparable to 18 inches or more precipitation. Suited for erosion control and has special value in revegetating forested lands in eastern Oregon, southern

Oregon, and the eastern portion of the Willamette Valley. Its late maturity may be an advantage under certain conditions, such as poorly drained soils.

Trefoil, big (*Lotus pedunculatus*)

Long-lived, rhizomatous legume. Used in western Oregon under long duration wetland conditions and where annual precipitation exceeds 60 inches. Withstands considerable winter inundation. Is not winter-hardy east of Cascade Range. Well adapted for erosion control.

Trefoil, birdsfoot (*Lotus corniculatus*)

Long-lived, vigorous, deep-rooted legume. Adapted where the moisture equivalent is comparable to 18 inches or more precipitation. Is very winter-hardy and useful at high elevations. Has drought tolerance under Western Oregon conditions. It is tolerant of poor drainage. Excellent plant for erosion control.

Wheatgrass, crested (*Agropyron desertorum*)

A long-lived, drought-tolerant bunchgrass. Adapted where moisture equivalent is comparable to 9 to 18 inches of precipitation.

Wheatgrass, intermediate (*Agropyron intermedium*)

A late-maturing, long-lived, mild sod-former. Suitable where the moisture equivalent is comparable to 15 inches or more precipitation. Requires good drainage and moderate to high fertility.

Wheatgrass, intermediate, dwarf (*Agropyron intermedium*)

Adapted for low maintenance cover where reduced clipping is an advantage. The only variety available is 'Tegmar.'

Wheatgrass, pubescent (*Agropyron trichophorum*)

A long-lived, sod-former. Adapted to low-fertility sites and fine-textured soils. Used where the moisture equivalent is comparable to 12 to 60 inches of precipitation. Will tolerate more alkali and drier conditions than intermediate wheatgrass.

Wheatgrass, streambank (*Agropyron riparium*)

A long-lived, drought-tolerant, creeping sod-former with excellent seedling vigor. Adapted where the moisture equivalent is comparable to 12 to 25 inches of precipitation. It is used primarily for stabilization of roadsides and canal banks.

Wheatgrass, tall (*Agropyron elongatum*)

A tall-growing, long-lived bunchgrass with good seedling vigor. Suitable where the moisture equivalent is comparable to 12 inches or more precipitation. Once established, it is tolerant of strongly to very strongly sodic soils —one of the most tolerant of all forage grasses used in Oregon. Adapted especially to clay soils. It is late maturing.

SUPPLEMENT C

Guide to Species Selection and Seed Mixture Formulation For Soil Conservation Efforts In Oregon's Western, Eastern, and Southwestern Forested Regions

WESTERN OREGON

[Consult the section on *Seeding Rates* (page 6) to evaluate the final seed mixture.]

1. Recommended Seeding Rates for Stabilization of Roadways and Other Disturbed Areas

Adapted species	Effective environmental (precipitation) zones 26-40″	41-60″	More than 60″
	lbs./a.	*lbs./a.*	*lbs./a.*
Pubescent wheatgrass	20	—	—
Annual ryegrass	3	3	3
Intermediate wheatgrass	20	20	—
Perennial ryegrass[3]	10	10	10
Birdsfoot trefoil	6	6	6[1]
Creeping red fescue	6	6	6
Chewings fescue	6	6	6
Tall fescue	15	15	15
Orchardgrass	7	7	7
Timothy	2	2	2
White clover	—	2	2
Subterranean clover	10	10	7
Colonial bentgrass	1	1	1
Big trefoil[2]	—	—	1
Desired total LPS/sq. ft. for a mixture	50–300	50–300	50–300

[1] (Cascades, not fogbelt)
[2] (Coastal)
[3] When in a mixture use a maximum of 3 pounds/acre because of its competitive nature.

