Chapter 13
Revegetation

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(Note: Figures 13-3 through 13-19 located at end of chapter.)

1.0 Introduction

Revegetation is critical to the proper functioning of detention basins, retention ponds, wetland basins, riparian areas. Revegetation is also necessary to stabilize adjacent areas disturbed during construction. Successful revegetation is required to close-out common regulatory permits associated with working in waterways, including stormwater discharge permits associated with construction activities and U.S. Army Corps of Engineers (USACE) 404 permits. Because of Colorado's semi-arid climate, prevalence of introduced weeds, and difficult soil conditions encountered on many projects, revegetation can be challenging and requires proper planning, installation, and maintenance to be successful.

Urban Drainage and Flood Control District (UDFCD) recommends that engineers include a revegetation specialist (i.e., ecologist, landscape architect, and wetland scientist) who is experienced in restoration ecology and local native plant communities as part of the overall project team to assist with project planning, direction, construction observation, monitoring, and long-term maintenance supervision for revegetation aspects of drainage projects. Early involvement of qualified professionals can help to identify site constraints and site preparation requirements, identify sensitive areas that should be protected during construction, select appropriate plants and installation procedures, and develop plans for continued plant establishment once the construction phase is complete.

This chapter provides guidelines and recommendations for revegetation efforts associated with drainage and water quality facilities. The guidance addresses three habitat types: uplands, riparian areas, and wetlands. For each habitat type, guidance is provided with regard to site preparation, plant material selection and installation, maintenance and post-construction monitoring.

Many municipalities have their own seed mixes and revegetation specifications that apply to development projects. When local guidelines and criteria differ from the criteria in this chapter, the engineer and revegetation specialist should work with the municipality to determine the appropriate revegetation criteria. UDFCD may also specify additional or different site-specific requirements, depending on site-specific considerations.

2.0 Habitat Types

There are three general habitat types or "planting zones" encountered on drainage-related projects: upland, riparian and wetland areas. As shown in Figure 13-1, these habitat types are characterized primarily by moisture and frequency of flooding, which affect the types of vegetation appropriate for each zone. Some streams may include all three habitat types, whereas on other streams some of the habitat types may be narrow or absent.

Basic descriptions of each habitat type are provided in Sections 2.1 through 2.3. It is important to recognize that although the revegetation sequence for each habitat type is similar, each habitat type has unique characteristics requiring somewhat different approaches and challenges to revegetation. For example, proper soil preparation and weed control are particularly important for upland revegetation projects. For riparian areas,

Cross-references to Related Urban Storm Drainage Criteria Manual (USDCM) Revegetation Criteria

- *Open Channels* Chapter: Stream Restoration, Naturalized Channels, and Swales
- Water Quality BMPs: BMP Fact Sheets for swales, buffers, bioretention and others in Volume 3, Treatment BMPs
- Construction Site Revegetation: BMP Fact Sheets for temporary and permanent seeding and mulching in Volume 3, Construction BMPs
- Extensive reference list at the end of this chapter for additional information on revegetation

addressing streambank erosion and properly assessing water levels for installation of cuttings and other plant material are important. For wetlands, adequate assessment of site hydrology to determine whether a site is capable of supporting wetlands is fundamental to success.

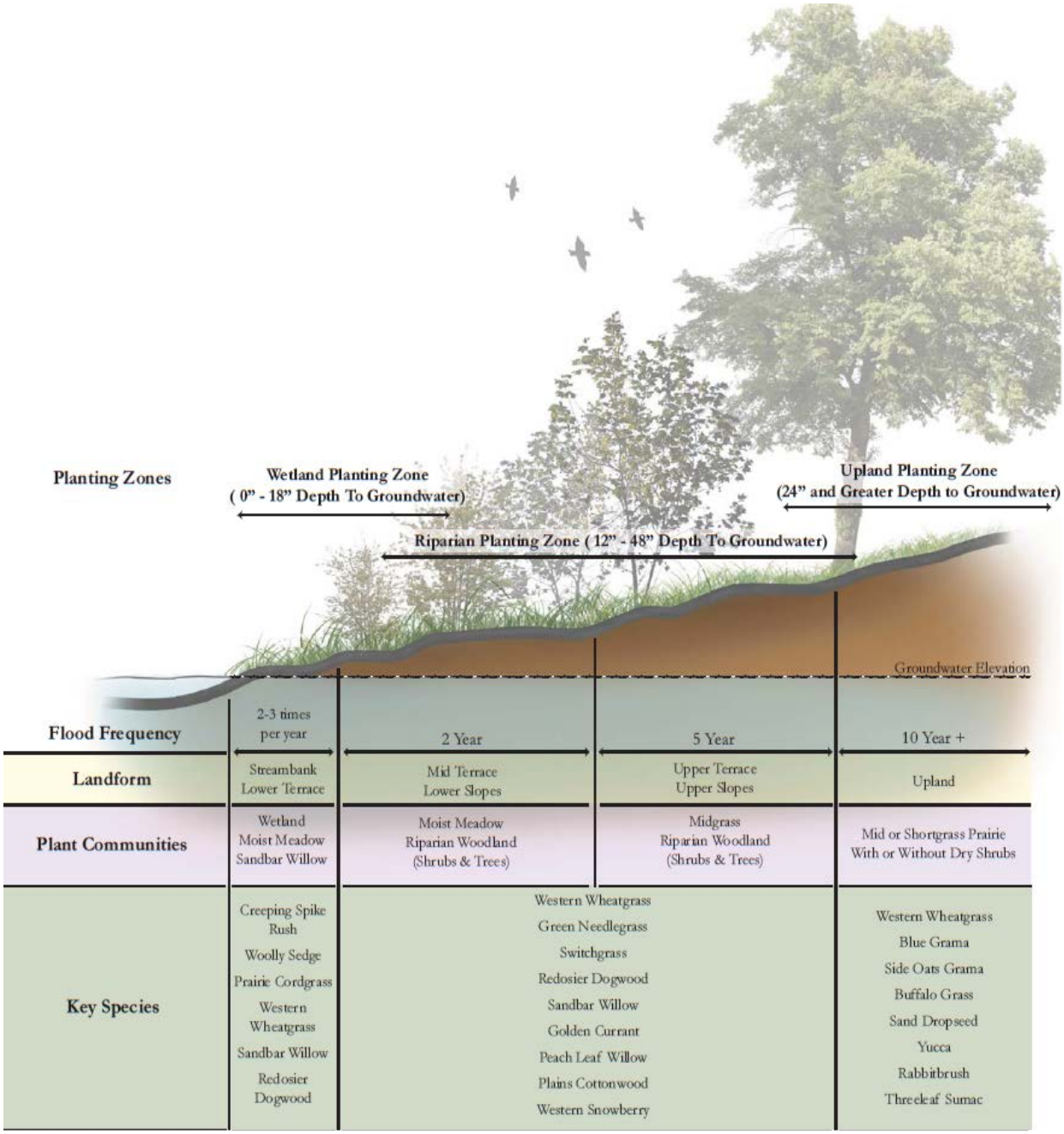

Figure 13-1. Wetland, riparian and upland habitats and planting zones

2.1 Upland

Native upland areas in the UDFCD area include plains grassland, shrubland, and/or woodland/forest. Plains grassland is the dominant upland vegetation type and is characterized by low-growing grasses, forbs, and scattered shrubs. Shrubland and woodland/forest are characterized by upland trees and shrubs. Upland areas can contain a combination of all three habitat types. Native upland vegetation is generally xeric, and these plants are well adapted to the UDFCD region with average rainfall of 15 inches per year. If a site is properly prepared before revegetating and the desired plant palette is correctly selected and planted in the appropriate season, average annual rainfall should be adequate for vegetation establishment (Colorado Natural Areas Program 1998).[1]

Common Front Range upland vegetation includes upland shrubs such as rabbitbrush (*Chrysothamnus nauseousus*), sage (*Artemisia* spp), and three-leaf sumac (*Rhus trilobata*) with an understory of upland grasses and herbaceous species. Trees are less common in the upland zone although there are several native species of both upland deciduous and coniferous trees located in this zone.

2.2 Riparian

Front Range riparian ecosystems are located directly adjacent to rivers, streams, creeks, ponds and other waterbodies. Riparian areas are shaped by the dynamic forces of water and are regularly inundated by rivers and streams. They provide flood control, streambank stability, nutrient cycling, stream food web support, pollutant filtering, sediment retention, and wildlife movement and migration corridors. In addition to these functions, they also provide passive recreational open space areas that are amenities in urban areas.

Photograph 13-1. Revegetation in progress in a riparian area along a recently constructed grade control structure. (Photograph courtesy of WWE.)

The riparian zone is generally flat with layered soils that have been deposited by previous flood events. On average, this zone floods every 2 to 5 years and is generally flat with layered soils that have been deposited by previous flood events. The riparian zone represents a transition from areas supporting water-adapted plant species to those supporting upland plant species. Common Front Range vegetation found in this zone includes an overstory of plains cottonwood (*Populus deltoides*), peachleaf willow (*Salix amygdaloides*), and box-elder (*Acer negundo*) with an understory of sandbar willow (*Salix exigua*), other native shrubs and transitional area grasses and herbaceous species. Large, inflexible trees and shrubs should not be planted in this zone because they may exacerbate flooding during high flow events by catching debris (or becoming debris).

Technically, riparian areas include several different plant communities and types of habitat, but for the purpose of this chapter, discussion of "riparian" areas generally refers to areas within the floodplain that are not wetlands.

[1] Because an "average" rainfall year cannot be assured, supplemental irrigation may be required for germination and establishment of vegetation in drier than average years.

2.3 Wetlands

As defined by the Clean Water Act (40 CFR 230.3(t)), wetlands are "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas." In lay terms, wetlands can be thought of as transitional areas between open water and dry land. Their unique character allows them to provide an array of valuable functions including water quality improvement, floodwater attenuation and storage, soil stabilization, fish and wildlife habitat, and food web support. In Colorado, creation of wetlands in excess of the wetland area disturbed and creation of wetlands where wetlands did not exist historically requires a water right.

Photograph 13-2. A recently revegetated wetland channel. (Photograph courtesy of Iris Mitigation and Design.)

The wetland zone along stream channels is located between the average water elevation and the bankfull discharge elevation (Figure 13-1). The lower section (near the streambank) is exposed to the highest velocity flows and typically has the highest potential for erosion (NRCS 2001b). The higher section (transitions into the lower riparian zone) is inundated less frequently and is exposed to less erosive forces. In high velocity streams, this zone may be naturally unvegetated. In lower velocity streams, it is often vegetated with water-tolerant herbaceous plant species. Flexible-stemmed willows and low-growing shrubs capable of withstanding frequent inundation should be planted in the lower section of this zone. Common Front Range wetland species include sandbar willow (*Salix exigua*) and redosier dogwood (*Corns sericea*) with an understory of wetland grasses, sedge and rush.

Prior to initiating a wetland revegetation plan, it is important to recognize that different types of wetland projects will require different approaches. Three general types of wetland projects include:

- Created wetlands that are constructed in upland areas that have not supported wetlands historically.
- Restored wetlands that are reestablished where a wetland existed historically but is no longer present.
- Enhanced wetlands that are existing wetlands improved to address degradation (usually human caused). Enhancement may include removing or constructing berms, filling ditches, grading, and/or modifying vegetation communities

3.0 Site Preparation

Initial evaluation of site conditions and appropriate site preparation are fundamental to successful revegetation for upland, riparian and wetland habitat types. Table 13-1 provides a summary of site preparation activities pertinent to each habitat type. Guidelines for each activity are provided in Sections 3.1 through 3.6.

Table 13-1. Site preparation activities for revegetating upland, riparian and wetland habitats

Revegetation Guidance Topic		Applicability to Habitat Type		
Activity	**Chapter Section**	**Upland**	**Riparian**	**Wetland**
Initial Hydrologic Evaluation	3.1		✓	✓
Initial Weed Evaluation and Control	3.2	✓	✓	✓
Topsoil Preservation (including Existing Wetland Soil)	3.3	✓	✓	✓
Soil Testing	3.4	✓	✓	✓
Soil Amendment	3.5	✓	✓	✓
Seed Bed Preparation	3.6	✓	✓	✓
Tree Protection	3.7	✓	✓	✓

3.1 Initial Hydrologic Evaluation

One of the most critical aspects for the successful revegetation of riparian and wetland areas is having sufficient hydrology to support the plants. An initial hydrologic investigation should be performed for both riparian and wetland revegetation efforts. According to Zedler and Weller (1989), understanding hydrology is the most basic and important need for a successful wetland project. During the planning process, the depth to groundwater and fluctuations in the groundwater depths should be monitored for at least one year (preferably longer, if feasible) for both riparian and wetland areas. The installation of monitoring wells and piezometers provides valuable information about groundwater levels. If limited groundwater data are available (i.e., from geotechnical reports or only one year of monitoring), it is very important to understand the data in the hydrologic context (e.g., wet year, dry year) and season in which it was collected.

As part of the wetland planning process, rigorous investigation of potential water sources should take place. Potential sources of water include groundwater, surface water, and precipitation. If the wetland's hydrology is to originate primarily from surface water, such as from a river or stream, water elevations near the proposed wetlands should be measured repeatedly during the active growing season (approximately April through September). Typically, multiple years of data are needed to make reliable determinations on water availability, since any given year may be wetter or drier than average. Groundwater levels adjacent to the stream or river should also be assessed to determine whether the river or stream is a gaining or losing system (i.e., either supplemented by the groundwater or losing water to the groundwater, respectively). In conjunction with detailed land surveys (preferably 1-foot contours), known groundwater levels and surface water levels can help to assess whether the final wetland grade will provide the hydrology necessary for supporting wetland vegetation. It is also important to consider temporary and/or periodic activities that may influence groundwater, including nearby wells, construction dewatering and/or plans for future buildings nearby that may require subterranean dewatering. Long-term monitoring wells, which may be used to collect groundwater data required for design, will require a separate state well permit.

