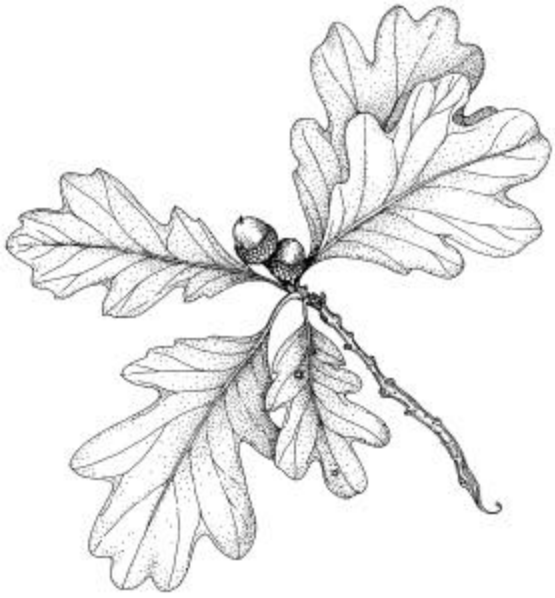
PITKIN COUNTY
REVEGETATION GUIDE



Quercus gambelli Gambel Oak

PITKIN COUNTY
NATURAL RESOURCES

UPDATED: NOVEMBER 2003

Colorado Natural Areas Program

COLORADO STATE PARKS

COLORADO DEPARTMENT OF NATURAL RESOURCES

This guide is a modified version of the Native Plant Revegetation Guide for Colorado. Please see Appendix I (pg. 28) for acknowledgements. Pitkin County thanks all those involved for allowing us to benefit from their fine work.

PLANT SELECTION

Plants to be introduced must be appropriate; that is, they should have proven themselves adaptable to the climate, soil and topographical conditions of the designated area. The use of native plants is strongly encouraged because it provides broad biological diversity and helps keep Colorado looking like Colorado with a unique regional landscape that sets us apart from other parts of the country.

Plants selected are expected to be healthy, vigorous, and pest free. Plant material should be drought resistant, heat and exhaust fume tolerant, not soil sensitive, and preferably fast growing, although the designer must recognize the advantage of both fast and slow growing plants and choose accordingly. Tree planting should be primarily deciduous to blend with the natural environment and provide adequate sight distance and view planes.

RECOMMENDED PLANT LIST

TREES

RIPARIAN AREAS (Creek/River Bottoms/Draws/Ponds/Lakes/Irrigation Ditches):

Aspen	*Populus tremuloides*
Colorado Blue Spruce	*Picea pungens*
Douglas Fir	*Pseudotsuga menziesii*
Narrowleaf Cottonwood	*Populus angustifolia*
River Birch	*Betula occidentalis*
Rocky Mountain Maple	*Acer glabrum*
Thinleaf Alder	*Alnus tenuifolia (syn. A. incana)*

NORTH TO EAST ASPECTS:

Aspen	*Populus tremuloides*
Douglas Fir	*Pseudotsuga menziesii*
Lodgepole Pine	*Pinus contorta*
Ponderosa Pine	*Pinus ponderosa*

SOUTH TO WEST ASPECTS:

Gambel Oak	*Quercus gambelli*
One-seed Juniper	*Juniperus monosperma*
Piñon Pine	*Pinus edulis*
Sticky Laurel	*Ceanothus velutinus*

SHRUBS

RIPARIAN AREAS:

Chokecherry	*Prunus virginiana*
Hawthorn	*Crataegus erythropoda*
Prickly Currant	*Ribes lacustre*
Red Osier Dogwood	*Cornus sericea*
Silverberry	*Shepherdia argentea*

Thimbleberry	*Rubus parviflorus*
Twinberry Honeysuckle	*Lonicera involucrata*
Wax Currant	*Ribes cereum*
Willows:	
	Salix bebbiana
	S. drummondiana
	S. geyeriana
	S .lasiandra
	S. monticola

NORTH TO EAST ASPECTS:

Chokecherry	*Prunus virginiana*
Common Snowberry	*Symphoricarpos albus*
Golden Currant	*Ribes aureum*
Mountain Snowberry	*Symphoricarpos oreophilus*
Prickly Currant	*Ribes lacustre*
Serviceberry	*Amelanchier alnifolia*
Wax Currant	*Ribes cereum*
Wood's Rose	*Rosa woodsii*

SOUTH TO WEST ASPECTS AND SAGEBRUSH FLATS:

Antelope Bitterbrush	*Purshia tridentata*
Chokecherry	*Prunus virginiana*
Common Snowberry	*Symphoricarpos albus*
Common Juniper	*Juniperus communis*
Mountain Mahogany	*Cercocarpus montanus*
Mountain Sagebrush	*Artemisia tridentata* ssp. *vaseyana*
Mountain Snowberry	*Symphoricarpos oreophilus*
Rabbitbrush	*Chrysothamnus nauseosus*
Serviceberry	*Amelanchier alnifolia*
Sticky Laurel	*Ceanothus velutinus*

SEEDING

The following seed mix has been formulated specifically for revegetation work in and adjacent to naturally vegetated areas in Pitkin County. If revegetation is required within active agricultural areas or old hay fields, pastures, etc. then non-native mixes such as Dry or Wet Pasture Mix from Roaring Fork Co-op is acceptable with approval from Pitkin County Natural Resources. Pitkin County Natural Resources Staff must authorize any deviation from these recommendation. The following seed list contains species known to occur naturally in Pitkin County and that have high rates of success when seeded properly. **Seed availability from vendors is somewhat unpredictable; consequently, substitutions are permissible with Staff approval.**

Revegetation Requirements - Seeding

- All seed must be certified weed free. No seed can contain any species on the County or State noxious weed lists (Available online at http://www.aspenpitkin.com/misc/weeds/weed_list_table3.htm and http://www.ag.state.co.us/dpi/weeds/statutes/weedrules.pdf, respectively) nor can it contain any of the following species (candidates for County list):
- Reed Canary Grass (*Phalaris arundinacea*)
- Purity tags must be submitted to the County Vegetation Manager (Jim Lewis, 920-5214) prior to installation.
- A viable seedbed must be prepared by either disking or hand raking.
- A seed drill should be used on slopes that are less than 2:1, and the drill tube spacing should be 6-7 inches. If a seed drill is not used on slopes less than 2:1, the area must be harrowed after seeding to incorporate seed into the soil.
- **Seeding rate: If a seed drill is used, 6-10 PLS/acre. Otherwise, 8-12 PLS/acre.**
- On slopes that are greater than 2:1 where drilling the seed is not practical, hand raking is required to incorporate the seed into the soil.
- The site must be mulched with weed-free mulch after planting. Mulch should be applied at the rate of 2 tons per acre.
- A Plantago-based tackifier or similar, approved product must be applied on all mulch at the rate of 150 lbs. per acre to prevent wind from blowing straw off the revegetated areas.
- If area to be revegetated is currently dominated by pasture grasses a dry or irrigated pasture mix available at places such as the Carbondale Co-op is acceptable.
- Recommended native seed mix (Substitutions must be approved by Vegetation Management prior to installation):