2. **Recommended Seeding Rates for Stabilization of Waterways**

Adapted species	Effective environmental (precipitation) zones			
	26-40″	41-60″	More than 60″	Coastal fog belt
	lbs./a.	*lbs./a.*	*lbs./a.*	*lbs./a.*
Pubescent wheatgrass	20	20	----	----
Annual ryegrass	10	10	10	10
Intermediate wheatgrass	20	20	----	----
Perennial ryegrass[3]	10	10	10	10
Birdsfoot trefoil	6	6	6[1]	----
Creeping red fescue	6	----	6	6
Chewings fescue	6	----	6	6
Tall fescue	15	15	15	15
Orchardgrass[3]	----	----	7	7
Timothy	----	----	2	2
White clover	----	2	2	2
Subterranean clover	7	----	----	----
Meadow foxtail	----	8	8	8
Colonial bentgrass	----	----	1	1
Reed canarygrass	----	----	----	10
Big trefoil	----	----	1[2]	1
Desired total LPS/sq. ft. for a mixture	50–130	75–200	75–250	75–250

[1] Cascades
[2] Coastal
[3] When in a mixture use a maximum of 3 pounds/acre because of its competitive nature.

3. **Recommended Seeding Rates for Stabilization of Logged or Burned Forest**

Adapted species	Effective environmental (precipitation) zones		
	41-60″	More than 60″	Coastal fog belt
	lbs./a.	*lbs./a.*	*lbs./a.*
Tall wheatgrass[4]	10	----	----
Annual ryegrass	3	3	3
Birdsfoot trefoil	4	4[1]	----
Orchardgrass[3]	4	----	----
Timothy	2	2	2
White clover	4	4	4
Subterranean clover	7	----	7
Mountain bromegrass	10	10	10
Big trefoil	----	2[2]	2
Desired total LPS/sq. ft. for a mixture	40–150	50–150	50–150

[1] Cascades
[2] Coastal
[3] May be overly competitive with tree seedlings.
[4] Use on rocky shallow soils.

4. **Recommended Seeding Rates for Interim Forage On Logged Areas**

Adapted species	Effective environmental (precipitation) zones		
	41-60″	More than 60″	Coastal fog belt
	lbs./a.	*lbs./a.*	*lbs./a.*
Annual ryegrass	3	3	3
Birdsfoot trefoil	2	2[1]	----
Orchardgrass[3]	4	----	----
Timothy	2	2	2
Hardinggrass	----	----	7
White clover	2	2	2
Subterranean clover	7	----	7
Mountain bromegrass	5	5	5
Big trefoil	----	1[2]	1
Desired total LPS/sq. ft. for a mixture	20–80	20–80	15–90

[1] Cascades
[2] Coastal
[3] May be overly competitive with tree seedlings.

5. **Recommended Seeding Rate for Stabilization of Construction Sites—Temporary Cover**

Annual ryegrass	at	30 pounds/acre

6. **Recommended Seeding Rates for Camp and Picnic Areas**

Adapted species	Effective environmental (precipitation) zones	
	41-60″	More than 60″
	Pounds/acre	*Pounds/acre*
Perennial ryegrass[1]	10	10
Birdsfoot trefoil	6	6
Creeping red fescue	6	6
White clover	2	2
Big trefoil	----	1
Desired total LPS/sq. ft. for a mixture	70–130	70–130

[1] When in a mixture use a maximum of 3 pounds/acre because of its competitive nature.

7. Recommended Seeding Rates for Ski Slope Stabilization

Adapted species	Seeding rate
	pounds/acre
Cereal rye	15
Annual ryegrass	3
Smooth brome	20
Perennial ryegrass[1]	10
Birdsfoot trefoil	6
Creeping red fescue	6
Chewing fescue	6
Tall fescue	15
Orchardgrass	7
Timothy	2
White clover	2
Colonial bentgrass	1
Desired total LPS/sq.ft. for a mixture	70–160

[1] When in a mixture use a maximum of 3 pounds/acre because of its competitive nature.

EASTERN OREGON

[Consult the section on *Seeding Rates* (page 6) to evaluate the final seed mixture.]