For riparian area planning, it is important to recognize that plantings must have contact with groundwater to survive. In the semi-arid West, groundwater often fluctuates throughout the year. If the depth to groundwater precludes planting/seeding species that require more available moisture, upland (also known as xeric) plant species may need to be seeded/planted instead of riparian plant species.

3.2 Initial Weed Condition Evaluation and Control

Weed infestations and, in some cases, non-native aggressive grasses that prevent the establishment of the desired native vegetation should be controlled. Ideally, weed control should be considered a year or more prior to soil disturbance. Weed control requirements should be evaluated for upland, riparian and wetland areas. For proven treatment methods and recommended treatment timing of common Front Range annual and perennial weeds, see Table 13-2. The listed weeds may be found in the habitat zone indicated and in other zones as the micro-ecology permits.

If a site has annual or perennial weed growth, weed management before revegetation is crucial for minimizing weeds and weed seed and to allow for desirable species establishment. Removing the weed seed source will help to reduce competition for soil moisture during desirable plant species establishment. Implementing weed control practices prior to and/or during construction can reduce the level of effort required for weed control later as new vegetation is becoming established. While construction activities are still on-going, maintaining weed control over the entire site, including on the topsoil stockpile, will reduce weed density once the topsoil is replaced and revegetation commences. Weed control strategies prior to construction for annual and perennial weeds are slightly different and are discussed separately in Sections 3.2.1 and 3.2.2. Weed control strategies during and following construction are included in the maintenance discussion in Section 7.4.

Table 13-2. Proven treatment methods and timing of treatment for common front range weeds
(Source: Weed Research and Information Center, University of California-Davis 2013)

Common Name	Scientific Name	CO Weed List Rating	Spring Treatment	Summer Treatment	Fall Treatment
Wetland Weeds					
Canada thistle	*Cirsium arvense*	B	H,MM	MM	H, MM
Common teasal	*Dipsacus fullonum*	B	H		H
Eurasian watermilfoil	*Myriophyllum spicatum*	B	BI, H	MP	MP
Purple loosestrife	*Lythrum salicaria*	A	MD, MP, H, BI		
Tamarisk	*Tamarix ramosissima*	B	BI, H[1]	H[1]	H[1]
Riparian Weeds					
Leafy spurge	*Euphorbia esula*	B	BI, H		H
Poison hemlock	*Conium maculatum*	C	HP, H	HP	H
Quackgrass	*Elymus repens*	B			H
Russian olive	*Elaeagnus angustifolia*	B	H[1]	H[1]	H[1]
Upland Weeds					
Bindweed	*Calystegia sepium*	NL	BI, MP[2]	H	H
Bouncingbet	*Saponaria vaccaria*	B		H	H
Bull thistle	*Cirsium vulgare (Savi) Tenore*	B	MP[2], BI, H, BG[3]	MM, BG[3]	H, BG[3]
Chinese clematis	*Clematis orientalis*	B	BG, MP	H	
Common burdock	*Arctium minus*	C	MP[2], MM, H, BI	MM	MM, H
Common mullein	*Verbascum Thapsus*	C	H		H
Dalmation toadflax	*Linaria dalmatica*	B	BI, MP[2], H		H
Diffuse Knapweed	*Centaurea diffusa*	B	MP[2], BI, H	MM, MC, H	H
Downy brome (Cheat grass)	*Bromus tectorum*	C			H
Kochia	*Kochia scoparia*	NL	MP[2]	MM, H	
Myrtle spurge	*Euphorbia myrsinites*	A	H	H	H
Musk thistle	*Carduus nutans*	B	BI, MP[2], MC, H, BG[3]	MM, BG[3]	H, BG[3]
Perennial pepperweed	*Lepidium latifolium*	B	MP[2], H, BG		
Plumeless thistle	*Carduus acanthoides*	B	BI, MP[2], H,MC, BG[3]	MM, BG[3]	H, BG[3]
Puncturevine (Goathead)	*Tribulus terrestris*	C	MP[2], BI, H	MD, H	
Redstem filaree	*Erodium cicutarium*	B	MP[2], H		H
Russian knapweed	*Acroptilon repens*	B	H		H
Russian thistle	*Salsola tragus*	NL	MP[2], BG, H	H	
Scotch thistle	*Onopordum acanthium*	B	MD, MP[2], H, BG[3]	MM, BG[3]	BG[3], H
Yellow starthistle	*Centaurea solstitialis*	A	MP[2], MM, BI, BG, H		
Yellow toadflax	*Linaria vulgaris Mill*	B	MP[2], BI		H
Whitetop (Hoary cress)	*Cardaria draba*	B	MM, H		H

Table Notes: [1]Grazing with sheep, goats and horses- no cattle. [2]Pull young seedlings. [3]Cut and treat stump if large plant or spray foliage if small plant.
Seasons: Spring = Sp, Summer = Sm, Fall = Fa. Mechanical Methods: Mowing = MM, Pulling, = MP, Cutting = MC, Digging = MD. Biological Methods: Insects = BI, Grazing animals = BG. Chemical Methods: Herbicides = H.

If herbicides will be needed to control weeds at the site, a certified applicator should be used. A copy of the applicator's license should be obtained and records should be kept of all applications that occur on the site. Only herbicides rated as aquatic safe should be used in riparian and wetland areas. A key consideration in herbicide selection should be how long the herbicide remains active in the soil (residual soil activity). No chemical residue should remain in the soil at seeding time, which could reduce desirable species germination.

In 2013, the Colorado Water Quality Control Division issued a Colorado Discharge Permit System (CDPS) General Permit for Discharges from Application of Pesticides, modeled after the U.S. Environmental Protection Agency's general permit issued in 2011. A Compliance Certification may be required for certain types of herbicide applications in Colorado.

Weed Control Considerations

- Consider weed control prior to construction to reduce competition with desirable vegetation during establishment.
- The label is the law! Follow herbicide label directions provided by the manufacturer.
- Controlling weeds by spot spraying and backpack applications is best for precise weed control treatments.
- Check to be sure that the county or other agency jurisdiction does not have the area designated as part of their weed control area – boom spraying may wipe out a revegetation effort.
- Cross-boundary weed control agreements may be needed with adjacent land management teams for more effective weed control in an area.

3.2.1 Control of Annual Weeds

Weed management is especially useful where annual weeds are abundant. Some common annual weeds such as kochia (*Bassia sieversiana*) and cheatgrass (*Anisantha tectorum*) have short-lived seed. If weed seed production can be prevented during the year prior to revegetation of a site, it will help reduce future weed growth. Be aware that a late summer mowing of untreated annual weeds followed by plowing and seeding generally results in a rebound of many of the weedy species, so proper weed management is important prior to seeding.

For mild to moderate weed infestations, a broad-spectrum herbicide treatment may be sufficient to control weeds before revegetating the site. Be sure to check herbicide labels regarding timing of treatments because a month or more may be needed between herbicide treatments and revegetating the site (seeding) to reduce residual impact of the chemicals.

If the site has heavy annual weed growth, the soil may be deeply plowed and turned over to bury weed seed. The plowing can then be followed by disking to level the area. Once remaining weeds geminate, an application of a broad-spectrum herbicide will kill establishing weedy species. Since some topsoil is lost with this method, deep plowing to bury weed seed should only be used in an area with adequate topsoil or on historic agricultural fields. Chiseling the deep plowed area should create a level seedbed. Seedbed preparation can begin in August, prior to the fall when seeding is recommended.

3.2.2 Control of Biennial and Perennial Weeds

Seeding Failures

"Inadequate weed suppression causes more seeding failures than any other single factor."

--NRCS, 1997

Ideally, control of biennial and perennial weeds should also begin a year or more prior to seeding a site to reduce competition with the seeded species. If project timing does not allow for weed control to precede construction, it may be implemented as the site is being prepared for revegetation, and weed control may still be necessary even if it is initiated prior to construction. Spring and fall are good times for spot herbicide treatment of developing rosettes (first year stage) of many biennial species and some perennials weeds. Spring and fall are especially good for common regional weeds including Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), scotch thistle (*Onopordum acanthium*), common teasel (*Dipsacus fullonum*) and knapweed (*Centaurea diffusa*). Always follow herbicide label recommendations for best treatment times and chemical mixtures for specific weed species.

3.2.3 Additional Weed Control Guidance for Wetland Areas

Cattails are native wetland plants which can form dense stands. If required for maintenance, deeply rooted cattails (*Typha latifolia* and *T. angustifolia*) may be controlled by fall application of aquatic labeled glyphosate followed by cutting the plant after the plant has died.

If an existing wetland is to be enhanced, elimination of undesirable species, such as reed canarygrass (*Phalaris arundinacea*) may be necessary. Herbicide application is generally the most effective means to eliminate a weedy species prior to planting. In wetland areas supporting weedy species, an EPA-approved aquatic use herbicide (such as glyphosate without polyethoxylated amine (POEA) surfactant) may be spot applied by a licensed applier prior to planting and seeding. Repeat application of herbicide every two weeks on remaining green growth. Allow two to three weeks after the last application prior to planting.

3.3 Topsoil Preservation

In undisturbed upland areas along the Front Range of Colorado, native topsoil depths vary. During construction activities, topsoil should be stripped and stockpiled separately from either sub-soil or wetland soil. In order to preserve soil microbs, which are helpful with plant establishment, it is best to limit topsoil stock piles to a height of 10 feet. Topsoil also supports mid and late seral species and can therefore promote the transition from an early, weed-dominated stage to a later, native-dominated stage (Goodwin et al. 2006). Once stockpiled, the topsoil may be seeded with a sterile non-native grass or a native seed mix, depending on how long it will remain. Use native seed when the stockpile will remain for over one year. Temporary vegetation will assist in stabilizing the topsoil to reduce erosion and weed infestations. Exotic perennial grasses such as smooth brome (Bromus inermis), crested wheatgrass (Agropyron cristata) and intermediate wheatgrass (Thinopyrum intermedium) should not be used for temporary cover on topsoil stockpiles because they will be difficult to eradicate later. Other aggressive non-native grass species to avoid include timothy (Phleum pratense), orchard grass (Dactylis glomerata), tall fescue (Schedonorus arundinacae) and meadow fescue (Schedonorus pratense). These exotic species are competitive and difficult to control when revegetating a project. Any soil containing weeds, such as reed canarygrass (Phalaris arundinacea) and Canada thistle (Cirsium arvense), will require great effort to control, and if possible should not be used (NRCS 2001a).

Once construction is complete, the topsoil can be spread before re-seeding and/or planting. Protecting the native topsoil is important because importing topsoil later is both labor intensive and expensive. If

stockpiling of topsoil is not possible, subsoil can be amended and decompacted before the site is revegetated (Colorado Natural Areas Program 1998). While this is an option, the seeding results will likely be less successful as those where topsoil is available.

Topsoil may be salvaged from a wetland that will be destroyed (on-site or at another location). A study by Brown and Bedford (1997) showed that wetlands with transplanted wetland soil exhibited higher plant cover and greater diversity than areas that did not receive transplanted wetland soil. Wetland topsoil contains seeds, roots, rhizomes, tubers and other fleshy propagules that can aid in revegetation. The top 8 to 10 inches should be scraped with a front-end loader and transported to the site where it will be applied. Ideally, the topsoil should be spread out on the new wetland immediately, to a depth of no more than 6 inches. Although wetland topsoil can be stockpiled for short periods, it will lose viability. Stockpiles should be kept for less than 4 weeks, should measure less than 3 x 3 feet (height/width) (NRCS 1997). Wetland topsoil should not be stockpiled during the summer because it will compost, and the seeds and propagules will be killed.

3.4 Soil Testing

Soil testing of both native and imported topsoil is recommended to select appropriate plant species for a site and to determine what types of soil amendment are required, if any. Soil samples can be delivered to a local soil testing laboratory, agricultural extension service, or university service for analysis. A standard agronomic test (e.g., nutrients, organic matter, and salinity), as well as full textural analyses, should be required for all topsoil fractions imported or salvaged from the site. Table 13-3 provides general guidance for viable topsoil composition for the establishment of native plants in upland areas in Colorado.

For upland areas along the Colorado Front Range, soil textures vary greatly. Soil texture characterizes a soil based on the size of particles found in a particular sample. Soil texture is described as sand, clay, and/or silt based on particle sizes (Figure 13-2). A U.S. Department of Agriculture (USDA) soil texture triangle diagram shows the types of soil texture combinations that are possible. Knowing the soil texture on a site will help with appropriate plant selection (Colorado Natural Areas Program 1998) and evaluation of potential for soil moisture retention. Plants are generally adapted to certain soil types although some plants can establish in a combination of soil types.