PLANT SPECIES

COMMON NAME	LATIN NAME	%
Slender Wheat 'San Luis'	*Elymus trachycaulus*	30
Mountain Brome 'Garnet'	*Bromus marginatus*	30
Western Wheatgrass 'Arriba' or 'Manchar'	*Pascopyrum (or Agropyron) smithii*	15
Arizona or Idaho Fescue	*Festuca arizonica or F. idahoensis*	15
Green Needlegrass 'Lodorm'	*Nassella (or Stipa) viridula*	10

This seed mix is available from many distributors, including:

Wind River Seed
3075 Lane 51 ½
Manderson, WY 82401
E-mail: wrstaff@windriverseed.com
Phone: (307) 568-3361 Fax: (307) 568-3364
Web Site: http://www.windriverseed.com/index.htm

Granite Seed Co.
1697 West 2100 North
Lehi, UT. 84043
Phone: 801-768-4422 Fax: 801-768-3967
Email: info@graniteseed.com
Web Site: http://www.graniteseed.com

Pawnee Buttes Seed
PO Box 100
605 25th Street, Greeley, CO. 80632
Phone: (800) 782-5947 Fax (970) 356-7263
E-mail Pawneeseed@ctos.com
Web Site: http://www.pawneebuttesseed.com

Western Native Seed
P.O. Box 1463, Salida, CO 81201
Phone: (719) 539-1071 FAX: (719) 539-6755
Email: westseed@chaffee.net
Web Site: http://westernnativeseed.com/

SEEDING AND PLANTING

Native plantings may be established by natural revegetation of a site, by seeding, or by planting sod, cuttings, or bare root, containerized, or salvaged stock. Natural revegetation may be the best option when native plants are established near the site and when weeds do not seriously threaten to outcompete the native plants. Seeding is often less expensive and more practical than planting nursery stock on large areas. Planting may be more expensive, but it may be the best option in certain situations and may result in more rapid establishment. For many revegetation projects, a combination of planting and seeding will be the most practical approach and will produce the best results.

With either method, care should be taken in planning the arrangement of plant materials on the site. In the natural landscape, plants are rarely arranged in regular rows or monocultural (single species) stands like agricultural crops or in dense patches like horticultural plantings. Instead, plants may be distributed across the landscape in irregular patterns, with many species mixed together and occasional bare areas between plants. For revegetation projects, a more dense, regular cover may be desirable, but the natural landscape can still provide a good guide to planning.

Seeding

Seeding is one of the most commonly used techniques for establishing native plants because it is usually the most cost-effective. However, the establishment of seeded plant stands can be difficult. Patience and experience are normally required for success. Expect to wait three to five years before seeing significant results of a seeding project. Whenever possible, seeding should be used with planting, described later in this section.
The variability of the soil and site conditions means that it is not possible to provide only one set of guidelines. Variation in soil, elevation, site exposure and climate may make establishment difficult.

Before planning a seeding operation, answer the following questions:

- Is seeding necessary?
- Do undesirable plants dominate the site?
- Is weed control practical?
- Is the desired amount and type of seed available and affordable?
- Does the site require additional preparation before the planting can be undertaken?

The answers to these questions will help you in determining the feasibility, timing, cost, and probability of success of your project. In some cases, enough sources of native seed will be present on the site and seeding may actually introduce undesired plant species or genetic variations. Proper management of the land can stimulate the native plants to reproduce and out compete undesired plants. In some areas, the law may require seeding of a disturbed site within a certain period to prevent erosion. Be sure to check with local agricultural and health agencies.

Plant establishment is more likely to be successful if locally adapted species are properly seeded at

the correct time (Horton 1989; R. Mandel, personal communication). Native seeds may be obtained by field collection or purchase.

Collecting Seed

Field collection of local seed has several advantages over purchasing seed: it can be very economical, it ensures that plantings are adapted to local environmental conditions, and it allows for use of species that may not be commercially available. Collecting seed is often most practical for small projects, but can be expanded for larger projects by collecting for several years or by collecting seeds and having them grown in a nursery. The following guidelines refer mainly to collection of seeds from plants with dry fruits that open at maturity. Collection of seeds from fleshy fruits or from fruits that do not open naturally may require different handling. See Young and Young (1986) for more information on seed collection, handling, and storage.

GENERAL GUIDELINES FOR COLLECTING SEED

- Locate collection sites as near to the planting area as possible.
- Identify several collection sites with different elevations, aspects, and geographic locations. Try to find sites separated by at least ¼ mile.
- Obtain permission from the owner to collect seed.
- Do not collect near sensitive plant sites, other environmentally sensitive areas, or weed infested areas. Avoid collecting weed seed.
- Select seeds from at least 30 to 50 healthy, vigorous parent plants at each site. To allow for natural reproduction in the community, leave at least 2/3 of the available seeds.
- Collect when seeds are mature, but before fruits shatter. Correct timing is important and may require observation of parent plants over several weeks. Seeds are usually mature if they feel hard and cannot easily be punctured by a thumbnail.
- Be aware that many native plants will not produce a good crop of strong, viable seeds each year even if flowering seems vigorous. It is possible that efforts invested in seed collection will be repaid at a low level.

HARVESTING AND PROCESSING

There are many techniques for hand harvesting. Some useful ones include the following:

- Cutting: Cut stems as close as possible below the seed head. A grass sickle is a good tool to use.
- Stripping: Wearing gloves, pull along seed heads to dislodge seed into a container.
- Shaking: Gently shake branches to dislodge seeds onto a tarp.

Separate collected seed or seedheads by species, place in paper bags, and label. If seed is going to be used for direct reseeding, a mix of species can be used.

Dry bags of collected seedheads in the sun for about a week with bags placed about two feet (0.5 m) apart, stirring every few days; or dry in a protected area indoors or outside, by spreading plant material in a thin layer on tarps, screens, wood or cardboard. Dry in a sunny area if the

temperature is not over 90° F (32° C). Bring the seed under cover on moist or cool nights and cover with screens if needed to protect from losses by wind or birds.

Clean seed by rubbing seedheads over a piece of 1/8 inch hardware cloth mounted in a wood frame. Dry again for another week in trays lined with newspaper. Cleaned seed can be stored for more than one year. For most species, freezing provides the best long term storage, but storage in a cool, dry environment may be adequate.

● Use caution when buying wildflower seed mixes. Make sure all species are listed and all are native to Colorado.