1. Recommended Seeding Rates for Stabilization of Roadways and Other Disturbed Areas

Adapted species	Effective environmental (precipitation) zones		
	12-14″	15-17″	18-40″
	lbs./a.	*lbs./a.*	*lbs./a.*
Crested wheatgrass	10	10	----
Streambank wheatgrass	10	----	----
Pubescent wheatgrass	10	10	8
Hard fescue	4	4	4
Intermediate wheatgrass	----	10	8
Orchardgrass	----	----	6
Timothy	----	----	2
Desired total LPS/sq. ft. for a mixture	20–50	20–50	15–110

2. Recommended Seeding Rates for Stabilization of Waterways

Adapted species	Effective environmental (precipitation) zones			
	12-14″	15-17″	18-25″	26-40″
	lbs./a.	*lbs./a.*	*lbs./a.*	*lbs./a.*
Crested wheatgrass	16	16	----	----
Streambank wheatgrass	16	----	----	----
Pubescent wheatgrass	16	16	----	----
Hard fescue	----	4	4	----
Intermediate wheatgrass	----	16	----	----
Perennial ryegrass[1]	----	----	2	2
Kentucky bluegrass	----	----	3	3
Creeping red fescue	----	----	10	10
Chewings fescue	----	----	10	10
Tall fescue	----	----	15	15
White clover[1]	----	----	2	2
Desired total LPS/sq. ft. for a mixture	50–70	30–60	100–130	70–130

[1] Use only in a mixture.

3. Recommended Seeding Rates for Stabilization of Logged or Burned Forest

Adapted species	Effective environmental (precipitation) zones		
	15-17″	18-25″	26-40″
	lbs./a.	*lbs./a.*	*lbs./a.*
Crested wheatgrass	6	----	----
Big bluegrass	2	----	----
Hard fescue	2	2	2
Alfalfa[1]	2	----	----
Smooth bromegrass	----	4	----
Intermediate wheatgrass	8	8	----
Sweetclover[1]	2	----	----
Birdsfoot trefoil[1]	----	----	2
Orchardgrass	----	4	4
Timothy	----	1	1
White clover[1]	----	2	2
Alsike clover[1]	----	2	2
Desired total LPS/sq. ft. for a mixture	50–70	50–70	40–75

[1] Use only in a grass mixture.

4. Recommended Seeding Rates for Stabilization of Deteriorated Mountain Meadows

Adapted species	Seeding rates
	pounds/acre
Kentucky bluegrass	2
Timothy	2
White clover[1]	2
Meadow foxtail	8
Desired total LPS/sq. ft. for a mixture	50–130

[1] Use only in a grass mixture.

5. Recommended Seeding Rates for Interim Forage on Logged Areas

Adapted species	Effective environmental (precipitation) zones 15-17″	18-25″	26-40″
	lbs./a.	*lbs./a.*	*lbs./a.*
Crested wheatgrass	6	----	----
Big bluegrass	2	----	----
Hard fescue	2	2	2
Alfalfa	2	----	----
Smooth bromegrass	----	4	----
Intermediate wheatgrass	2	8	----
Sweetclover	2	----	----
Birdsfoot trefoil	----	----	2
Orchardgrass[1]	----	4	4
Timothy[1]	----	1	1
White clover	----	2	2
Alsike clover	----	2	2
Desired total LPS/sq. ft. for a mixture	50–70	50–70	60–75

[1] Provides quick and somewhat temporary cover—use in a mixture with other species.