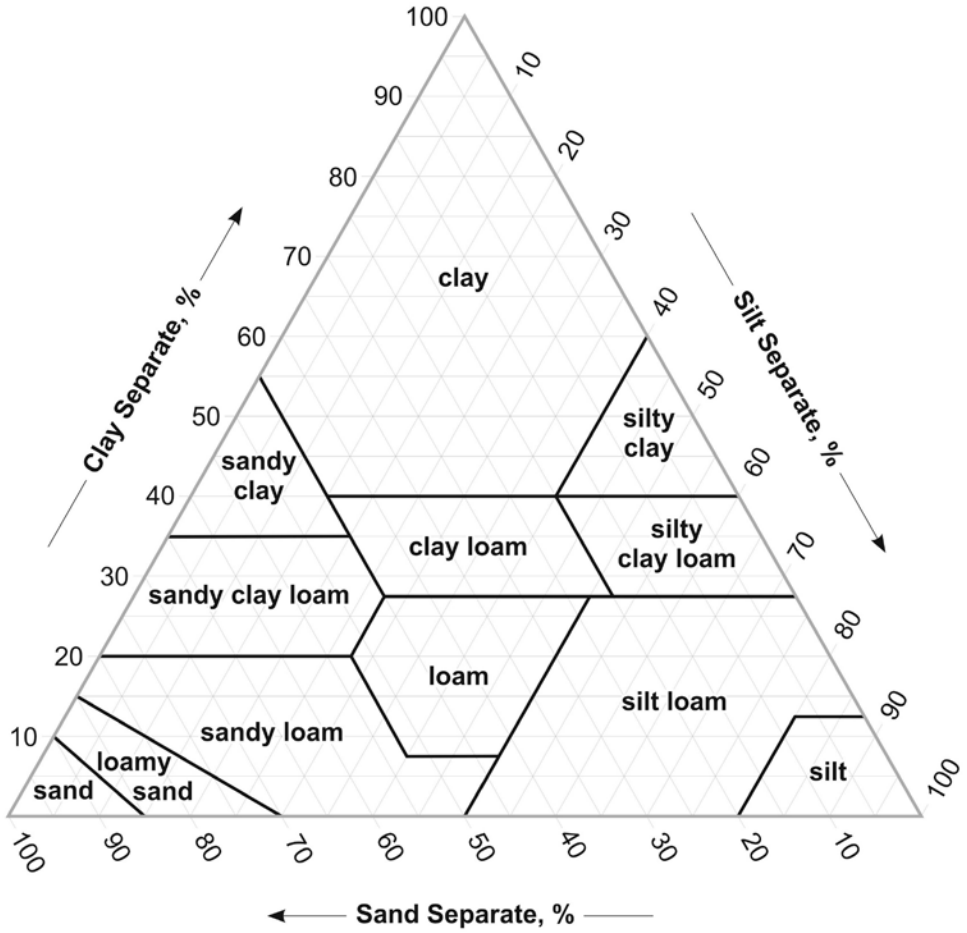

Figure 13-2. Soil textural triangle

When collecting soil samples and reviewing analysis results, follow these guidelines:

- Soils should be evaluated during design (visually and by lab analysis). Observation of soil prior to salvage may help determine quality of the soil to support herbaceous growth and presence of noxious weeds. Soils tests (both agronomic and full textural analyses) should be obtained during construction because grading activities and the process of stripping and stockpiling can result in very different conditions.

- The revegetation specialist and the contractor should work together to identify soil sampling locations based on planned earthwork. It is advisable for the contractor to visit the site with the revegetation specialist to understand the depth and character of the topsoil to be stockpiled. Observation of the soil source areas in the field is necessary to assist with determination of quality of the soil as a topsoil source.

- Salvage piles should be labeled and not mixed or moved until just before reapplying.

- In some cases, the subsoil should also be tested for suitability as a plant growth medium. In general, shale or weathered clay stone should be exported from the site and should not be within 18 inches of the surface. At least 18 inches of suitable subsoil and topsoil should be provided in areas that will be revegetated.

- If topsoil is to be imported from an off-site location, it is best to test it separately before it is brought on-site to be sure that it is good quality topsoil for the project. Soil amendments may still be (and often are) needed once a topsoil is brought on-site and reapplied to the existing subsoil.

- Soil test recommendations are usually geared toward agricultural crops, which may require substantially more soil amendments than what are necessary for native plant establishment. When submitting the samples, be sure to inform the testing laboratory that the soil testing is related to native plant establishment and that recommendations on soil amendments should be geared for this type of plant establishment.

- Soil test results should then be reviewed by a revegetation specialist who is familiar with the project so that the proper soil amendments are applied for the type of vegetation that will be seeded/planted.

- Saline soil conditions require special attention to plant species selection. When soil electrical conductivity is greater than 3 to 6 mmhos/cm, then saline soil conditions may be problematic (sensitivity also depends on plant species) (Swift and Koski 2007; Cardon et al. 2007). This condition commonly occurs in clay soils where the natural leaching of salts is limited. Both the surface and subsoils should be tested for salinity. If the soils are found to be highly saline, plant species should be chosen that are adapted to these conditions. CSU Cooperative Extension has developed lists of salt tolerant plants (Swift 1997; GreenCO 2008). Other research is ongoing to test the salinity tolerance of a range of riparian plant species (Goodwin et al. 2006). Native grass seed mixes of species that can tolerate more saline soil conditions are provided in Appendix A of this chapter.

Table 13-3. Viable topsoil composition for Colorado native plant establishment in upland areas

Chemical Attributes	**Preferred Range**		**Additional Description**
pH	6.0-7.5		A pH < 6 indicates possible acid problems, and pH > 8.0 indicates an alkaline soil. A pH> 8.5 indicates possible sodium problems. Most nutrients are most available to plants around a pH of 6.5.
Organic Matter	1-3%		Desirable range for good topsoil is a minimum of 1%.
Salinity	EC < 3 - 6 mmhos/cm		The desired EC varies depending on the plant selected, but EC values >2 mmhos/cm could indicate a problem for germination.
Sodium Absorption Ratio (SAR)	<6		SAR provides an indirect measure of percent exchangeable sodium on the soil colloid.
Free Lime	<10		Free lime represents the carbonates of calcium and magnesium which are not combined in the soil. Values > 10 may indicate a high amount of "lime", poor soil structure, and an increase in water and wind erosion susceptibility. Plant-available phosphorus may be reduced because of this condition.
Cation Exchange Capacity (CEC)	12-25		Exchangeable cations include calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), and potassium (K^{+}).
Saturation Percentage	> 25 and <80		Saturation percentage is the amount (percentage by weight) of water needed to saturate a soil. Values >80 may indicate high montmorillonite clay content and/or high quantities of exchangeable sodium, whereas values < 25 may indicate coarse soil materials with a low water-holding capacity. The full soil textural analyses may also report the clay content directly.
Minimum ammonia DPTA (chelate) Extractable Nutrients			Nitrogen (N) – Phosphorus (P) – Potassium (K): ratio of important elements in a fertilizer or soil amendment. Nitrogen is responsible for strong stem and foliage growth. High nitrogen levels favor quick-growing invasive weeds, while low nitrogen levels favor slow-growing, late-seral species (Goodwin et al. 2006). Phosphorus aids in healthy root growth and flower and seed production. Potassium improves overall health and disease resistance.
Nitrogen	5 ppm air dried basis		
Phosphorus	5-12 ppm		
Potassium	20-50 ppm		
Iron	3-5 ppm		
Texture Class	**% of Total Weight**	**Average %**	Soil Texture by Hydrometer Method provides the percentages of sand, silt, and clay in the soil. There are 12 textural designations (excluding modifiers such as very fine, cobbley, etc.) which can appear on a soil report. Each of these designations has a range of percentages of sand, silt, and clay, which could apply. Suitable soil textures for good topsoil material are silt loam, loam, silty clay loam, very fine sandy loam, and fine sandy loam. Soil textures with greater amounts of clay or sand can be problematic for achieving revegetation success.
Sand (0.05-2.0 mm diameter)	25 to 65	5	
Silt (0.002-0.05 mm diameter)	20 to 50	30	
Clay (<0.002 mm diameter)	20 to 30	25	

3.5 Soil Amendment

Depending on the results of soil tests, soil amendments may be required, particularly when test results fall outside of desired ranges in Table 13-2. Wetland areas typically do not require soil amendments. Soil amendment for upland and riparian areas is discussed in Section 3.5.1 and conditions where wetland soils may require amendment are discussed in Section 3.5.2.

3.5.1 Soil Amendment for Upland and Riparian Areas

Once the soils have been tested, amendments may be needed to improve soil conditions (e.g., nutrients, soil chemistry) or texture prior to revegetating the site, particularly for upland and riparian sites. The revegetation specialist should review the soil test results and identify soil amendments that may be needed. As long as the proper soil-specific seed mixtures are used, most native topsoil can be revegetated with little or no amendment beyond the addition of a slow-release organic fertilizer.

Fertilizers may have a positive, negative, or neutral effect on the survival and growth of planted species (NRCS 2001a). Nitrogen fertilizers should be used only when soil tests show a gross nitrogen deficiency because they can stimulate annual weeds and may pollute waterbodies if applied in lower riparian zones. In some cases, nitrogen fertilizers can decrease valuable mycorrhizal activity (Goodwin et al. 2006). Nitrogen is rarely needed for native species, which have evolved in low nutrient environments characteristic of prairie grasslands. If fertilizer is expected to have a beneficial effect on seeded species, it should be added shortly before or shortly after seeding (Goodwin et al. 2006) and in accordance with soil test results.

If the original topsoil from a site is stockpiled and then replaced, soil amendments may not be required to successfully revegetate the site. If amendments are needed based on the soil test, amendments may include a slow-release organic fertilizer (such as 4-6-4 or 7-2-2 N:P:K), compost, peat, humates, sulfur, gypsum, lime, wood chips and soil micro-organisms. Application of chemical fertilizers should be avoided as this can stimulate annual weeds and may contaminate water bodies if applied in lower riparian zones.

For upland sites, most sites with low organic matter (including overworked agricultural soils, steep slopes, and sub-soils) will benefit from the addition of between 800 to 1200 pounds per acre of a slow-release organic fertilizer. This organic fertilizer is often granular and low in phosphorus. Organic fertilizers are useful for high-use areas such as park sites, along roads, and highly visible native turf areas. Chemical fertilizers generally have higher phosphorus and nitrogen levels, which encourage weedy growth that may compete with the desirable planted/seeded species. Chemical fertilizers or fertilizers produced from poultry waste are often fast-release, which encourages weed establishment. The applicator should understand the quantities/rates of fertilizer needed to avoid over fertilizing an area. Soil amendments should be applied prior to the final tilling of the soil, and should be incorporated at least 6 inches into the soil.

Soils which are low in organic matter can be amended with an approved composted material to improve soil texture. Manure is usually not recommended (NRCS 2001a). Usually, 2 cubic yards of quality compost per 1000 square feet is adequate to improve the organic content of poor soils for native revegetation. (If the revegetation effort will be in a manicured area where turf will be installed, 3-5 cubic yards per 1000 square feet is recommended. See GreenCO [2008] for more information on turf areas.) Organic matter should be incorporated at least 6 inches into the soil by tilling the soil 8 to 12 inches until no clumps or areas of thick compost remain on the surface. Table 13-4 summarizes the characteristics of mature compost that are suitable for organic matter soil amendments.

Table 13-4. Characteristics of mature compost suitable for soil amendment

Maturity Indicator	Desired Result
Ammonia N/Nitrate N Ratio	<6
Carbon to Nitrogen Ratio	<18
Percentage of Germination and Vigor	80% or more for both germination and vigor
pH	5.5-8.0
Soluble Salts Concentrations	2.5 dS (mmhos/cm) or less preferred
Particle Size	Pass through 1-inch screen or smaller
Moisture Content	35% - 55%
Maturity/Growth Screening	Demonstrate ability to enhance plant growth
Stability	Stable to highly stable, providing nutrients for plant growth
Organic Matter Content	30% - 70%

In upland and riparian areas, the addition of soil microorganisms can aid the establishment of native vegetation. Soil microorganisms process mulch and dead plant material into nutrients that are available for plant uptake. Common microorganisms present in soil include bacteria, protozoa, and mycorrhizal fungi. Mycorrhizal fungi adhere to roots and develop a beneficial relationship with the plant by improving nutrient uptake, drought tolerance, and pathogen resistance (Goodwin et al. 2006). They are plentiful in the litter layer of established plant communities. For riparian areas, if an adjacent riparian area has a rich layer of litter and a lack of weeds, some of the litter can be collected and mixed in with the seed mix to be applied to the riparian area to be revegetated. Mycorrhizal fungi are also available commercially.

Other amendments, such as polymer and vermiculite root dips are generally not necessary and may be detrimental (NRCS 2001a). Similarly, special treatments for willow and cottonwood cuttings (such as rooting hormones and fungicides) are unnecessary (Hoag 1998). These cuttings root easily without special treatments.

3.5.2 Soil Amendment for Wetland Areas

In general, wetland revegetation projects do not require soil amendments. Wetland plants can successfully establish in a wide range of soil textures, from heavy clay with no organic matter to coarse gravels (NRCS 2011). In particular, the use of mulch is not recommended (EPA 1994), and fertilizers are rarely necessary or helpful (Colorado Natural Areas Program 1998, NRCS 2003). The addition of fertilizers may be especially detrimental by favoring the growth of weed species in the wetland and contributing to nutrient overloads already present in many waterways. However, each site is unique. To determine whether specific fertilizers may be necessary for a given project, the soil should be tested and compared with the optimum nutrient conditions for the species to be planted (Colorado Natural Areas Program 1998).

A notable exception to this generalization includes wetland creation projects in which the topsoil is removed (excavated) to reach the appropriate grade and the subsoil is exposed without replacing the topsoil. In these situations, virtually all of the naturally-occurring nutrients have been removed. Unless water entering the wetland has a high nutrient load, fertilization will probably be necessary (NRCS 2003). Not surprisingly, studies have shown that without suitable soil conditions, wetland creation projects tend to provide lower functions than natural wetlands (Bruland and Richardson 2005). In particular, soils in created wetlands tend to have a lower organic content than natural wetlands (Fajardo 2006).

3.6 Seedbed Preparation

When seeding is used to revegetate a site, then seedbed preparation is required and generally consists of decompacting the soil, adding soil amendment (if needed), and then firming the soil surface prior to seeding.

Cultipacker

A cultipacker is an agricultural implement used to crush dirt clods, remove air pockets, eliminate cracks, and bury small stones to form a smooth, firm seedbed. The cultipacker is used after ripping or disking the soil as a secondary tillage. It can be used either before or after seeding to firm the seedbed and to eliminate air pockets. After broadcast seeding the cultipacker can be used to gently firm the soil around the seeds, ensuring shallow seed placement and excellent seed/soil contact.

3.6.1 Addressing Soil Compaction

Soil compaction in upland, riparian and wetland areas is a common problem for revegetation. Seedbed preparation (tilling) is crucial before revegetating a site. Compaction can be found in naturally occurring soils with high clay content or can result from heavy equipment at construction sites, cattle grazing, working soils when wet, and other causes. When soil is compacted, seeds and plant roots and rootlets cannot penetrate through the hard surface and less oxygen is available for plant establishment and growth. Less water is available for plant establishment due to the hard compacted soil surface, and the site may be vulnerable to excessive runoff due to less water penetration. Microorganisms may be inhibited due to both a lack of oxygen and large pore space needed to survive. Loss of microorganisms leads to a further degraded soil unsuitable for plant growth and affects the nutrient cycling in soils (Natural Resources Conservation Service [NRCS] 1998).