Purchasing Seed

Native seed should be free of weeds, recently tested for the ability to germinate, and have a high germination rate. Some native species germinate best when seeds are several years old. Consider the following factors to obtain the best possible seed:

- Plan seed orders early, at least 120 days prior to the planting time. This will allow sufficient time to design a seed mix that will perform properly and to check for availability and price.
- Buy seed approximately 90 days prior to planned use. This will allow enough time to examine the seed tags and the seed.

To ensure receipt of Certified Seed, specify the following language on seed orders:

"Certified Seed with blue tags attached to the seed bag shall be supplied where a named variety is specified. The vendor shall indicate on the bid whether Certified or common seed is being offered, as well as the origin of the seed. The blue tags which are removed to mix the seed shall be given to the revegetation engineer. In addition, mix tags showing the weighted averages of the ingredients shall be attached to each bag." (Dunne and Dunne1996)

- Check the seed tags and bag labels to verify you are receiving what you ordered. Seed quality can be improved dramatically by requesting certified seed. *How do you know that you are receiving the variety that you ordered?* The only way to tell for certain is to **receive your desired variety in the original bag with the Certified Seed Blue Tag.**

BUYING PREMIXED VERSUS MIXING YOUR OWN

Buy seed by individual species, unmixed, whenever possible. Buying mixed seed may be more convenient for the buyer, but the buyer should be aware of the hidden risks.

- If Blue Tagged Certified Seed is specified in the mix, there is no way to assure that certified seed will be used. The buyer should ask for the blue tags removed from the bags of certified seed used in the mix.

- The expensive component in the mix may actually be reduced while the cheaper component may be increased.
- Lower quality, weedy lots can be blended into the mix.

If you do purchase mixes, send a good sample in for purity and germination testing to an AOSCA (National Association of Seed Certification Analysts) approved seed lab.

SEED CERTIFICATION

The two types of certified seed that a buyer is most likely to purchase are **Blue Tagged Certified Seed** and **Yellow Tagged Source Identified Seed.**

1. **Certified Seed (Blue Tag)**: In the seed industry, Seed Certification is the means of maintaining the pedigree of a specific variety of seed, such as the named variety "Vaughn" which is a variety of sideoats grama. Each variety is released for propagation because it is deemed superior in one or more characteristics, such as seedling vigor, low dormancy, broad range of adaptability, seed production, forage production, form and color, or palatability. Each state has a seed certifying agency or crop improvement association that writes the rules for seed certification. Some seed growers voluntarily use certification to assure their customers of correctly identified, genetically pure seed. Blue Tagged Certified Seed must meet high purity and germination standards and have a low weed content, usually less than 0.25 percent. **There are no standards for noncertified seed other than state limits on weed, which can be as high as two percent!**

2. **Source Identified Seed (Yellow Tag)**: There is a strong market for native plant materials, but there may not be certified ecotypes available due to a lack of breeding, low supply, or high cost. In many cases a buyer will accept native material if the material was harvested within a prescribed distance from its intended area of use. While the buyer may request the state and county of origin, state seed law only requires that the actual state of origin be on the label. To receive seed from the area you designate, it is advisable to request "Source Identified Seed" in order to ensure that a certification agency has verified the exact location from which the seed was harvested. Source Identified certification is in place in Colorado, New Mexico, Utah, Wyoming and Montana. The inspector travels to the collection site to verify the species, location (county, state, and elevation), the extent of noxious weeds present, and an estimate of the pounds collected on site. Yellow tags do not guarantee that the seed is free of noxious weeds. Buyers should refer to the vendor's label for analysis and weed content, or better yet, test the seed themselves. If the seed is to be mixed by the vendor, the buyer should request that the vendor provide the yellow tags.

Take note of several questionable practices sometimes employed by disreputable seed dealers.

- An accepted practice in the seed industry is to label seed as "Variety Not Stated (VNS)" when the source is not known or where there is an oversupply of a particular variety. Some suppliers, however, have informed their customers that VNS seed is an elite type, but can

not be labeled as such because of marketing restrictions. The supplier may sell this seed for a higher price than "Common Class" but less than the actual certified variety. Seed sold in this manner should be purchased as common since there is no proof as to its origin.

➲ Seed is not certified unless there is a tag attached to the seed bag that clearly states: Certified Seed (Blue Tag) or Source Identified Seed (Yellow Tag). Do not be misled by suppliers who state that the "seed came from a certified field," or "we don't have the tags yet," or "it's just as good as certified." Plain and simple, **bags of certified seed have certified seed tags.**

Reputable seed companies will not use these practices, so it is worth your time to get to know which companies are ethical and trustworthy. The only way to completely ensure that what you receive is what you ordered is through proper sampling and testing (Dunne and Dunne 1996).

Testing seed mixes instead of testing individual species of seeds is more expensive and the results are less reliable.

SPECIAL CONSIDERATIONS

Even though a bag may not have a blue tag, it may still contain the variety claimed. A seed lot may fail certification because

- Purity was slightly lower than the standard for that variety.
- Seed suppliers may not go to the trouble and expense of having the field and cleaning plants inspected by the seed certifying agency since certified seed often does not command a much higher price than common seed.

"Substandard" Notation

Certification for variety and genetic purity means that a seed lot meets high quality standards for purity and germination, and contains strictly limited amounts of other crop seed, weed seed, inert matter and diseased seed. Some seed of varieties in short supply may be labeled "Substandard" if quality factors other than varietal identity and genetic purity do not meet normal certification standards. In some restricted cases, when the substandard factor will not have a detrimental effect on your project, substandard seed may be acceptable for use. The substandard factor will be listed on the certification tag. (Horton 1989, USDA-NRCS 1992, Young 1994, Colorado Seed Growers Association 1996, R. Mandel, personal communication).

ANALYSIS LABELS

In addition to the seed tags, bags of seed should come with an "Analysis Label." Knowing how to read one will prove useful.