6. Recommended Seeding Rates for Camp and Picnic Grounds

Adapted species	Effective environmental (precipitation) areas 12-14″	15-17″	18-25″	26-40″	Irrigated areas
	lbs./a.	*lbs./a.*	*lbs./a.*	*lbs./a.*	*lbs./a.*
Crested wheatgrass	----	----	----	----	12
Streambank wheatgrass	10	----	----	----	10
Hard fescue	----	4	4	----	----
Kentucky bluegrass	----	----	3	3	3
Creeping red fescue	----	----	10	10	----
Tall fescue	----	15	15	----	----
Timothy	----	----	2	2	----
White clover	----	----	----	3	----

7. Recommended Seeding Rates for Stabilization of Ski Slopes

Adapted species	Seeding rates
	pounds/acre
Cereal rye	15
Pubescent wheatgrass	16
Hard fescue	4
Smooth bromegrass	20
Perennial ryegrass	10
Kentucky bluegrass	3
Birdsfoot trefoil[1]	2
Creeping red fescue	10
Chewings fescue	10
Orchardgrass	6
Timothy	2
White clover[1]	2
Canada bluegrass	3
Redtop bentgrass	1
Meadow foxtail	8
Desired total LPS/sq. ft. for a mixture	60–140

[1] Use only in a grass mixture.

8. Recommended Seeding Rate for Stabilization of Subalpine Areas

Adapted species	Seeding rates
	pounds/acre
Cereal rye	15
Pubescent wheatgrass	16
Hard fescue	4
Smooth bromegrass	20
Kentucky bluegrass	3
Birdsfoot trefoil[1]	2
Creeping red fescue	10
Chewings fescue	10
Orchardgrass	6
Timothy	2
White clover[1]	2
Canada bluegrass	3
Redtop bentgrass	1
Meadow foxtail	8
Desired total LPS/sq. ft. for a mixture	60–140

[1] Use only in a grass mixture.

SOUTHWESTERN OREGON

[Consult the section on *Seeding Rates* (page 6) to evaluate the final seed mixture.]

1. Recommended Seeding Rates for Stabilization of Roadways and Other Disturbed Areas

Adapted species	Effective environmental (precipitation) zones						
	15-17″		18-25″		26-35″		
	Below 3,500′	Above 3,500′	Granitic soils	Other	Granitic soils	Other	36-60″
	lbs./a.	*lbs./a.*	*lbs./a.*	*lbs./a.*	*lbs./a.*	*lbs./a.*	*lbs./a.*
Big bluegrass	——	8	——	——	——	——	——
Bulbous bluegrass	10	——	10	——	10	10	——
Pubescent wheatgrass	12	12	——	12	——	12	——
Hard fescue	——	8	——	8	——	8	8
Annual ryegrass	12	12	12	12	12	12	12
Intermediate wheatgrass	——	15	——	——	——	——	15
Yellow sweetclover	——	——	——	——	——	10	10
Perennial ryegrass[1]	12	12	12	12	12	12	12
Rose clover	10	——	——	10	——	10	——
Birdsfoot trefoil	——	——	——	——	——	6	6
Creeping red fescue	——	——	——	——	——	8	8
Tall fescue	——	——	——	15	——	15	15
Orchardgrass	——	——	——	——	——	——	8
Timothy	——	——	——	——	——	3	3
Bentgrass	——	——	——	——	——	——	1
Desired total LPS/sq. ft. for a mixture	60–150	60–150	60–130		60–150		80–220

[1] When in a mixture use a maximum of 5 pounds/acre because of its competitive nature.

2. Recommended Seeding Rates for Stabilization of Waterways

Adapted species	Effective environmental (precipitation) zones			
	15-17″	18-25″	26-35″	36-60″
	lbs./a.	*lbs./a.*	*lbs./a.*	*lbs./a.*
Bulbous bluegrass	10	——	——	——
Pubescent wheatgrass	15	15	15	——
Hard fescue	8	8	8	8
Tall wheatgrass	——	15	15	15
Annual ryegrass	12	12	12	12
Intermediate wheatgrass	——	——	——	15
Perennial ryegrass[1]	12	12	12	12
Birdsfoot trefoil	——	——	6	6
Creeping red fescue	——	——	10	10
Tall fescue	——	15	15	15
Meadow foxtail	——	——	——	8
Bentgrass	——	——	1	1
Desired total LPS/sq. ft. for a mixture	25–90	20–90	80–220	80–220

[1] When in a mixture use a maximum of 5 pounds/acre because of its competitive nature.