Decompaction will allow water to more easily penetrate into the soil where it can be used by roots and will enhance infiltration on the site, reducing the potential for runoff, especially during smaller, frequent events. Special attention should be given to staging areas, roads, and other high traffic areas that are severely compacted. Decompaction should occur in two steps:

- Before the topsoil is replaced, the sub-soil should be ripped to a depth of 12 inches. This can be accomplished by disking, ripping, plowing, and rototilling, made more effective by ripping in two directions perpendicular to each other. An effective method to reduce soil compaction in created and restored wetlands is to use a chisel plow to mechanically rip both the topsoil and subsoil layers prior to planting (Bantilan-Smith et al. 2009). This process is more difficult to complete on slopes greater than 3:1. On steeper slopes, a track hoe and with a ripper tooth can be used to decompact soil to the proper depth.

- Once the sub-soil is ripped and the topsoil is replaced, soil amendments should be added, if needed per the soil test and habitat type, then the soil should be tilled to 6 inches, leaving no clod over 3 inches in diameter.

These two processes will allow for a total of 18 inches of decompaction, thus providing a better growing medium for native vegetation.

3.6.2 Seedbed Firming

Once the final tilling is completed, fine grading will ensure a smooth seeding/planting surface. The soil surface should be relatively firm as described for each habitat type:

- For upland and riparian areas, the soil surface should then be prepared for seeding so that a footprint will imprint between ¼ to ¾ inch only (NRCS 2011b).

- For wetland areas, the surface is considered firm enough when a person's footprint penetrates ¼ to ½ inch deep (NRCS 1997). Some newly created wetlands may be very difficult to firm. If necessary and when possible, firming of wetlands may be achieved by disking followed by rolling or harrowing just prior to seeding (NRCS 2008).

Firming of the seedbed soil should be performed prior to seeding, particularly if seeding in late spring or summer. Natural precipitation can sometimes be heavy enough to settle the worked soil, but waiting for such rainfall may not be realistic. If soils are sandy and contain a small amount of moisture already, a cultipacker can be used to firm the seedbed soil. Soils that are wet or silt loam to clay loam should not be cultipacked because they can become too firm, making drill seeding or crimping much less successful. Chiseling after plowing may adequately firm finer textured soils. It is also possible to firm the soil with irrigation following seeding and mulching.

3.7 Tree Protection

Protection of existing trees is an important aspect of site preparation, which should occur at the beginning of the construction phase. Figure 13-3 provides a detail for installation of construction fencing to protect existing trees.

4.0 Plant Material Selection

Appropriate plant selection is crucial in successful native revegetation of upland, riparian and wetland sites. A site plan should be created by a revegetation specialist trained in native vegetation restoration. A variety of plant materials can be used to revegetate a site. The materials used will depend greatly on budget as well as the schedule and goals of the project. Generally, these materials include seed, plugs, containerized plant material, balled and burlapped (B&B) trees and shrubs, cuttings, and transplanted plants (particularly in the case of wetlands). Table 13-5 identifies plant materials typically used in each habitat type, followed by guidance related to plant selection, seeding, and trees and shrubs.

Table 13-5. Plant material for revegetating upland, riparian and wetland habitat types

Revegetation Guidance Topic		Applicability to Habitat Type		
Plant Material	**Chapter Section**	**Upland**	**Riparian**	**Wetland**
Seed (permanent and temporary)	4.2	✓	✓	✓ **(limited)**
Plugs	4.4.1	✓	✓	✓
Containers	4.4.2			
Bare Root	4.4.3	✓	✓	✓
Balled and Burlapped (B&B)	4.4.4	✓	✓	✓
Cuttings	4.4.5		✓	✓
Wetland Sod, Rhizomes, Tubers	4.5			✓

4.1 Plant Selection Guidance for Habitat Types

Plant selection guidelines for upland, riparian and wetland areas differ somewhat and are discussed separately below. See Figure 13-1 for a summary of planting zones within each habitat type.

4.1.1 Plant Selection for Upland Areas

When present, a nearby reference site with similar conditions (soils, slope, and aspect) should be examined to assist with plant selection for upland areas.

Photograph 13-3. An upland area vegetated with native grasses along a riparian corridor in open space area. (Photograph courtesy of Iris Mitigation and Design.)

Upland sites are generally revegetated by seeding with a native seed mixture selected based on the soil texture and to a lesser extent, chemistry. Seeds are best obtained from a local nursery and regional seed mixtures have been found to be successful in most of the soil conditions which occur in the Colorado Front Range. Sites with sandy soils or elevated salinities (EC> 3) should use alternative seed mixtures for those soil conditions.

Plant materials used to revegetate upland areas may include also include grass and herbaceous species plugs, containers, bare root, B&B plants, and cuttings. Regardless of the plant material selected, several general principles should be considered. First, the genetic source of the plant material may affect the long-term revegetation success. Plant material that originates in proximity to the revegetation project will be better adapted to the local area's environmental conditions, may be more resistant to pests, and may exhibit more robust growth over the long term. Similarly, plant species should be chosen that closely match the environmental conditions at the project site. Such plant species are typically adapted to water availability, salinity, elevations, and soil conditions.

Seeding is generally not feasible for establishing trees and shrubs. However, containers, and bare root plant material can be good options for both herbaceous and woody plant species.

4.1.2 Plant Selection for Riparian Areas

Evaluating reference sites on the same watercourse at a similar elevation may be particularly useful when revegetating riparian areas. However, many urban streams are degraded, and healthy native vegetation useful for reference areas may not be present nearby. When good reference sites exist, these areas should be assessed for the species present, the types of plant forms present (herbaceous, shrubs, or trees), and the location of species and plant forms relative to the stream. In the absence of a nearby reference area, it is possible in to rely on a proven regional riparian plant palette for most projects because riparian areas along the Front Range are typically very similar in species composition.

Unlike riprap and other inert materials, riparian plants are able to bend during high flow events and/or regenerate following flooding or other natural disturbances. This means plant selection is particularly important when revegetating riparian areas. If the appropriate species are chosen and planted in the proper locations, the entire project can be "self-healing" following disturbance (NRCS 2005b).

A primary limiting factor in semi-arid environments is water availability. This is particularly true in riparian areas where the soil moisture varies dramatically with the distance from the watercourse. Vegetation plans should reflect a gradient of vegetation from the streambank/wetland edge to the upper stream terrace areas. Use at least two seed mixtures to cover this gradient and plant woody species where they are best adapted to the hydrology.

Although it is rare in riparian areas, when soil tests reveal that the area is excessively saline, choose species that have adapted to these conditions. Similarly, if herbivore predation has been demonstrated to be problematic, species can be chosen that are thorny or otherwise unpalatable. Grazing should also be limited during establishment with the use of enclosures.

4.1.3 Plant Selection for Wetland Areas

A wide variety of plant material is available for revegetating wetlands, as summarized in Table 13-5. Wetland and stream edge areas are generally revegetated with a combination of wetland seed mixtures, herbaceous wetland plugs, dormant woody cuttings and some potted woody plants. Ultimately, plant selection should be based on:

- Elevation of the planting area above normal water elevation (hydrology).
- Frequency of flooding.
- Permit requirements.
- Soil type.

Photograph 13-4. A Front Range creek restored with a gradient of vegetation types, including wetland plants. (Photograph courtesy of Iris Mitigation.)

Regardless of the plant material selected, several general principles should be considered to improve chances for success:

- The genetic source of the plant material may affect long-term revegetation success. Native woody nursery stock produced from locally collected plant materials, local dormant cuttings, and regional seed sources will be better adapted to local climatic conditions.
- Plant species should be chosen that closely match the existing environmental conditions, especially the hydrology.
- Some plant species may also be adapted to particular soil types (EPA 1994, Colorado Natural Areas Program 1998) and elevations.
- Only native species should be used.
- Common cattail (*Typha latifolia*) and reed canarygrass (*Phalaris arundinacea*) should not be seeded or planted in wetlands because they tend to be invasive.

Good reference sites with conditions similar to the project area are also a valuable tool in determining appropriate plant species, densities, distribution, abundance and diversity and should be considered when available.

4.2 Seeding

Guidance for permanent seed selection for each habitat type is provided below, followed by guidance for temporary seeding. Seed mix tables are provided in Appendix A. Local jurisdictions may require alternative seed mixes and/or require that the seed mix used for the project be approved prior to use.

4.2.1 Seeding Upland Areas

Seeding is the most common and least costly method of revegetation for upland areas. Seed is usually obtained from a commercial seed supplier. Grasses, forbs (wildflowers), and certain shrubs can all be seeded. Basic upland seed mixes are provided in Appendix A to this chapter. Wildflower species can be omitted if not available or another recommended wildflower seed can be increased. Seed mixtures provided in Appendix A are appropriate for most of the typical site conditions and can be mixed upon request by commercial seed companies. Pre-mixed "native" mixtures of grasses or wildflowers offered by seed companies can contain non-native aggressive and even weedy species which are not well suited to revegetation of regional upland areas. It is better to select a mixture provided in Appendix A which contains native species well suited to the task of providing erosion protection in this high plains area.

Fall is the preferred time for non-irrigated seeding. Late summer seedbed preparation followed by installation of the seed in the fall (October) allows winter months for additional firming of the seedbed before spring and germination. Fall seeding benefits from winter and spring moisture and usually assures maximum soil moisture availability for establishment.

Late winter to early spring (February to early April) is typically the next favorable time period for seeding. Winter and early spring seeding should not be conducted if the soil is frozen, snow covered, or wet (muddy). Although of greater risk, spring seeding (mid-April into early June) can be successful, especially during moist spring years. Mid- to late-summer seeding can be successful, with adequate precipitation and/or irrigation to wet and settle the seed bed. Firming of the seedbed following seeding will improve results during dry or warm seeding times.

4.2.2 Seeding Riparian Areas

Seeding is a good option for revegetating the herbaceous understory of a riparian plant community. Seeding timeframes for riparian areas are similar to those described for upland areas. Most native seed mixes (see Appendix A) are commercially available.

4.2.3 Seeding Wetland Areas

The least expensive wetland plant material is wetland seed (NRCS 1997). Often revegetation of wetlands is done through a combination of seeding and plugs which can add to the overall species diversity of a wetland and provides additional root structure and above-ground biomass (NRCS 2003). With proper seedbed preparation and use of blanket protection, UDFCD has observed a high rate of success.

4.2.4 Temporary Seeding

Temporary seeding is an erosion control best management practice (BMP) that prevents soil erosion on a construction site, soil stockpile, or other disturbed site prior to final site stabilization and helps to control weeds. Typically it is appropriate to utilize this practice when the disturbed area will not be finally prepared and seeded for a month or more (depending on local requirements).

The soil may be temporarily stabilized with sterile non-native annual or perennial grasses or native perennial grasses. The selected grass species for this temporary seeding, if non-native, should be either an annual grain or a sterile wheat/wheatgrass hybrid. Sterile grass will not re-seed and compete with more desirable native plantings. Annual grains should be selected depending on the time of year when they will be seeded. Oats, spring wheat, and spring barley are seeded in the spring, followed by millet from May through July. Winter wheat or winter barley may be seeded in the fall and winter months. These annual crop grasses allow for approximately 12 months of coverage. For a slightly longer period of

annual grass coverage, a sterile short-lived perennial wheat/wheatgrass hybrid may be seeded.

Perennial, faster-growing, native grasses can also be seeded as a cover crop. (See the Temporary Native Seed Mixes in Appendix A). However, non-native perennial grasses should never be seeded for temporary cover because they are difficult to eradicate later. Non-native perennial fast-growing grasses to avoid include smooth brome, timothy, orchard grass, crested wheatgrass, tall and meadow fescue, and intermediate wheatgrass.

See the Temporary Seeding Fact Sheet in Volume 3, Chapter 7, Construction BMPs for more information.

4.3 Trees and Shrubs

4.3.1 Upland Trees and Shrubs

Table 13-6 summarizes native upland trees and shrubs that are generally appropriate for planting at an upland revegetation site. Containerized plants, bare root or B&B trees and shrubs can be used. A revegetation specialist must determine which of these native trees and shrubs are appropriate for the specific upland site. Each tree and shrub species listed requires different amounts of sunlight, soil condition and moisture in order to establish and thrive. Temporary irrigation is recommended for tree and shrub establishment.

4.3.2 Riparian Trees and Shrubs

The riparian ecosystem is a transition area between wetland and upland ecosystems and is dominated by large cottonwood (*Populus* spp.) and peachleaf willow (*Salix amygdaloides*) trees with an understory of willow (*Salix* spp.), other woody riparian shrubs, transitional area grasses and herbaceous species. The riparian vegetation has varying widths from the edge of the waterbody depending on factors including: geology, topography, elevation, soil type, hydrology, and upstream and upgradient build-out. Trees and shrubs depend on access to water but can handle occasional dry periods once established.

The cottonwood tree is a relatively short-lived species (80-100 years), and fallen cottonwood make excellent wildlife habitat. It is important to allow for cottonwood and willow regeneration in the riparian zone for replacement species. Cottonwood and willow will regenerate naturally in the riparian zone. The riparian vegetation provides flood control, nutrient cycling, stream food web support, pollutant filtering, sediment retention, and wildlife movement and migration corridors. Healthy riparian vegetation provides streambank stability and erosion control. However, vegetation in this zone can also reduce flood capacity when it's not managed. Non-native riparian species such as the crack willow (*Salix fragilis*) should be avoided as this fast growing and aggressive species has fragile branches which break off along with root mass and cause further erosion issues.

Table 13-7 provides a list of common Front Range native riparian trees and shrubs appropriate for the revegetation of riparian areas.