Accept only seed with a complete analysis label on the bag and a current germination test conducted by an accredited laboratory. In many states, seed cannot be legally sold without an analysis label. Analysis information and net weight may be written on the bag or on an attached tag. The bag should show at least the lot number. The information found on an analysis label includes:

a) **Variety** and **Kind**: Kind is the species. The variety need not be stated, but if the seed is supposed to be a certain variety, this variety should be listed on the label.

b) **Purity**: Purity is the actual proportion of seeds of the desired species present in the bagged material. Purity + inert matter + weed seed + other crop seed percentages must add up to 100 percent. Graminoid seed should contain no more than 10 to 15 percent inert matter or it will be difficult to plant. Even if the percentage of inert matter is low, seed should not contain pieces of stem or unthreshed clusters that will block passage through a drill. The acceptable purity and inert matter for shrubs and forbs will vary by species and by state. To find out the standards for a given species in Colorado you should contact the Colorado Seed Growers Association at (970) 491-6202 or a National Association of Official Seed Certification Analysts (AOSCA) approved seed testing laboratory.

c) **Weed Seed**: The analysis should indicate that no noxious weed seeds are present (Contact Pitkin County Natural Resources for a copy of the Noxious Weed List). The name and number of seeds per pound of any restricted weeds must be listed on the label. In Colorado the number of restricted weed seeds allowed varies by certification class and species. The general grass seed standards for Colorado are the following:

Table 1: General Grass Seed Standards For Colorado

Factor	Maximum Permitted for Certified Seed
Prohibited noxious weeds	None
Restricted noxious weeds	6 per lb
Total other crop seed	1.00%
Other varieties	1.00%
Other inseparable spp.	0.25%
In graminoid for forage use	0.50%

NOTE: "Other varieties" and "Other inseparable spp." may include aggressive nonnatives that, even in allowed small amounts may pose a long term problem in the reestablishment of native vegetation.

NOTE: Each state has different lists of prohibited noxious weeds and restricted noxious weeds. If you are buying seed from out of state or if the origin of your seed is from out of state, request that the seed be tested with an "All-States Noxious Weed Exam." Colorado state law only requires that Colorado seed testing labs report weeds considered noxious in Colorado. Reputable seed companies will test their own lots of seed regardless of origin and will list for which states they tested noxious weeds. Unscrupulous seed companies may list seed as originating from out-of-state to circumvent Colorado seed laws. Again, the only way to be sure you are not getting a noxious weed in your seed is to test the seed yourself. Although certified seed is worth buying, it does not guarantee that the seed is weed free.

For specific information you should contact the Colorado Seed Growers Association at (970) 491-6202 or an AOSCA (National Association of Official Seed Certification Analysts) approved testing laboratory.

d) **Germination:** Total germination may include the sum of all seeds germinated plus hard seed and dormant seed. Dormant seed is viable but requires time or a physiological stimulus to induce germination. Hard seed is alive but has a thick seed coat that must be scarified, either mechanically, thermally or biologically, before it will germinate. The higher the total germination, the better the seed quality. In general, the germination of a given graminoid species should not be lower than 60 percent, while the germination percentages for various shrub and forb types vary widely by species.

Total germination may be given as a percent followed by "TZ", which means that a staining technique with tetrazolium chloride was used to evaluate seed viability. While this technique can be an acceptable substitute for a germination test, it provides no information about the percentage of hard or dormant seed present. In addition, a TZ test is only as good as the experience of the analyst who administers the test. There are many variables that can give a positive or negative TZ viability indication.

Under Colorado state law, if the seed has been grown in and sold in Colorado, it must have had a germination test within the last year of its date of sale. If the seed has been grown outside of Colorado and is to be brought into the state or if the seed has been grown within Colorado and is to be shipped outside of the state, it must be germination tested within 5 months of its date of sale.

e) **Pure Live Seed** (**PLS**): Most species are sold on a PLS basis, with the price adjusted accordingly. PLS equals the percent purity times percent germination. When given a choice between buying on a PLS or bulk basis, PLS is always preferable.

How To Use PLS

If your plan calls for a specific weight of PLS seed per acre, how much bulk seed is needed? To calculate, divide the PLS percentage into the number of pounds recommended. For example, you want to plant 5 pounds PLS of bluebunch wheatgrass per acre. The analysis label indicates 85 percent pure seed and 79 percent total germination; 0.85 x 0.79 = 0.67 PLS. Divide 0.67 into 5 pounds per acre and you find that 7.5 pounds of bulk bluebunch wheatgrass seed is required to plant 5 pounds PLS per acre.

Testing Seed

Testing seed is the only way to insure the quality of the seed (purity and viability), that you received what you ordered and that no undesirable species are present.

Purity tests will show the percentages of crop, weed and inert matter (material other than seed such as stems or chaff), and tell you if the percentage of each species in the mix meets the standards you ordered.

The terms germination and viability are sometimes used interchangeably, but do not have the same meaning. A germination test will determine how seeds perform under favorable conditions (which are seldom encountered in the field); however, some seeds are dormant and do not germinate even though they are still alive. Dormant seeds have the potential to germinate if dormancy is broken, usually through time and/or physiological stimulus. A viability test will tell you the sum of the percent germinated and percent dormant seeds in a seed lot, providing information on the potential germination of the lot.

Proper seed sampling is very important. The test results received can be no better than the sample sent in. Samples should be sent to a seed lab that tests according to the standards established by AOSCA.

GENERAL PROCEDURE FOR SECURING A SAMPLE FOR TESTING

To secure a representative seed sample, equal portions should be taken from evenly distributed parts of the quantity of seed to be sampled.

- For free-flowing seed in bags or bulk, a probe or tier should be used.
- For non-free-flowing seed, such as certain graminoid seed, uncleaned seed, screenings, or other seed difficult to sample with a probe or tier, sampling should be done by thrusting one's hand into the bulk and withdrawing representative portions. If the seed has been chemically treated, be sure to wear protective equipment. When a sample is taken with the hand the following procedure should be used:
  1. Insert the hand flat and with the fingers together.
  2. Keep the fingers together as the hand is closed and withdrawn.
  3. Hand samples should be taken from various locations in bags or in bulk.
- Composite samples should be obtained in order to determine the overall quality of a seed lot, including factors such as percentage of pure seed, other crop seed, weed seed, inert matter, noxious weed seed, germination, varietal purity, freedom from disease, and effectiveness of seed treatment.
- Individual bag samples may be obtained to determine whether or not the seed is of uniform quality.

SIZE OF SUBMITTED SAMPLE

For a composite sample to test for quality (purity, germination, and noxious weed examination), the sample should contain a minimum of 2500 seeds. Samples can be compiled by carefully weighing a smaller number of seeds and multiplying to obtain the total weight of seed required. Sample weights may vary from a few ounces for very small seeds to several pounds for large seeds. Always contact the testing lab for specific requirements before submitting a sample. To test for uniformity, the size of any individual-bag samples should be no smaller than the amounts specified for composite samples.

SEED TESTING LABORATORIES

The following Colorado laboratories are approved by AOSCA to test certified seed.

Colorado Seed Laboratory
E-10 Plant Science Bldg.
Colorado State University
Ft. Collins, CO 80523
(970) 491-6406

STA Laboratories, Agricultural Testing Services
630 S. Sunset St.
Longmont, CO 80501
(970) 651-6417
1-800-426-9124

Some seed companies have their own seed testing laboratories that are allowed to test and label uncertified seed only.