3. Recommended Seeding Rates for Interim Forage on Logged Areas

Adapted species	Effective environmental (precipitation) zones		
	18-25″	26-35″	36-60″
	lbs./a.	*lbs./a.*	*lbs./a.*
Big bluegrass[1]	4	4	——
Intermediate wheatgrass[1]	——	——	6
Perennial ryegrass[3]	5	5	5
Tall fescue	6	6	6[3]
Orchardgrass	——	5	5[2]
Timothy	——	2	2
Hardinggrass[1]	6	6	——
White clover	——	——	2
Desired total LPS/sq. ft. for a mixture	20–60	25–70	10–50

[1] Low shade tolerance.
[2] May be overly competitive with tree seedlings.
[3] When in a mixture use a maximum of 5 pounds/acre because of its competitive nature.

4. Recommended Seeding Rates for Camp and Picnic Areas

Adapted species	Effective environmental (precipitation) zones		
	15-17″	18-25″	26-60″
	lbs./a.	*lbs./a.*	*lbs./a.*
Hard fescue	4	4	4
Perennial ryegrass[1]	10	10	10
Kentucky bluegrass	----	3	3
Creeping red fescue	----	----	6
Tall fescue	----	15	15
Bentgrass	----	----	1

[1] When in a mixture use a maximum of 5 pounds/acre because of its competitive nature.

5. Recommended Species for Seeding for Ski Slope Stabilization

The following species are adaptable to subalpine conditions although local trials above 6,000′ elevation have been unsuccessful:

Cereal rye	Chewings fescue
Pubescent wheatgrass	Tall fescue
Hard fescue	Orchardgrass
Annual ryegrass	Timothy
Smooth bromegrass	White clover
Perennial ryegrass	Canada bluegrass
Kentucky bluegrass	Redtop bentgrass
Birdsfoot trefoil	Meadow foxtail
Creeping red fescue	Bentgrass

SUPPLEMENT D

Manufacturers of Equipment to Apply Seed, Fertilizer, and/or Mulch

Oregon State University Extension Service neither endorses these manufacturers nor acknowledges them as sole manufacturers of such equipment.

Rotary Disk (seed and fertilizer)

Cyclone Seeder, Inc. (Portable models available.)
P. O. Box 68
Urbana, Indiana 46990
Tel. (219) 774-3339

Blowers (straw mulch)

Finn Equipment Company
2525 Duck Creek Road
Cincinnati, Ohio 45208
Tel. (513) 871-2529

Reinco Equipment Company
P.O. Box 584
Plainfield, New Jersey 07061
Tel. (201) 755-0921

Blowers (seed and fertilizer)

Gallogly Machine
P. O. Box 512
1602 N. 18 St.
Sweet Home, Oregon 97386
Tel. (503) 367-2751

Miller Dehydrater Company
256 Bethel Drive
Eugene, Oregon 97402
Tel. (503) 688-5281

Solo Equipment (Portable models available)

Jack Erhardt & Associates
Rt. 1 Box 168A
Forest Grove, Oregon 97116
Tel. (503) 357-6367

Water Slurry Applicators (seed, fertilizer, and fiber mulch)

Bowie Industries, Inc.
P. O. Box 931
Bowie, Texas 76230
Tel. (817) 872-2286

Finn Equipment Company
2525 Duck Creek Road
Cincinnati, Ohio 45208
Tel. (513) 871-2529

Lynnwood Truck Equipment
2224 S. W. 196
Lynnwood, Washington 98036
Tel. (206) 776-0911

Reinco Equipment Company
P. O. Box 584
Plainfield, New Jersey 07061
Tel. (201) 755-0921

Rangeland Drill

Specifications are available from:

USDA Forest Service
Equipment Development Center
444 E. Vonita Avenue
San Dimas, California 91773
Tel. (213) 332-6231

OREGON STATE UNIVERSITY

EXTENSION SERVICE

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