Table 13-6. Upland trees and shrubs for revegetating sites on the Colorado front range

Upland Trees	
Common Name	**Scientific Name**
Ponderosa pine[1]	*Pinus ponderosa*
Rocky Mountain juniper[1]	*Juniperus scopulorum*
Pinyon pine[1]	*Pinus edulis*
One-seeded juniper[1]	*Juniperus monosperma*
Hackberry[1]	*Celtis laevigata*
Upland Shrubs	
Common Name	**Scientific Name**
Big sagebrush	*Artemisia tridentata*
Yucca	*Yucca glauca*
Sand sagebrush	*Artemisia filifolia (sandy soils only)*
Fringe sagebrush	*Artemisia frigida*
Common juniper[1]	*Juniperus communis*
Winterfat	*Krascheninnikovia lantana*
Western sandcherry	*Prunus pumila*
Smooth sumac	*Rhus glabra*
Mountain mahogany[1]	*Cercocarpus montanus*
American plum	*Prunus americana*
Wax currant	*Ribes cereum*
Wood's rose	*Rosa woodsii*
Rabbitbrush	*Chrysothamnus nauseosus*
Threeleaf sumac	*Rhus trilobata*
Snowberry	*Symphoricarpos occidentalis*
Gambel oak[1]	*Quercus gambelii*
Fourwing saltbush	*Atriplex canescens*

[1] Temporary irrigation is recommended for establishment

Table 13-7. Common Colorado front range native riparian trees and shrubs

Common Name	Scientific Name	Plains	Foothills
Riparian Trees			
Aspen	*Populus tremuloides*		X
Boxelder	*Acer negundo*	X	X
Colorado blue spruce	*Picea coloradensis*		X
Narrowleaf cottonwood	*Populus angustifolia*	X	X
Plains cottonwood	*Populus deltoides*	X	X
Peachleaf willow	*Salix amygdaloides*	X	X
River birch	*Betula*		X
Rocky Mountain maple	*Acer glabrum*		X
Thinleaf alder	*Alnus incana*		
Riparian Shrubs			
American plum	*Prunus americana*	X	X
Bebb's willow	*Salix bebbiana*		X
Bluestem willow	*Salix irrorata*		X
Chokecherry	*Prunus virginiana*	X	X
Drummond's willow	*Salix drummondiana*		X
Geyer's willow	*Salix geyeriana*		X
Golden currant	*Ribes aureum*	X	X
Redosier dogwood	*Cornus sericea*	X	X
River hawthorne	*Crataegus rivularis*		X
Rocky Mountain willow	*Salix monticola*		X
Sandbar willow	*Salix exigua*	X	X
Skunkbush sumac	*Rhus triobata*	X	X
Snowberry	*Symphoricarpos occidentalis*	X	X
Wax currant	*Ribes cereum*	X	X
Wood's rose	*Rosa woodsii*	X	X

4.3.3 Wetland Tree and Shrub Plantings

Riparian woody plant materials (trees and shrubs) are also appropriate for planting around the edge of wetland areas. Seeding is generally not appropriate for revegetating trees and shrubs. If possible, woody plants that are pre-inoculated with my corrhizal fungi, nitrogen-fixing bacteria, and/or other beneficial microbes should be requested (NRCS 2001). The following types of riparian woody plant material are commercially available for wetlands: B&B, plugs, bare root, and containers. Cuttings are the least expensive way to easily install riparian trees and shrubs and generally include cottonwoods (*Populus* spp.) and willows such as the sandbar willow (*Salix exigua*). Willows can be planted around the perimeter of wetland areas while riparian trees and most other riparian shrubs are planted adjacent to the wetland area but away from standing water so that the plants roots are not in fully inundated water conditions.

4.4 Types of Tree and Shrub Plant Material

Types of tree and shrub material include plugs, containers, B&B material, and cuttings.

4.4.1 Plugs

Plugs, typically used for wetland revegetation and enhancement, are long, cylindrical or square planting tubes, measuring 22 in^3 or less, that contain stems, roots, underground perennial parts, and soil (Colorado Natural Areas Program 1998). Plugs are available for both herbaceous and woody plant species.

Wetland plugs may be obtained at a local wetland nursery. Determine availability early in the planning/design phase. Wetland plugs are sometimes grown specifically for a project so ordering them 6 months to a year in advance may be required. Revegetating wetlands with nursery-grown plugs has demonstrated a much higher establishment rate than with seeding or transplanted plants (NRCS 2003). In general, a project should purchase the largest plugs afforded by the budget (NRCS 2003). The plants should be free of injuries, wounds, or insect damage. The above-ground and underground material should have approximately the same density. Additionally, the roots should extend to the bottom of the tube but should not wind around the tube (i.e., not "root bound"). Figure 13-6 provides a detail for wetland plug planting.

4.4.2 Containerized Material

Containerized plant material is typically grown from seed or cuttings at a nursery and is available in various container sizes, such as 4-inch, 6-inch, 1-gallon, 2-gallon, and 5-gallon pots. An advantage of using containerized stock is that it can be stored (under proper conditions) for a moderate period prior to installation.

When inspecting containerized material, look for well-proportioned above-ground plant material that is not excessively large or small for the container. Also, the roots should exhibit development throughout the soil but should not be growing through the bottom of the container or around the periphery of the container.

4.4.3 Bare Root

Bare root plant material consists of the entire plant (upper plant parts and root systems) without a container or soil. These plants are typically dug up and sold when they are dormant and are commonly available for woody plant species. Because they are less hardy than containerized material, bare root plants tend to have a lower survival rate than containerized stock (Colorado Natural Areas Program 1998). However, they are also less expensive. Because bare root plants lack a container and soil, care should be taken to either install them immediately or carefully store them. In general, bare root seedlings should have a top length of at least 18 inches, a collar of at least 3/8 inch, and well developed terminal buds. The roots should also be well developed, should not be pruned, and should be highly fibrous (NRCS 1997).

4.4.4 Balled and Burlapped

Balled and burlapped (B&B) trees and shrubs are grown in nurseries, dug out with the soil intact, wrapped in burlap, and tied with twine. Most plants sold as B&B are relatively large plants and may be cost prohibitive for some projects. When used, B&B trees may be planted in the upland transitional planting zone to achieve a forested component relatively quickly. The most important aspect to evaluate when inspecting a B&B plant is whether the root ball is moist and intact. If it is not intact or has dried out, the plant may not survive.

4.4.5 Cuttings

Live cuttings are a cost effective way to install woody riparian species such as cottonwood trees. When properly installed, the cuttings can establish readily. The costs for obtaining cuttings will consist primarily of labor costs associated with collecting, storing, and transporting the cuttings. Although inexpensive on a unit basis, costs per square foot can be somewhat high because cuttings are typically densely installed in large quantities. The overall success rates and low establishment costs lower the final cost per plant.

Collecting cuttings from the vicinity of the revegetation project allows for securing locally-adapted, native plant material. When possible, cuttings should be collected from areas that are similar to the area to be revegetated and be collected from multiple locations to provide genetic diversity (NRCS 2005b). It is important to make sure that the native stands used as donor sites are not destroyed by the collection.

Collect cuttings when dormant, preferable from late winter to early spring (prior to bud swell). In Colorado, the most successful time to collect cuttings is in early spring before the buds leaf out (usually between February 1st and April 15th). Cuttings may be classified as willow stakes, willow fascines, willow bundles, and cottonwood poles. Cuttings have varying diameters and lengths and can be grouped into bundles, fascines (wattles), brush layering, brush mattresses, etc. Cuttings are most often obtained from nurseries or from donor sites and are collected during the dormant season. In general, the larger the diameter of the cutting, the more successful it will be (Hoag 1995). Species most often used for cuttings along the Colorado Front Range include coyote or sandbar willow (*Salix exigua*) and plains cottonwood (*Populus deltoides* subsp. *monlifera*).

Table 13-8 presents a common classification system for cut woody plant material. Other classifications may also be found.

Table 13-8. Classifications and typical sizes of woody plant material cuttings

Classification	Size
Willow Stakes	24 to 30 inches long 0.5 to 1.0 inch diameter
Willow Fascines and Bundles	3 to 5 feet long 0.5 to 1.0 inch diameter
Cottonwood Poles	10 to 15 feet long 2 to 4 inch diameter

Although Table 13-8 specifies a range of lengths for willow cuttings and cottonwood poles, the final length of all cuttings will be determined by the depth to groundwater. In lower to middle terraces of riparian areas, the water table is expected to be relatively high. Consequently, cuttings do not need to be installed as deeply as in drier habitats. Regardless, cuttings should be installed to extend approximately 6 inches into the water table and should be tall enough to avoid shading by herbaceous vegetation (Hoag 1995). In general, willow species tend to be adapted to wetter environments than cottonwoods. Consequently, willows are commonly planted nearer to the streambanks and on the lower terraces, whereas cottonwoods are planted in slightly drier areas (higher middle to upper terraces). Planting holes for live stakes can be prepared using rebar and small sledge hammers, pry bars, or drills fitted with larger drill bits. Larger cottonwood poles can be planted using 4 to 8 foot augers. Allow time for the groundwater to fill the hole prior to installation, to ensure adequate depth for the cutting. The higher on the bank, the longer the cuttings will need to be.

All cuttings should be collected from insect-free and rot-free live woody vegetation. In general, collect green wood rather than older more mature wood (Hoag 1998). Do not collect cuttings with thick, cracked bark or suckers because they do not have the energy reserves necessary to consistently sprout. Collection guidance includes:

- **Willow Cuttings**: Live stakes should be cut with sharp pruning shears or a weed cutter with a saw blade near the ground surface to 10 inches above. Cuts must be clean, without stripping the bark or splitting the wood. The top should be cut straight across and the base cut should be cut at an angle. This will allow the cutting to be more easily installed and also differentiates the tip from the base. Another technique to help identify the correct ends of the cutting is to dip the upper part (angled end) in paraffin wax or another sealing substance (such as a non-toxic latex paint). For willow stakes and bundles, all side branches and leaves of a cutting should be trimmed. Branches should be left on cuttings for willow fascines. Live cuttings can be bound together with twine at the collection site for ease of handling and protection during transport.

- **Cottonwood Pole Cuttings**: Live poles should be pruned from live cottonwood trees at an approved harvest site. Cuts must be clean, without striping the bark or splitting the wood. The best cottonwood pole cuttings are those from trees less than 18 inches in diameter. The base cut should be at a 45-degree angle and all the side branches trimmed off. The terminal bud (end of branch) must remain intact.

Immediately after cutting, all live stakes and poles should be carefully protected from desiccation by keeping the ends in water (tanks, buckets, or streams) at all times. During transportation, the cuttings should be placed in an orderly fashion in containers with water at least one foot deep and covered with tarp or burlap to prevent damage from the wind and to facilitate handling. If cuttings are collected in the late fall, they may be dry-stored in a cooler (kept at 29 to 34 degrees Fahrenheit) for up to 6 months (Hoag 1998). This should only be when necessary to extend dormancy. One method that may help initiate the growth process on the willow cuttings is to soak the bottom half of the cuttings in water for 2 to 7 days prior to installation (Hoag 1998).

4.5 Wetland Sod/Rhizomes/Tubers

The least costly means for using existing wetland plant materials is to direct haul them in a wetland topsoil salvage operation. It is also possible to cut and transfer salvaged wetland plants. This plant material includes partial or entire plants, rhizomes, tubers, seeds, and sod mats. Salvaged plant material has the advantage of having local genetics and allowing the use of plant material that would otherwise be destroyed. These activities should take place only when the donor wetland (or portion thereof) will be destroyed as part of an activity permitted under a Section 404 permit.

Photograph 13-5. Installation of wetland sod along a reconstructed channel.

Wetland sod refers to large pieces of wetland plants and substrate that can be rolled up or placed flat for transport. Wetland sod should be collected from weed-free areas and ideally, should be collected when the soils are moist but well drained. A wetland sod mat is cut from a wetland with shovels and a front-end loader that is modified with a sharp-edged steel blade. The sections can then be placed on flat-bed trucks and transported to the wetland to be revegetated.

Commercially produced wetland sod grown in coir can be a cost effective means to reestablish protective shoreline wetland vegetation very quickly. Sod should be placed on the day of delivery to the site into the prepared planting locations with 1 to 2 inches of water to cover the roots of the vegetation in the coir. Cost for wetland sod is comparable to installing wetland plugs 12 inches on center. Wetland sod provides excellent erosion protection for the shoreline once staked in place. It requires anchoring except in backwater areas (see Figures 13-4 and 13-5). Check with commercial nurseries early to determine timeline of species and sod availability. Wetland sod is sometimes grown specifically for a project so ordering it six months to a year in advance may be required. If a donor site can be utilized, wetland plants can be harvested from an existing wetland at almost any time of the year (NRCS 2003). A rule of thumb for collecting herbaceous transplants from donor sites is to remove no more than 1-square-foot of plant material from a 4-square-foot area (NRCS 2003). This allows the remaining plants to rapidly fill in the harvest hole while still providing adequate transplant material. A depth of 5 to 6 inches of root and soil removal is adequate and will include beneficial organisms on the roots of the plants that will greatly aid the new wetland. At the new wetland site, the 1-square-foot transplant may be separated into four to five individual plants, depending on the species.

Rhizomes and tubers from existing remaining wetland areas may also be harvested. Rhizomes are underground stems that are capable of re-sprouting into new plants. Many bulrush species have large rhizomes containing a large amount of stored reserves. With significant stored reserves and local genetics, these large rhizomes tend to be more vigorous than relatively small nursery plugs. Many sedge species also have rhizomes. Rhizomes can be dug from donor sites and divided into sections that contain at least one viable growth point or node (NRCS 2003). Rhizomes should be collected in the spring before plants break dormancy and can be transplanted immediately or temporarily stored in sand or peat moss in a shaded, cool area.

Tubers may also be obtained from donor sites and occasionally from nurseries. Tubers are underground storage organs produced by some plants such as arrowhead (*Sagittaria* spp.), yellow pond lily (*Nuphar lutea*), and flatsedge (*Cyperus* spp.). Like rhizomes, tubers contain significant stored reserves and can be dug up from a donor site or purchased from a nursery and transplanted to a new wetland.