Seeding Techniques

TIME OF SEEDING

When seed is planted in non-irrigated conditions, the planting season must be chosen to take advantage of natural moisture. Seeding success is greatly influenced by temperature and precipitation; the best germination occurs when temperatures are above freezing and precipitation is high. In Colorado, seasons that reflect these conditions for cool season species are usually the early spring and late fall; seeding should not be done when the ground is frozen. For warm season species, seeding in late spring or early summer is more likely to accompany temperatures warm enough to support germination. For most sites, proper seeding time is dependent on

- A period of adequate moisture for seed germination.
- A period of adequate moisture for early seedling growth and establishment.
- Adequate soil temperatures for seed growth (Ostler and Allred 1987).

It is important to seed a site as soon as final grading and topsoil placement have occurred to minimize erosion and weed establishment on the project. During periods of time when seeding cannot be accomplished, soils should not remain unprotected.

SEEDING METHODS

There are three primary seeding methods: drilling, broadcasting and hydroseeding. The best method to use will depend on

- Site accessibility and terrain
- Seedbed characteristics
- Time of seeding

Percent slope, aspect, soil type and microclimates will influence the moisture and temperature of a site and should be considered when determining the seeding window for the project.

Drill Seeding

- Proven high revegetation rates.
- Most successful on slopes 3:1 or flatter.
- Preferred because seed depths and seeding rates can be more closely controlled.
- Seed-soil contact is high, which maximizes germination results.

- Drill seeding cannot be accomplished where soils are extremely rocky or slopes are steep.
- Unless specially modified drills are used, all seeds, regardless of size, will be planted at the same depth; the smallest seeds are likely to be planted too deep.
- Seeds drilled in rows may suffer from high interseedling competition.
- Drill seeding leaves "rows" which often persist for many years (or even decades on dry sites); this may be a visual or aesthetic liability.

Tips For Drill Seeding

In general, seeding to a depth of 0.25 to 0.5 inches (0.6 to 1.3 centimeters) should be adequate. Seeding should be conducted along the contour to avoid erosion from water flowing down drill furrows.

Greater success can often be achieved with smaller grass seed and forbs by placing them in a separate seed box and alternating the seeding depth between rows or dropping them directly on the ground to be covered by the action of heavy, trailing chains.

The following components are required in a drill suitable for general use in native seeding:

- Multiple seed boxes for different types of seed (agitators and picker wheels in at least one box for fluffy seed).
- Double disc furrow openers
- Intact depth bands with functioning scrapers on all disc openers to ensure consistent, uniform seed depth placement
- Seed tubes, which drop between disc openers, large enough to handle fluffy seed
- Packer wheels with adjustable tension, to provide proper soil compaction over and adjacent to the seed
- Coulter wheels to allow penetration of furrow openers where seeding into heavy mulch or cover crop.

Broadcast Seeding

Careful attention to seedbed preparation is critical, especially harrowing/raking both before and after seeding.

- Can be used on slopes that are steep, extremely rocky, remote or inaccessible.
- The variable planting depths that result from broadcast seeding allows better establishment of smaller seeds than with drill seeding.
- Resulting vegetation not in "rows", which is more aesthetically acceptable on many sites.
- If broadcasting is not performed correctly, germination and seedling establishment tends to be slower with this method.

- Broadcast seeding **requires double or triple the seeding rate of drill seeding**, and calibration of seeding rates is less precise than with drill seeding

Hydroseeding

The hydroseeder consists of a water tanker with a special pump and agitation device to apply the seed under pressure in a water slurry. Seed is sprayed on a roughened slope using a hydroseeding machine.

- The water spray can reach areas that are inaccessible by drilling methods.
- The results of hydroseeding are less satisfactory than the results of drill or broadcast seeding because the seed does not make a good soil to seed contact. As a result, fewer seeds germinate. In addition, the slurry mix often rolls off the steep, hard slopes it is applied to, leaving very erratic and uneven distribution of seed.
- As a rule of thumb, hydroseeding in areas receiving less than 20 inches (51 cm) of precipitation will be unsuccessful.
- Hydroseeding is dependent on local water supply for the hydroseeding slurry.

Tips For Hydroseeding

Hydroseeding may be a good choice for seed that needs sunlight for germination, such as sand dropseed and sagebrush. However, its use should be limited to steep, inaccessible slopes in areas with adequate and dependable moisture during the growing season.

- Be aware that the sheet flow of sprayed water on steep, impermeable slopes may wash the seeds off the slope.

Hydromulching should occur as a separate process after hydroseeding. Do not mix seed and mulch together in one water application process because this will prevent seeds from coming into contact with the soil.

Post Seeding Techniques

After seeding, most sites will benefit from placement of a protective mulch cover. Such covers protect soil and seeds from erosion by wind and water, and conserve soil moisture from the effects

Tips For Broadcast Seeding

Soils “accept” broadcast seed much better if they have been very recently raked or harrowed to eliminate crusting. After broadcasting the seed, cover the seed by harrowing, chaining, raking or using a similar technique. Raking or harrowing immediately before and after broadcast is highly recommended.

Care should be taken when seeding to provide uniform coverage (even seed application rates) over the site. Seeding should not be attempted on windy days.

of wind and sun. To be effective, mulches must cover the ground nearly completely and have sufficient durability to survive until the seeds germinate.

MULCH TYPES

In general, mulch should be applied immediately after seeding to protect seed and to avoid disturbing germinating seeds. The following are commonly used mulch types:

Hay

- These materials are often relatively inexpensive to apply.
- Native grass hay may be available in some areas.
- May introduce undesirable weeds or non-natives that will destroy carefully planned and acquired native plantings.

Tips For Using Hay Mulch

In general, hay mulches are more durable the longer the average unbroken stem length. Loose hay is usually highly susceptible to being blown off the surface in most Colorado sites. To counteract this shortcoming, hay is often "crimped" into the soil surface by using a modified disc plow to jam the hay stems into the soil. This does little directly to enhance or stabilize the important cover function of mulch but it can mimic the effects of reducing surface wind speeds and soil desiccation that stubble mulch provides.

Durability of the applied mulch cover is also enhanced by addition of organic tackifier products that "glue" (at least temporarily) the hay to itself and to the ground.
When used, hay is typically applied at the rate of 3,000 to 4,000 pounds per acre (3360-4480 kg/ha).

- Weed content of such material must be very carefully monitored and controlled by inspection and certification as required in project specifications.
- Straw is often used for this purpose, but the almost inevitable inclusion of grain seed in straw materials makes the use of straw highly inadvisable because of the competition that results from germinating grain plants.
- Do not use hay of nonnative species such as smooth brome that may germinate and compete with seeded natives.

For hay mulch, a list of certified weed-free hay producers is available from the Colorado Department of Agriculture. The list can be faxed or mailed to interested parties.

Colorado Department of Agriculture
Division of Plant Industry
700 Kipling Street, Suite 4000
Lakewood, Colorado 80215
303-239-4149

Tips For Planted Stubble Mulch Crops

Wheat, rye, and barley should not be used unless they will be mowed before seed maturity, since they produce seed that will compete with the seeded native species.

The annual forage graminoids must be mown prior to seed maturation to prevent reseeding and allow easier drilling of the permanent seed. Planting into such cover requires a grass or no-till seed drill equipped to handle low tillage and high "trash" conditions.

Stubble mulch is most appropriate on low-slope sites because water erosion control capabilities of such covers are limited. Steep slopes such as highway embankments require very intensive efforts and careful species selection to control erosion.

Planted Stubble Mulch Crops

Annual grasses, such as sterile forage sorghums, sudan, or forage millets, are planted the growing season prior to permanent seeding. After crop maturation, native seeds are sown into the residual standing dead material. This method differs distinctly from use of a "nurse crop" in which the annual grain and the perennial mix are planted simultaneously. The "nurse" usually ends up out competing the slow-growing perennials. In a relatively few locations, where moisture can be anticipated to be sufficient to support both the nurse crop and the native seedlings, the method may be beneficial.

- Very cost effective method of providing mulch cover.
- Potential for rill erosion.
- Not recommended for steep slopes.

Hydromulch

Wood fibers are mixed into a water slurry and sprayed onto the ground surface to apply a mulch coating of varying thickness. Hydromulch should be applied separately following seed application. The hydromulch mix is often colored green to assist operators in applying an even cover during spraying. The green color usually fades to tan or gray within a few weeks.

- Overspraying may result in erosion.
- Substantially more expensive than other mulch types.

Tip For Using Bonded Fiber Matrix

The key is to find a certified contractor who knows how to apply the material appropriately.

Tips For Using Hydromulch

An organic tackifier is typically added to the slurry to enhance the durability of the applied mulch cover.

Although typically applied at a rate of approximately 1,500 pounds per acre (1680 kg/ha), it is more effective at a rate of 3,000 pounds per acre (3360 kg/ha) with a guar gum tackifier.

Bonded Fiber Matrix

Bonded fiber matrix is a relatively new product. It is essentially a spray-on mat consisting of a continuous layer of elongated fiber strands held together by a water-resistant bonding agent which creates a very durable and ground-fitting cover.

- ❖ Bonded fiber matrix is especially useful where steep and very rocky surface conditions would make the use of mats ineffective.

- ➲ Great care must be exercised by trained technicians to apply the correct ammount of material. A continuous cover is needed to create the integrated shell, but if the material is applied too thickly it can prevent penetration of seedling shoots.

Erosion Control Mats or Blankets

There are a large variety of mats which can perform the function of mulch. Mats composed of aspen shavings attached to or sandwiched between one or two plastic nets have long been used with good success. There are also many mats comprised of different combinations of coconut fiber, straw and other materials that double as both mulch and erosion control.

- ➲ Erosion control mats are generally expensive (although the least expensive are similar to bonded fiber matrix).
- ➲ Installation on rough ground is less efficient because the mulch to ground contact is poor compared to other mulches. Where the surface is very rocky, material ends up suspended above most of the surface stretched between protruding rock “peaks.”
- ➲ Some mats have unsightly plastic netting that does not biodegrade and can be stripped off in large pieces by wind or wildlife.
- ➲ Plastic netting has been reported to trap snakes, whose scales become snagged on the monofilament netting.
- ➲ Paper mats are not recommended in Colorado. They have a tendency to form a paper-mâché-like crust which makes it difficult for plants to sprout.

Planting

Planting can compliment seeding efforts and increase the overall success of a restoration project and should not be overlooked because of the initial higher cost. Planting will be most desirable and cost effective when

Tips For using Erosion Control Mats

Biodegradable netting (not to be confused with "photodegradable" plastic netting) is available from some manufacturers at a slightly higher cost.

Mats are most cost-effective when used on areas where erosion potential is high and the site surface is relatively smooth.

- The desired species are difficult to establish from seed, unavailable, or the only seed sources available have low germination rates.
- The revegetation site is highly erodible or quick results are needed for aesthetic reasons.
- The revegetation site has abnormally stressful environmental conditions, such as extremely low nutrients, alkalinity, salinity, erosion potential or a short growing season.
- The existing plant community will present severe competition during seedling establishment.
- A need for more rapid plant establishment exists than can be met through seeding.

If planting is limited by budget constraints, fewer plants may be used by creating islands of more mature plants, with the following results:

- A more diverse and natural looking landscape.
- A central, established stand of native plants which can reproduce and spread.
- Creation of habitat for wildlife.

In general, site establishment from plants is far more rapid than from seed. (Ostler and Allred 1987, R. Mandel, personal communication).

➲ Be aware that nursery stock is costly, and that a successful project will require additional effort and investment to protect planted stock from both wildlife predation and competition from other vegetation (see Protection of Plantings on page 22).

There are two basic options for obtaining native plant materials: 1) purchasing stock from a nursery, or 2) collecting or salvaging plants in the wild, either from the site itself before it is disturbed or from near-by areas.

Plant Materials

BAREROOT AND CONTAINERIZED

Bareroot and containerized plants are common types of transplant stock usually purchased from a nursery. If you are purchasing plant materials from a commercial supplier, the decision to use bareroot or containerized stock should be based on the information summarized in Table 2 below.

With containerized stock, the choice of container size and shape should be based on

- Species.
- Seedling size and growth tendencies.
- Characteristics of the site to be planted.
- Economics.

Larger containers are more expensive to purchase, transport, store, handle and transplant. However, post-transplant growth has been shown to increase with container sizes. In addition, deeper containers are less likely to result in root spiraling for tap-rooted species. Finally, as a whole, larger stock performs better under more adverse site conditions (Landis and Simonich 1984).

Ideal ages of containerized stock

herbaceous plants	1 to 3 years
woody plants/shrubs	3 to 5 years
trees	5 to 10 years

Table 2: Bareroot vs Containerized Planting Stock

	Bareroot	**Containerized**
SPECIES TYPES	Shallow root systems	Deeper or tap-rooted systems
Processing and planting	Require greater care and planning during shipping, storage, handling, and planting.	Shorter production periods and increased survival after transplanting due to less root disturbance during processing.
	Require irrigated or moist soils.	Perform better on adverse sites, especially in rocky or high-stress areas.
Processing and planting	Lack the advantage of being established with their own soil.	Established with their own soil to which beneficial amendments can be added before planting at the site.
Scheduling	Must be either harvested in late fall, after the onset of dormancy, and held over the winter in cold storage or harvested early in the spring, before the onset of leaf emergence, and directly planted to the field.	Can be established during the spring or fall or any other time of the year when there is adequate moisture and favorable site conditions.