5.0 Plant Installation

Proper installation of plants is critical to successful revegetation. Installation methods depend on the type of plant material selected, as well as the habitat type. Installation methods generally include various seeding methods, installation of plug, containerized, B&B and bare root stock, and cuttings, as summarized in Table 13-9.

Table 13-9. Installation methods for revegetating upland, riparian and wetland habitat types

Revegetation Guidance Topic		Applicability to Habitat Type		
Installation Method	Chapter Section	Upland	Riparian	Wetland
Seeding (multiple methods)	5.1 & 5.2	✓	✓	✓
Herbaceous Plug, Containerized, B&B, and Bare Root Stock Installation	5.3	✓	✓	✓
Cutting Installation	5.4		✓	✓
Transplanting Wetland Plants (Wetland Sod, Rhizomes, Tubers)	5.5			✓

The most important consideration is placement Install each individual plant in its favored microhabitat areas as well as in the appropriate planting zone for the habitat type (Figure 13-1). A revegetation specialist or wetland scientist should be present before and/or during planting to mark the installation locations for each plant (for example, using colored pin flags to represent each species).

Along the Colorado Front Range, the generally accepted planting window in upland and riparian areas for seeding, containerized tree and shrub stock, grass and herbaceous plug, and B&B plants is similar. The planting window for wetland plants is generally longer, given available hydrology and precipitation (NRCS 2003). Planting wetland plugs in the fall and winter can result in frost heave whereby the plug is pushed out of the ground. Spring planting can have slower initial growth but allows the plant to have a long establishment period before winter dormancy. Along the Colorado Front Range, the generally accepted planting window for upland, riparian, and wetland areas is summarized in Table 13-10. Irrigation will assist with plant establishment.

Table 13-10. Planting/seeding schedule

Type of Plant	Time to Plant/Seed
Wetland and Riparian Species	
Riparian Containerized Trees and Shrubs	Spring[1]/Summer/Fall[1]
Wetland and Riparian Grass and Herbaceous Plugs	Spring[1]/Summer/Fall
Wetland and Riparian Bare-root Plants	Spring[1]/Summer
Wetland Seeding	Spring[1]/Summer/Fall
Riparian Area Seeding	Spring[1]/Summer/Fall[1]
Willow Stakes	Late Fall/Winter/Early Spring[1]
Cottonwood Poles	Late Fall/Winter/Early Spring[1]
Upland Species	
Upland Containerized Trees and Shrubs	Winter/Spring[1]/Fall
Upland Grass and Herbaceous Plugs	Spring[1]/Summer/Fall
Upland Bare-root Plants	Spring[1]/Fall
Upland Seeding	Spring[1]/Summer/Fall[1]

[1]Preferred Season

5.1 Seeding Upland and Riparian Areas

Once the soil has been decompacted and amended based on the soil test and the seed bed has been adequately prepared, the site is ready for seed application. Seeding can be completed with a drill, broadcast spreader, or through hydroseeding (when allowed by the local jurisdiction). Interseeding may also be used in upland areas. (Seeding methods are described in Sections 5.1.1 through 5.1.4.) Seeding is best achieved on a roughened seed bed with soil clods no greater than 3 inches.

Seeding rates are determined by the method of seeding, selected grass species, and also the purity of the seed. Seed mixes should only be developed based on pure live seed (PLS) to account for species that have low germination rates or mixes that would otherwise have a high amount of inert material, including dirt or other plant parts. The seed tag from the supplier should be inspected before planting to ensure the seed mix is of high quality and contains the correct percentage of PLS.

To determine the pounds of seed per acre, determine the amount of seeds per square foot desired and the amount of seeds per pound of each species selected. A revegetation specialist can assist in determining the correct amount of seed per acre to be used on the site; however, local jurisdictions often specify seeding rates. On average, seeding rates for upland areas are approximately 18-25 lbs of seed per acre (or approximately 3,500,000 to 5,000,000 seeds per acre, depending on seed size).

Timing of seeding is an important aspect of the revegetation process. For upland and riparian areas on the Colorado Front Range, the suitable timing for seeding is from October through May (NRCS 2011b). The most favorable time to plant non-irrigated areas is during the fall, so that seed can take advantage of winter and spring moisture. Seed should not be planted if the soil is frozen, snow covered, or wet. Proper seeding time is dependent on adequate moisture for germination and seedling growth as well as adequate soil temperatures (Colorado Natural Areas Program 1998).

5.1.1 Drill Seeding

Drill seeding is the most commonly used mechanism for planting seed in the ground, if the site is large enough, has 3:1 slopes or flatter, and is not rocky. The seeding depth will vary based on seed selected but, on average, 1/4-inch to 1/2-inch seeding depth will suffice. Another method of determining seed depth is 2.5 times the width of the seed (NRCS 2011b). Seeding parallel to the contours of the site will reduce erosion caused by water flowing down drill furrows (Colorado Natural Areas Program 1998). Since the size and texture of seed for warm and cool season grasses differ, the drill seeder should have boxes for both warm and cool season seed applications or agitators for mixing the fluffy and smaller seeds (Colorado Natural Areas Program 1998). Warm season seed is usually fluffier than cool season seed and tends to get stuck in the box without the right type of agitator and picker wheel.

Native grass drills should also be equipped with Coulter wheels, adjustable depth bands, and drill row spacing of 7 inches or less. Drilling the seed in two directions perpendicular to one another will improve coverage and establishment. If seeded in only one direction, drilling should follow the contour to reduce a tendancy for rilling down furrows. Partial broadcasting with some of the seed prior to or during drilling operations can also improve results, especially for finer seeded species.

5.1.2 Broadcast Seeding

Broadcast seeding consists of spreading the seed onto the surface of the soil by hand or with a hand spreader (also known as a belly grinder) or a mechanized rotary or cyclone seeder. Broadcast seeding may be cost effective in small areas and may be necessary in areas that are inaccessible to seeding equipment, such as rocky slopes, slopes steeper than 3:1, and areas without roads or other vehicular access.

Broadcast seeding is best completed after the ground has been raked or harrowed. This preparation will allow for better seed/soil contact than a hard-packed surface. Broadcast seeding is less reliable than drill seeding, so the seeding rate will need to be doubled or even tripled to achieve the recommended amount of seed at the desired depth. After seeding is complete, the seed should be raked or harrowed in to provide better seed to soil contact. After the seed has germinated, it may be necessary to spot-seed areas that did not establish. On-going spot seeding may be needed to revegetate bare areas.

Inaccessible small, steep, or soft seedbed areas may be broadcast seeded and harrowed or raked to cover the seed. Broadcast seeding rates of 35 to 45 pounds PLS per acre are adequate for most dryland broadcasting, depending on the plant species in the mix. To improve site diversity, hand-collected native seed can be broadcast before, during or after the main seeding operation. Stream edge seeding rates can be up to 50 to 60 pounds per acre to assure faster establishment or erosion protection.

5.1.3 Hydroseeding

Hydroseeding consists of a slurry of seed, fertilizer (if necessary), wood fiber mulch, water, and other additives (such as mycorrhizal fungi) that is blown onto the surface of an area to be seeded. It is mixed in a tank-mounted truck and is applied from the truck through long hoses. On steep slopes, a tackifier (a chemical compound that helps the material adhere to the slope) is often added. The term hydroseeding is sometimes mistakenly used interchangeably with the term hydromulching, which does not typically include seed.

The wood fiber mulch portion of the slurry is usually dyed to show which areas have been seeded. Hydroseeding provides for a single application of all additives, including seeds and mulch and can be used on steep slopes where it can help prevent erosion.

Hydroseeding is generally not recommended unless the slope is too steep to safety walk on (1.5:1) because it provides less soil to seed contact compared to other methods. If desirable, it may be used in flatter areas when the area is raked following hydroseeding. Some local jurisdictions do not allow hydroseeding due to low success rates on previous projects.

Hydroseeding is best achieved in three steps:

1. Soil preparation.

2. Application of the seed and water slurry. (The hydoseeder is constantly agitated so that the seed and water mixture is consistent.) Where site conditions permit, the seed should be raked into the soil.

3. Mulching.

5.1.4 Interseeding

Relatively weed-free sites with some residual native prairie species may be interseeded with a rangeland-type drill to minimize disturbance to existing grass cover. Interseeding directly into these areas without plowing or chiseling is preferable. A rangeland drill will cut furrows and place the seed at the proper depth. Weed seeds present on the site will be stimulated by interseeding and will probably result in additional annual weeds for a year or two after seeding. Mowing during establishment will help reduce competition from these weeds. Interseeding is an excellent way to enhance an existing upland field that has established vegetation but needs additional cover and possibly species diversity.

5.2 Seeding Wetland Areas

Seeding wetlands can be successful in shoreline areas where the seed will be raked to cover and blanketed immediately. Seed will germinate on muddy surfaces but tends to float in standing water. Once seeded, germination should occur in a week or two.

Wetland plants establish best in fluctuating water conditions, such as those found in nature (NRCS 2003). Where possible, it may be beneficial to manipulate the water levels during establishment. Water can be lowered to expose at least some muddy surfaces so that floating seed will drift into muddy areas. The water level can remain low until muddy areas begin to dry, and then water can be returned to re-wet these surfaces, then drawn down again to allow further growth of the seedling plants. NRCS outlines a detailed hydrologic regime to stimulate wetland plant establishment in *Riparian/Wetland Project Information Series Number 22* (NRCS 2007).

Along the Colorado Front Range, the window for seeding wetland species is in the spring, summer, or fall, depending on hydrological conditions on the site.

5.3 Plug, Containerized, B&B, and Bare Root Stock Installation

The density of plantings, especially when installing nursery stock, will greatly influence the overall cost of the project. In addition to the project's budget, careful consideration must be given to the character of the area to be revegetated when determining planting density. For riparian areas, use of cuttings (Section 5.4) may substantially lower the cost, allowing for higher planting densities.

5.3.1 Wetland Plugs

Wetland plugs should be planted 18 to 24 inches on center (NRCS 2003). Plantings at a wider spacing

exhibited less overall success, perhaps due to plant exposure. If the project budget does not allow 18- to 24-inch spacing, it is better to install plugs in patches at the proper spacing, separated by approximately 10 feet. Over time, plants will spread into the bare areas. As the hydrology within the cross-section changes and distance from the stream increases, species composition should change and spacing can widen to up to 2-3 feet depending upon erosion hazard and budget.

Each flat or rack of wetland plugs should come from the nursery clearly labeled by species. They should be wet upon transfer to the contractor and maintained with consistently moist soil in a shaded area until planted. This can sometimes be better accommodated at the contractor's yard than on site. Plugs delivered to the site should be planted the same day. When planting each plug, dig a generously-sized hole that allows the plug to be planted at the proper depth – not too shallow and not too deep. Avoid "J-rooting" the roots (bending into a "J" due to inadequate hole size). Also be sure to fill in air pockets near the roots to prevent the roots from drying out. Topping the surface of the plug with 1/2 to 2 inches of native soil can help to prevent desiccation. In areas where waterfowl grazing is possible, a 6- to 8-inch steel landscape staple can be used to secure each plant. Staples rust quickly and prevent the plants from being pulled up by the grazing birds.

5.3.2 Containerized, B&B, and Bare Root Stock

Guidelines for planting container stock, B&B plants, and bare roots are similar to the guidelines for planting plugs, described above. As with plugs, be sure to keep the plants moist and cool in the shade at the site. Keeping the plant containers buried in damp wood chip mulch or placing them under a reflective blanket or shade cloth can also prevent desiccation (NRCS, 2001a). Check moisture frequently. If the container and plant are not large and the substrate is easily worked with (such as deep friable soils), the hole may be dug with a shovel. In contrast, if the plant is large and/or the substrate is rocky, planting hoes (hoedads) or small backhoes may be advantageous. Because B&B plants tend to be larger, special equipment may be necessary for their installation. A relatively large hole should be dug enabling the soils around the newly installed plant to be effectively tilled and loosened, providing a medium for the new roots to grow into. Each hole should be filled in soon after digging to prevent the soil from drying out, and the soil should be firmly tamped down around the new plant after the hole is filled. For additional details on tree and shrub planting, see Figures 13-7 through 13-13.

Do not pick up plants, especially trees, by the trunk or upper parts, but by the container. B&B plants should be carried by the root ball.

Seedlings, and especially tree saplings, that have been grown in a greenhouse are highly susceptible to both drought and freeze damage (NRCS 1997). These plants should be "hardened" for a few days prior to planting by placing them in an enclosure that is several degrees above freezing, and they should be watered only sparingly before planting. Because bare root nursery stock is dormant, no hardening is necessary prior to planting.

Each plant should be mulched and deeply watered soon after installation. In relatively dry areas, watering tubes or hydrogel packs can be installed with the plant to provide additional moisture after installation. These allow a temporary source of moisture to the new planting. Although container stock will be more resistant to desiccation during the planting process, bare root plants should be carefully protected from desiccation during the planting process. These can be kept in 5-gallon buckets of water until ready for planting.

5.4 Cutting Installation

Cuttings are commonly installed in riparian and wetland areas. Installation guidance for each habitat type

is discussed separately below.

5.4.1 Installing Cuttings in Riparian Areas

Willows should be installed in the bank riparian planting zone where they can function to stabilize the bank. Cottonwoods should be planted in either the higher reaches of the overbank zone or the transitional zone (Figure 13-1). Regardless of the planting zone, cuttings need to be installed deep enough to contact groundwater year round. In areas with significant fluctuations in seasonal groundwater levels, cuttings will need to be installed deeper to ensure that they contact groundwater even during the driest season. Ideally, cuttings will be installed at least 6 inches into the lowest water table of the year with three to four buds above the ground surface (also includes the terminal bud on cottonwoods). Preferably, two-thirds (or at least half) of the length of the cutting should be in the ground (Hoag 1998). In areas with high erosion, cuttings should be installed 3 to 4 feet into the ground with the buds up.