Table 2: Bareroot vs Containerized Planting Stock

	Bareroot	Containerized
	The time from nursery establishment to lifting varies from approximately 1 to 3 years.	The time from nursery establishment to lifting averages less than 2 years.
Cost	Cost less and, as a consequence of their relatively lighter weight, are less expensive to ship.	More expensive to produce and ship.

(Landis and Simonich 1984, Shaw 1984, Ostler and Allred 1987)

Ordering And Delivery

Order bareroot or containerized seedlings **from 1 to 4 years in advance** of the planting date. In general, containerized seedlings should be ordered from between 1 to 2 years prior to planting; bareroot seedlings should be ordered from 2 to 4 years prior to planting (Townsend et al. 1993, Shaw 1984). Advanced planning and ordering will ensure the availability of desired species and proper hardening of the stock. In addition to their standard stock, some nurseries offer custom growing and may be able to propagate materials that are collected from the project site. However, custom grown materials have a higher initial purchase cost and may require additional production time as well as an initial contract and down payment (Townsend et al. 1993).

Upon receipt, all containerized stock should be examined to ensure

- It has a root system adequate to hold the ball together but is not root bound.
- It is adequately hardened.

Hardening is the process of plant adjustment to cold temperatures. During hardening, a seedling's growth is reduced, stored carbohydrates accumulate, and the plant becomes more able to withstand adverse conditions. Hardening is a gradual process, accomplished by reducing the supply of moisture, altering the nutrient balance, reducing the temperature, and increasing the seedling's exposure to direct sunlight as well as to other environmental conditions typical of the planting site. If conditions at the planting site are much different from those at the nursery, site hardening may also be beneficial. The hardening process can not be rushed or accomplished at the last minute. Seedlings which are stressed just prior to establishment have reduced survival rates (Ostler and Allred 1987).

The handling and transportation of bareroot materials must be more carefully planned than that for containerized materials due to their exposed root mass (Shaw 1984, Ostler and Allred 1987). Most nurseries package their seedlings prior to delivery in order to protect their materials during shipping and handling. Seedlings are usually shipped either via express transportation services or in enclosed, refrigerated vehicles. Shipment should not be made in open vehicles or trailers to prevent desiccation and wind damage (Townsend et al. 1993).

The physiological state of the plants should be examined upon delivery. Potential dormancy problems can be indicated by:

- Elongated buds.
- Leaf emergence.
- Root growth and/or elongation of white root buds.
- Root molds (not to be confused with mycorrhizae).

The seedlings should also be examined for their moisture level, which can be determined by observing the root condition, the twig, needle or root flexibility, and the overall appearance (Townsend et al. 1993).

- Any damage or deficiencies in the stock should be immediately reported to the nursery and/or contractor from whom it was received. If deficiencies occur in the number of plants shipped or the packaging or transportation procedures, the nursery should be able to correct the problem. If serious problems are noted for the received materials, they should not be planted and should be classified as cull stock. Again, in such case, contact your nursery and/or contractor to correct the problem before payment is made (Townsend et al. 1993).

Protection of Plantings

- Nursery plantings, especially shrubs, trees and weaker forbs/grasses, will suffer from competition from other vegetation unless they are properly protected. Use a square or circle of landscape cloth or similar material up to 9 ft^2 (1m^2) and cover with mulch to moderate soil temperature rise and extend the life of the cloth.
- At many sites, protective tubes or cages should be installed on trees and shrubs to protect them from wildlife predation until they are well established.

SALVAGE

An alternative to purchasing plants is to collect them in the wild (refered to herein as “salvage”). Salvaging native plants is ideal because 1) locally-adapted plants are “recycled,” 2) success of transplant survival can be high when the native soil accompanies the salvaged plant, and 3) salvaged plants can be more cost effective than purchased plants, especially for projects with limited budgets but plenty of labor (paid or volunteer). Salvaged plants can either be directly transplanted onto another site or potted and tended until the next planting season.

- Salvaging from areas that have noxious weeds or undesirable plants should be avoided.

Acquiring Salvaged Plants

There are several ways to obtain salvaged plant material.

- Native plants or sod on sites slated for development can be salvaged. This method requires some advanced knowledge of construction areas and planning for the destination of salvaged plants.
- Small numbers of plants may be transplanted from sites ecologically similar to the revegetation site. Do not remove too many individual plants when collecting from such sites. This method is suitable for small restoration projects only.
- If you are planning your revegetation project in advance of the site being disturbed, plants can be salvaged from the site itself.

What To Salvage

Some experimentation may be necessary to determine which native plants are best for salvage; here are some general guidelines.

- Plants that reproduce through vegetative sprouting (root shoots) should be ideal for salvaging.
- Native plants that grow in disturbed areas have been found to be particularly suited for transplanting (Goeldner 1995).

- Plants with taproots and extensive root systems are least likely to tolerate transplanting.
- Diseased or weak plants should be avoided.

Native salvaged seedlings should be provided with as much of a competitive edge as possible.

- Direct transplants should be watered at the time of transplanting, and will benefit greatly from supplemental waterings. Generally, direct transplants will require at least one year of regular waterings. A soaking once every three weeks should be sufficient in cool weather, with increased waterings during warm periods.
- Dormant plants that are potted need to be watered periodically through the dormant season. A soaking once every three weeks should be sufficient in cool weather. Increase waterings during warm spells.
- All salvaged plants should be weeded to prevent contamination from the donor site.
- For wetland plants, water is more critical than soil in plant salvage since wetland plants do not rely on soil microbes and mycorrhizae for survival. Bareroot plants from wetlands can be salvaged and even stored for short periods of time if the plants are kept cool and in a shallow bucket or pool of water. Wetland plants can also be salvaged and transplanted in the summer months as long as the salvaged plants are transplanted directly into wet or moist soils.

When To Salvage

The ideal time to salvage plants is from October to April. Plants can be salvaged at other times of the year if one-third to two-thirds of the plant is cut back and a good rootball is saved and

kept moist. A typical salvage day might consist of digging up plants in the morning and transplanting on another site or potting the plants in the afternoon.

Any plants held over the dormant season or held in a temporary salvage nursery should be transplanted as soon as possible to increase the survival of the salvaged plants. If plants are dug up when dormant, they can also be "heeled in" in a pile of mulch or soil, and kept moist until they are transplanted. Dormant plants that are potted will need to be watered periodically through the dormant season.

Salvage when the soil is moist. If salvaging by hand, transport plants or chunks of sod in plastic grocery bags or moist burlap bags to conserve water. Heavy machinery can be used to move large areas of sod or clumps of shrubs.

CUTTINGS

Some native planting stock is more easily and cheaply produced from cuttings. Cuttings can also be used to maintain the genetic identity and desirable traits of parent material. Plants can be propagated from cuttings as poles, wattles (fascines) or whips. Poles, wattles/fascines and whips are techniques used primarily with cottonwood, poplar and willow propagation for riparian stabilization and restoration (Mandel 1990, R. Mandel, personal communication).

"Heeling in" consists of digging a trench with a sloped side, laying the plants at a 45 degree angle, and placing soil over the root ball to provide winter protection. This system provides more even soil moisture within the ball and prevents the root system from freezing during low temperature periods. Water thoroughly, especially if the soil is dry.

When roots form, the cuttings should be transplanted to containers. After several months of greenhouse acclimation, the transplanted cuttings should be gradually hardened off and used as containerized stock for transplant establishment (Mandel 1990).

SOD

The use of sod is confined to rhizomatous and stoloniferous graminoids. It is not well-suited for use with bunchgrass. Sodding with native species is an effective means of providing rapid plant establishment on critical slopes, grassed waterways, reconstructed drainages, and other priority areas. Sodding can also be used when a desired species produces little viable seed (e.g., inland saltgrass) (Shaw 1984).

While cuttings, sodding, and plant salvage are all valid means of site establishment, they are less commonly used for upland species reintroduction than are containerized or bareroot stock.

Native sod (usually buffalograss) can be purchased from a commercial vendor or can be salvaged (see below). Watering will most likely be required for sod to be successfully established.

Planting Techniques

All stock, whether purchased or salvaged, should be handled as little as possible before transplanting. Even a few minutes of root exposure or extended shoot exposure to warm temperatures and/or high winds can result in plant damage and reduced survival. Only the minimum number of seedlings necessary to complete a designated section of the planting should be removed from their containers/packaging at any one time (Townsend et al. 1993).

STORAGE

Ideally the planting site will be fully prepared and all personnel ready to begin planting when seedlings are delivered. Short-term (under two weeks) storage at the planting site can be facilitated by "heeling in" bareroot materials or by constructing a temporary storage facility for containerized stock.

- Heeling-in must be done in such a manner as to ensure good soil coverage and protection from moisture loss. Roots should be adequately covered with soil to the root stem, tamped-in, and immediately watered (Townsend et al. 1993).
- All materials should be stored in a fenced area which minimizes the chances for damage from humans, birds or animals and should be adequately watered and protected from excess sun, wind and cold.
- Transplanting stock should be checked daily for moisture, cold-tolerance, insect or animal damage, and disease.
- With proper timing, most deciduous species can be safely stored for more than 90 days.
- Plants which are stored for extended periods should have adequate root ventilation to minimize heat build-up from respiration (Townsend et al. 1993, Shaw 1984, Ostler and Allred 1987, Landis and Simonich 1984).
- Fall-lifted bareroot transplants can be over-wintered in an appropriate cold storage facility. Proper cold storage involves over-wintering dormant transplants between 34° and 40° Fahrenheit (1°- 4° C) and at approximately 86 percent relative humidity.

➲ Some species, especially those with persistent leaves, can not be stored for more than one week without risking damage and/or mold infestation.

WATERING

All temperate western plantings require supplemental moisture at the time of planting, unless they are being transplanted into a wetland or riparian habitat. Whenever possible, soil moisture reserves should be built up prior to plant establishment. This can be accomplished through the use of irrigation and/or snow-fencing on the windward side of the planting area (Townsend et al. 1993). As a general rule, properly hardened transplants should be planted in early spring, as soon as the ground has thawed and while moisture is available.

In general, larger sized or bareroot and salvaged materials will require more moisture than smaller sized and commercially obtained containerized seedlings. At least two quarts (1.9 l) of water per bareroot tubeling and at least one gallon (3.8 l) of water per containerized plant will be needed.

PLANTING

Planting holes may be made with motor-driven augers, planting bars, hoedads, picks, shovels or other means. To avoid drying out the soil, do not excavate holes too far in advance of plant establishment. Holes must be deep enough to allow roots to penetrate into the soil and wide enough so that the roots will drop in at approximately their natural form. However, to minimize labor costs, excavation time, and moisture loss, hole size should not be any larger than necessary.

Place transplants quickly but carefully into the holes to minimize drying the roots. Insert plants into the hole as close to vertical as possible. Plant roots should not be bent, kinked or tangled, or bunched up at the bottom of the hole. Once the seedling is placed in the hole, pack the soil firmly around the root in order to avoid air pockets. Be careful not to mash the roots between the tamped soil and the surrounding substrate. The soil line should be maintained 0.5 to 1 inch (1.3 to 2.5 cm) above the root plug.

To assure good soil to root contact and minimize air pockets, all transplants should be irrigated at the time of establishment. At least two quarts (1.9 l) of water should be used per tubeling and at least one gallon (3.8 l) of water should be used per containerized plant (Townsend et al. 1993, Ostler and Allred 1987).

Planting On Steep Slopes

Working on steep slopes requires that planters begin at the top of the slope and traverse, eventually working downslope. Do not work below another planter; they may dislodge soil which will bury the plants below. The positioning of transplants on steep slopes is critical. Form precipitation catchment basins approximately 12 inches (30 cm) in diameter around each transplant to trap additional water and prevent soil erosion around the plant. Scrape the area directly up-slope from the planting hole with a hoedad or shovel to remove excess soil which might slough off and bury the seedling. Position the hole near the outer lip of the basin to prevent the plant from being covered by soil eroding from above or exposure of the roots by erosion. Align the crown of the transplanted plug with the plane of the undisturbed slope. Again, to assure good soil to root contact and to minimize air pockets, all transplants should be irrigated at the time of establishment (Ostler and Allred 1987).

> In addition to providing moisture and reducing transplant stress, the supplemental water will assist in packing soil around the transplanted root systems and eliminating any remaining air pockets, ensuring good soil to root contact (Ostler and Allred 1987, Townsend et al. 1993, R. Mandel, personal communication).

A Note About Fertilizer

Test the soil from the planting site before adding any amendments. Once you have determined the actual site nutrient conditions, compare these conditions with those considered optimum, if that information exists for the species involved. The available literature differs on its opinions concerning fertilizer use at the time of transplanting. Ostler and Allred (1987) state that Osmocote tablets, a commercial slow-release fertilizer, should be included at the bottom of the transplanting hole to assist with establishment. Wallace (1987) and Mandel (personal

communication) report that many native species, especially those with increased drought tolerance, react adversely to fertilizer use at the time of establishment. With such species, even mild fertilization can cause root-dieback and shoot burning. It is also an excellent idea to consult with a nursery, a plant ecologist, or the Natural Resource Conservation Service (NRCS) in order to determine the specific requirements (Wallace 1987, R. Mandel, personal communication).

APPENDIX I. ACKNOWLEDGMENTS

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