Installing cuttings in riparian areas can be challenging depending on the substrate present. Cobbles can be impossible to auger, while holes dug in dry sands and gravels often collapse in on themselves (Los Lunas Plant Materials Center N.D.). Depending upon the substrate and the depth to groundwater, the following tools and equipment may be necessary to install cuttings: planting bars, augers, backhoes, rotary hammer drills, stingers, or post-hole diggers. The most important consideration when planting willow cuttings and cottonwood poles is to use equipment that will allow the cuttings to be planted at the depth that provides a constant water source (Hoag 1995). Additionally, the installation must result in good contact between the soil and the cutting.

Installation guidelines for willow stakes and bundles as well as cottonwood poles are provided within the details included in the chapter. Willow fascines can also be used, although UDFCD has observed this technique to be less successful than the above listed technics. For this reason a detail is not provided. See Hoag (2002) for installation guidance for willow fascines.

Recommended planting densities for cuttings include:

- When planting shrubby-type willows, such as coyote (sandbar) willows, a recommended planting density is 1 to 3 feet apart.
- When planting tree-type growth forms, such as cottonwoods and larger willows, a recommended planting density is 6 to 12 feet on center (Hoag 1998).
- If erosion is a concern in a portion of the project, plant shrubby-type willows 1 foot apart (Hoag 1998).

5.4.2 Installing Cuttings in Wetland Areas

Installing wetland shrubs such as sandbar willow within or adjacent to wetlands will most likely include the installation of willow cuttings, which may be installed individually or in bundles. If water erosion is anticipated, willow fascines, stakes, or the somewhat sturdier willow logs or biologs, may be installed along the water's edge. Regardless of the size or assemblage of the cuttings, they should be installed while dormant (after leaf abscission and before bud break), which extends from winter through early spring.

The equipment needed to install the cuttings will depend on the number of cuttings to be installed, size of the cuttings, and on the substrate they are to be placed in. A relatively low number of small cuttings can usually be installed with a planting bar. Larger cuttings, such as poles, may be installed with hand or

power augers. Wheel mounted augers on all-terrain vehicles can be extremely useful when planting thousands of cuttings. When planting in riprap or steep cut-banks, backhoes may be used. The most important consideration when planting cuttings of any size is to use the equipment that will allow the cuttings to be planted at the depth that provides a constant water source (Hoag 1995).

Cuttings should be installed to a depth that allows the end of the cutting to be in contact with groundwater throughout the growing season, even if the water table drops. Assessing groundwater depths prior to planting is highly recommended (Los Lunas N.D.). The basic technique to install a cutting, regardless of its size, is to auger or punch a hole into the substrate (to the appropriate depth) and then place the cutting in the hole. The soil should then be tamped down around the cutting to remove all air pockets. All cuttings, whether stakes or poles, should be planted with the buds pointed up and at least one healthy bud above the ground surface. Smaller cuttings should be installed to approximately three-quarters of their total length (NRCS 1997). In areas where the groundwater is relatively low (such as in adjacent upland or riparian areas), poles or posts may be installed 2 to 7 feet deep (Hoag 1995). For additional information on willow and cottonwood pole cuttings, see Section 4.4.4.

5.5 Transplanting Wetland Plants

Plugs, whole plants, rhizomes, and tubers salvaged from a donor wetland site are most easily transplanted when the site is slightly saturated. All plant material should be reinstalled in the same hydrologic zone that it was removed from. If 1-square-foot plugs are to be transplanted, they may be separated into smaller plantings. Use a small saw or shovel to chop them into smaller pieces (NRCS 2011). Both rhizomes and tubers should be placed in holes dug in the mud. Rhizomes should be planted just below the soil surface and tamped in to ensure good soil contact. Tubers should be placed in a hole that is approximately twice the size of the tuber (NRCS 1997). When transplanting shrubs or trees, the plant should be placed directly to the new location from the equipment used to dig it out. Ideally, a spade machine would be used to remove larger plants and would be sized to match the plants being removed (Colorado Natural Areas Program 1998). To avoid desiccation, trees and shrubs should be transplanted when dormant.

When donor topsoil is obtained from a wetland for its seed bank, it should be spread carefully over the new wetland at a thickness of 6 inches or less (NRCS 1997, Colorado Natural Areas Program 1998). Care should be taken to avoid damaging the plants and propagules that are present within the topsoil. The soils should be spread in the same hydrologic zone from which it was taken. Similarly, wetland sod that is obtained from a donor site should to be placed in the hydrologic zone matching the one from which it was taken. If several pieces of sod are available, they should be placed together in a bricklaying fashion on the soil surface and secured with wooden stakes (NRCS 2011). Gaps between the mats should be avoided to the extent practical.

6.0 Mulching

Mulching is the practice of applying a protective layer of material onto the soil surface of individually planted trees and shrubs or a broadly seeded area. Mulching is important in both upland and riparian areas but should not be conducted in wetland areas (EPA 1994). Mulching can be achieved through straw, hydromulch, or rolled erosion control product (RECP) installation. Applying mulch provides many benefits such as:

- Decreases germination of many weed seeds.
- Moderates soil temperatures.

- Retains soil moisture during dry weather (i.e., decrease evaporation).
- Increases infiltration.
- Decreases erosion.
- Adds organic matter to soil.
- Protects soil from "crusting" caused by raindrops on bare soil.
- Reduces compaction caused by heavy rains.

Mulching practices differ for individually planted trees and shrubs and seeded areas, as described below.

6.1 Mulching Individually Planted Trees and Shrubs

Individually planted trees and shrubs should be mulched immediately after planting. Mulch should be thickest at the edge of the planting saucer and taper to a zero depth at about one inch from the shrub/tree. Too much mulch can be smothering or produce excess moisture that could cause disease. Appropriate mulch includes straw, wood and bark chips, grass clippings, leaves, compost, wood and straw pellets, and inorganic material such as rock.

Mulching with wood and bark chips is less effective per unit weight than mulching with straw (NRCS 2005a). Additionally, it may discourage plant growth if applied at excessive rates. Wood and bark chips tend to have high carbon to nitrogen ratios. Additionally, nitrogen gets tied up during the breakdown of wood and bark making it less available for plants. This may actually provide a slight benefit for natives over weed species, which have higher nitrogen needs. A different form of wood and bark mulch is pellets. Wood and straw can be partially chemically digested and the "mash" formed into pellets. These pellets can be easily broadcast over a site (NRCS 2005a) but should not be used on slopes where they could readily slide downhill.

Photograph 13-6. Crimped straw mulch. (Photograph courtesy of David Chenowith.)

Although often overlooked, rock is excellent inorganic mulch (NRCS 2005a). It holds up well and doesn't float. The biggest constraints are its heavy weight and cost to transport. It may also require greater attention to weed control.

6.2 Mulching Seeded Areas

In seeded upland and riparian areas, one of the most important functions of mulching is to reduce erosion. Because riparian areas are often located on slopes draining into waterways, they are prone to erosion and may increase sediment loading to streams. Because upland seeded areas are often located on open dry areas, they establish better and more rapidly if mulched. Many materials are available for use as mulch on seeded areas, including but not limited to straw, wood and bark chips, grass clippings, leaves, compost, wood/straw pellets, blankets and netting, and inorganic materials such as rock. The more common materials are discussed below.

6.3 Types of Mulch

6.3.1 Straw Mulch

Straw mulch is the most widely used product for upland and riparian area seeding because it is cost-effective, readily available and conveniently packaged in bales. Straw mulch can be spread and crimped successfully on slopes of 4:1 or less. Steeper slopes may require a different type of mulch. Straw is fairly durable, easily applied, and provides excellent erosion protection.

Although straw includes the stalks of plants without the seed heads, some seeds may be present. Straw mulch containing weed seeds can drastically alter the success of revegetation on a site (Kruse et al. 2004). Using non-certified mulch may introduce noxious weeds and undesirable plant species onto the site. Additionally, many agencies require the use of certified weed-free mulch.

Long straw is appropriate for straw mulching but fragmented straw should be avoided. At least 50% of the straw mulch should be a minimum of 10 inches long for stability once crimped. The straw mulch can be applied by hand in small areas or by a chopper/spreader or blower in larger areas. The NRCS-recommended application rate is between 1000 to 8000 pounds of straw mulch per acre (NRCS 2005a). In general, the more straw used, the better the erosion protection. However, a high application rate may interfere with seedling emergence. A good rule of thumb when mulching over a seeded area is to mulch to a density where some soil is visible beneath the straw (between 2 to 2.5 tons of straw per acre is a recommended rate in Colorado).

The disadvantage of straw mulch is that it is highly susceptible to blowing away, so it must be anchored or crimped. The straw should be crimped into the soil to a depth of 2 to 3 inches with a crimping tool. The straw can also be anchored with a roller or empty drill (with heavy press wheels) pulled behind a tractor (NRCS 2005a). Disks and chisels should not be used to crimp because they will cut the straw, allowing it to blow free. If the slope is too steep for equipment access, a tackifier may be blown on top of the mulch by a hydromulching/hydroseeding truck. A tackifier should be applied at a rate of 150 pounds per acre. In cases where extra care is needed to avoid straw mulch blowing away, crimping and tackifier may both be utilized.

Because hay includes the entire plant including seed, mulching with hay will actually seed the site during mulching activities with non-native grass species and should be avoided. Alternatively, native grass species of hay may be purchased, but are difficult to find and expensive. Purchasing and utilizing a certified weed-free straw is an easier and less costly mulching method.

6.3.2 Rolled Erosion Control Products

Rolled Erosion Control Products (RECPs) include a variety of temporary or permanently installed manufactured products designed to control erosion and enhance vegetation establishment and survivability, particularly on slopes and in channels. For applications where natural vegetation alone will provide sufficient permanent erosion protection, temporary products such as netting, open weave textiles and a variety of erosion control blankets (ECBs) made of biodegradable natural materials (e.g., straw, jute, coconut) can be used. See the RECP fact sheet in Chapter 7, Construction BMPs, of Volume 3 for more information on appropriate uses and installation guidance for RECPs.

Although RECPs can be expensive, they are often the best approach for facilitating revegetation on steep slopes (such as 3:1 or steeper). For purposes of revegetation, it is best to avoid thick straw or excelsior blankets because they can impede grass establishment. RECPs must be installed correctly to be effective.

RECP Recommendations

- UDFCD recommends only biodegradable RECPs because plastic netting products may trap snakes, deer and other wildlife.
- Heavy woven coconut fiber blankets (coir) are preferable on stream edges due to strength, flexibility and relative durability of the blanket.
- Coir, non-woven coconut blankets or biodegradable coconut straw composite blankets can be used in biologs and willow log construction.
- UDFCD uses coir mat placed over straw to hold topsoil and seed in place. See details located at the end of this chapter.
- Non-woven coconut blankets can be used on streambanks where less intense flows occur.
- Areas that are not as frequently inundated can use biodegradable coconut straw composite blankets. These blankets and straw blankets tend be stiffer and not drape as well. Jute netting is soft and drapes very well, but is typically limited to a 4-foot width.

6.3.3 Hydromulch

Hydromulch is a slurry of water, wood fiber or recycled paper mulch, and an organic tackifier that is mixed in a large tank (mounted on a truck) and applied with a pump and hoses. It is a more expensive but can be an effective erosion control method that is used in areas where blowing loose straw may not be suitable (such as in established neighborhoods and along roadsides). Because the hydromulch holds the seed in place (with the tackifier), it is especially beneficial when applied to a slope that has been broadcast seeded (Goodwin et al. 2006). It is also valuable for stabilizing soil on steep slopes that cannot readily hold straw mulch. Hydromulch is a sterile product without weed seed concerns and should not be confused with hydroseeding, which combines seed with hydromulch.

Hydromulch should be specified to be “mechanically defibrated virgin wood fiber” and should be applied at a rate of 2000 to 3000 pounds per acre (NRCS 2005a). Approximately 2500 pounds of mulch and 150 pounds of organic psillium derived tackifier per acre is a recommended rate for Colorado. At the rate specified, 95% of the soil surface should appear covered after it dries. For every 500 pounds of wood fiber, 1000 gallons of water is needed. Accessibility to the site by the hydromulching truck and availability of water at the site, via a waterway (with water rights for the activity) or water truck, are essential. Because the hydromulch is applied through hoses, vehicular access throughout the entire site is not necessary provided that the hoses can reach all of the areas to be mulched. Always check installation rates, areas and quantities to be sure that the specified rate has been applied. Most failures result from low application rates.

6.3.4 Compost

Compost is a mulch option that may be considered for use in upland and riparian areas. Compost consists of decomposed organic material and therefore has higher nutrient availability than other mulch materials (NRCS 2005a). This is a potential disadvantage in riparian areas where it could wash into waterways and impact downstream water quality. In contrast, in riparian areas where the topsoil has been completely removed, compost may be appropriate. On seeded upland and riparian areas, compost may also be a more costly mulching alternative because of the quantity required. However, in upland areas where the topsoil has been completely removed, compost may be a beneficial mulching alternative.

7.0 Maintenance

To achieve successful revegetation, the project's resources and budget must extend beyond the active construction phase to include maintenance for several years following construction. A maintenance and management plan should be completed for the site to include the following activities:

- Weed control and long-term management.
- Replanting dead trees and shrubs.
- Reseeding bare areas where grasses did not establish.
- Repairing ECB or other erosion control fabrics, if applicable.
- Stabilizing eroded areas, particularly following large storm events.
- Installing protection from animal damage.
- Temporary or permanent irrigation, as needed.
- Debris removal.
- Installing and/or repairing temporary fencing to control foot traffic, particularly in heavily used park areas.

Wetland areas have some additional unique maintenance requirements, which are discussed separately in Section 7.6.

7.1 Irrigation

When selection of plant species is based on the available moisture and soil conditions at a given site, the plants should thrive once established without the need for long-term irrigation. Temporary irrigation can be helpful for initial establishment, especially when seeding occurs in mid-summer or in a drought. In warmer urban settings, periodic supplemental irrigation can be helpful because heat from roads and buildings tends to warm and dry adjacent areas. Temporary irrigation of native species may not be necessary after initial watering, depending on the site and the hydrologic conditions during establishment.

When provided, temporary irrigation should be applied only during the plant establishment period, usually the first growing season. This is the period when seedling roots are near the surface and can benefit from occasional irrigation. Because frequent supplemental irrigation can encourage shallow rooting, irrigation should progress to less frequent and deeper (longer duration) irrigation (Table 13-11).

If irrigating from the adjacent stream, be sure to obtain water rights or do this during "free river" conditions. If water rights are not available, use a water truck.

Irrigation can occur through any of a combination of the following methods:

- Hand watering.
- Water truck.
- Water tubes or hydrogel packs (needs to be closely monitored and eventually removed).
- Drip system irrigation.
- Spray head irrigation.

The type of revegetation project may guide the type of irrigation necessary for the site. If, for example, the project is a U.S. Army Corps of Engineers 404 permit related project, longer-term permanent irrigation is not favored and should be avoided. (Irrigation is not allowed during the three to five year monitoring period for such projects.)

7.1.1 Seeded Area Irrigation

Properly designed and installed seeded areas can be expected to germinate and establish with natural precipitation in average or wetter than average years. Even a single heavy precipitation event can be adequate to stimulate germination. If seeding is done during a drought season, or during the summer, some initial irrigation can assist with germination and establishment.

Monitoring of irrigation is a critical management activity that should occur if irrigation is to be used on a site. Either too much water or too little water can be detrimental to the survival of newly planted seedlings and plantings. Soil type will also influence the amount of irrigation needed since clay soils require less water to remain moist than do sandy soils. Moist soils in April encourage cool season native species to grow, whereas warm season grasses start to grow when soil is warmer with adequate moisture in mid to late May.

In order for native seed to germinate, the top 1 to 2 inches of soil should be moist, but not saturated. Initial irrigation should maintain moist soil in the seed bed, watering up to twice a day. Use of mulch or landscape fabric will reduce the frequency of irrigation required to maintain surface moisture. Once the grasses begin to establish, the roots will penetrate into the soil more deeply and irrigation should be reduced to three or four times a week, but for a longer duration, to allow for up to 6 inches of moisture in the soil. Irrigation should then be curtailed to one to two times per week later in the summer until the fall months when irrigation would cease to allow the plants to harden for the winter months. Table 13-11 provides a sample irrigation schedule for establishing native areas. Mulching/crimping/hydromulching seeded areas is also crucial to keep moisture in the soil.

Where an access road is available near the seeded area, a water truck can be used to spray-irrigate seeded areas on the same time basis as described above. The labor costs for using a water truck may eventually outweigh the costs of installing a more permanent irrigation system, depending on the site logistics.

Table 13-11. Sample irrigation schedule for establishing native areas

Time Of Year	Frequency	Time of Day	Soil Moisture Depth
Mid-April (Cool Season) Mid-May (Warm Season)	1-2 times per day until temperatures reach 80 degrees	Once in early morning once in late evening	Maintain soil moisture to 2-inch depth
Early June to July	Every other day or more if temperatures are above 90 degrees	Early morning or late evening	Maintain soil moisture to 6-inch depth Cycle and soak technique may be used to reach 4 inch-depth[1]
July to Mid-August	One application per week	Early morning or late evening	Maintain soil moisture to 6-inch depth
Mid-August to Mid-September	One application every other week	Early morning or late evening	Maintain soil moisture to 6-inch depth
Mid-September and on	Withhold watering to allow plants to harden for winter	NA	NA

[1] To maintain soil moisture in soils that are finer in texture, a cycle and soak technique of water application may need to be used. A cycle and soak technique is performed by watering in short durations, with multiple applications. This allows the water to infiltrate the soil rather than run off the site.

7.1.2 Tree and Shrub Irrigation

When properly located and planted, native trees and shrubs should be fairly self-sustaining with limited initial watering. Deep planting of trees and shrubs (which places the base of the root ball at the top of the ground water level, dormant season planting (before leaf out), and use of smaller nursery stock (which requires less water to establish) all can help reduce watering requirements for woody vegetation. All containerized plants should be well watered at installation time. When leafy plants are installed later in the spring or summer, a more prolonged irrigation program may be necessary.

Trees and shrubs should be deeply watered when first planted so that the entire root ball and soil around the root ball are inundated. Depending on the species selected, available soil moisture, and available precipitation, the trees and shrubs should be watered at least once a week during the first growing season. The need for a second growing season of irrigation can be monitored and assessed the following year. Monitoring the trees and shrubs is essential in order to be proactive with temporary irrigation before plants begin to stress and then die.

7.2 Replacing Dead Trees and Shrubs/Spot Reseeding of Bare Areas

Routine maintenance in establishing upland areas generally includes reseeding of bare areas and replacing dead, diseased, or dying planted trees and shrubs. At least some replacement of dying plants is typically required in riparian areas. If diversity is limited, additional species should be planted to add diversity to the establishing upland plant community. If a significant number of plants are diseased or infested by insects, a fungicide or insecticide application may be warranted.

In riparian areas, although newly establishing willows need relatively little maintenance, several maintenance activities will improve the riparian plant community's functions. As willows age, some may

need to be trimmed or cut down to stimulate smaller, denser growth (Hoag 1998). This should be completed in the dormant season. Similarly, on river floodplains no longer exposed to historic flooding (due to irrigation withdraws, dams, etc.), cottonwood and willow trees will no longer naturally replace themselves. These larger riparian species evolved to regenerate with natural cycles of intermittent flooding. When these cycles are disturbed, the larger riparian species are eventually replaced by a xeric plant community (Los Lunas Plant Materials Center 2005). Preserving these riparian plant communities will require ongoing planting and management.

In both riparian and upland areas, bare areas that were seeded will need to be weeded and spot-seeded/mulched annually until the bare areas fill in. In some cases, additional soil sampling and application of soil amendments in perpetual bare areas may be warranted. Irrigation concerns may need to be addressed in the bare areas until the grasses establish.

7.3 Vegetation Protection from Animal Predation

Additional maintenance often required for establishing upland and riparian plant communities includes replacing or installing fencing and protection to minimize animal damage. General browse protection can be provided by flexible tube tree protectors that trap moisture and protect the tree from browsing animals, wind desiccation, small rodents, and insects. They can be obtained in various thicknesses and heights. Rigid seedling protector tubes are plastic-like mesh tubes that protect young woody plants from browsing by larger animals. Metal deer fencing can also be installed around larger plantings to protect them from browse by deer. Deer may also be discouraged by bud caps (pieces of paper that hide buds from deer). Where voles are a concern, wrap the base of the planted tree twice with 6- to 8-inch-wide strips of tinfoil. This can be effective for up to two years (NRCS 2001a).

When in an area heavily populated by prairie dogs, it is not always realistic to keep all prairie dogs out of the newly planted area. Use a perimeter fence to deter prairie dogs from entering the area of construction and consider a more permanent fence during the time of plant establishment. This can be constructed using a wire mesh that is buried 3 feet into the ground and extends above ground 3 feet. Alternatively, the buried portion of the fence could be placed horizontally and just buried a couple inches (in an "L" formation). Attach silt fence onto the upper portion to limit visibility to the protected area. This fence will require maintenance and should remain in place for 1 to 2 years. Fumigation may also be beneficial during this time.

Photograph 13-7. Prairie dogs will attempt to dig under the fence. Bury the wire mesh portion vertically (shown) or in the form of an "L" to deter prairie dogs from burrowing under the fence.

If beavers are a concern, new plantings can be protected by 5-foot-high wire tree guards. This should be done with the understanding that the beaver will look for other (mature) trees. Unlike prairie dogs, when the project requires removal of beaver (although rare), there are typically landowners that will accept them. An experienced trapper can live-trap and safely relocate beaver to a new location.

Geese can cause significant damage to a newly planted wetland. Waterfowl may mouth the plants looking for seed and uproot the planted material. Wetlands often need waterfowl predator control through the placement of a grid of T-posts installed 10 foot on center with wire strung between the posts (see Figure 13-16). Brightly colored flagging is then tied onto the wire. This grid of predator control will

reduce waterfowl landing in the newly planted area. Alternatively a 6- to 8-inch steel landscape staple can be used to secure each seedling. Staples rust quickly and prevent the plants form being pulled up by the grazing birds.

7.4 Weed Management

Control of weeds, especially noxious weeds, is a critical component of maintaining establishing upland and riparian areas. Any weeds on the Colorado Noxious Weed "A List" should be promptly and aggressively treated. Similarly, areas with infestations of Colorado Noxious Weed "B or C List" species with more than 10% cover should be promptly addressed; however, a tolerable range of what species can be present and/or the cover of an individual species can vary by state or local jurisdiction and by specific permitting requirements for an individual project. Using GPS to mark the locations of noxious weeds may be beneficial for both short and long-term management. Developing an integrated weed management plan is highly recommended for most newly revegetated sites. Integrated weed management is defined as using a variety of techniques to control weeds (Colorado Natural Areas Program 1998). Techniques that may be used include mowing, herbicide application, rotational grazing, biocontrol, and hand-removal or cutting. The integrated weed management plan should evaluate the weed species found at the site and determine the best combination of control strategies for each species. Note that newly seeded plants will be especially vulnerable to all herbicides; therefore, herbicides should not be applied to newly-seeded areas until the plants are relatively hardy [when the plants have four to six blades (Goodwin et al. 2006)]. Following the initial years of intensive management, a long-term commitment for spot-spraying of re-sprouting weeds must be part of any control plan. The herbicide label should be read to determine when to re-seed because the time an herbicide remains active in the ground differs for each herbicide.

Newly seeded areas can be very weedy during the first year of growth. Annual weed seeds are abundant in most topsoil and germinate readily. It is critical that annual weeds be mowed when they are in flower and before they produce seeds. Two or three mowing operations in the first year of growth can generally address most of the annual weeds on a site. UDFCD has also found that starting weed control one to two years prior to construction can be beneficial in controlling new weeds following seeding. Biennial and perennial weeds can be spot-treated by a certified weed control specialist with approved herbicides by mid-summer or when the seeded grasses have three to four leaves. A boom sprayer should not be used during the first summer after seeding.

Weed control of established seeded areas during the second growing season may involve a combination of techniques including spot spraying weedy areas. However, herbicide applications should be closely managed and herbicide selection, method of application, times and rates should be chosen carefully and recorded based on the type and amount of weeds present. A certified applicator should be used for all herbicide applications. A copy of their applicator license should be obtained and records should be kept of all applications that occur on the site. A Compliance Certification for the CDPS General Permit for Discharges from Application of Pesticides may be required for herbicide applications exceeding certain thresholds.

A seeded area without shrubs may be mowed during the first year of establishment as a good early weed control method. Weedy areas should be mowed 6 to 8 inches when they exceed 12 inches in height or just begin to produce seed. A small or tandem wheeled tractor is appropriate for this type of mowing. Mowing should not be used to limit plant height. A low-growing grass seed mix should be used if shorter grasses are desired. The normal mowing height for established grasses should be no less than 6 inches because mowing too low is detrimental to grass establishment.

Additional natural weed control methods have a variety of levels of success depending on the species of weed. These include goat/sheep temporary grazing, insect releases, rotational grazing, hand

cutting/pulling, spot seeding, and other natural methods. These methods can be integrated with herbicide treatments and mowing for best results. Spot seeding bare areas with desirable grass and/or planted species once weeds are controlled is highly encouraged so that the bare areas do not become established with additional weedy species.

7.5 Managing Erosion in Riparian Areas

Riparian areas commonly require maintenance to address erosion. The site should be inspected closely for signs of erosion. If necessary, install additional erosion control measures such as erosion control blankets or consider the need for other bioengineered solutions (see the Bioengineered Channels section of the *Major Drainage* Chapter for further detail on bioengineered bank stabilization methods). Existing erosion control matting, netting, or blankets should be repaired or replaced as required and in areas where it is still needed. In locations where major erosion is occurring and cannot be controlled with bioengineering techniques, other types of engineered structural measures may be necessary.

7.6 Maintenance for Created, Restored and Enhanced Wetland Areas

A maintenance plan should be part of the wetland creation, restoration and enhancement project. A maintenance plan should include periodic observations of the wetland area during the growing season to observe existing hydrological conditions, wetland establishment, weed control, spot revegetation and other maintenance needs at the site.

During the maintenance visit, it is important to observe and document existing hydrologic conditions for wetland establishment as designed. Hydrologic observations should include these conditions:

- Standing water.
- Subsurface water through digging of soil pits.
- Observation of established wetland vegetation.

If wetland plants are not fully established, but adequate hydrologic conditions exist, one can assume that the plants will eventually establish throughout the area. Additionally, in areas where water control is possible, wetland plant growth can be stimulated by alternating flooding and drawdown in the wetland. If wetland plants are not establishing and there is a lack of adequate hydrologic conditions, additional excavations, water diversion, or grading may be warranted. If the water depths are too deep for wetland plant establishment, additional fill, water diversion, water pumping, or outlet reconfiguration may be warranted. Once appropriate hydrological conditions have been achieved, additional spot seeding/planting of wetland plant material may be necessary.

A weed management plan is an important part of wetland area design before the seeding/planting occurs. Observation and documentation of weedy species establishing in and around the wetland area is an important first step in weed control. Weeds are controlled through the following actions:

- Applying EPA-approved aquatic herbicides (application at the correct time of year for the targeted weed).
- Hand-pulling of weed species.
- Hand mowing or weed cutter (avoid large vehicles that will damage vegetation).
- Using biological controls (insects other natural control).

- Coordination of weed control planning with adjacent property managers.
- Additional spot seeding/planting of wetland plants may be needed to fill in areas where volunteer weed species may again become established.

Other maintenance activities should include:

- Flood debris (natural and human origin) can create a smothering buildup in riparian wetland areas. If left for long periods of time, it will encourage invasion by weeds from seeds carried by the high water. Sediment deposits on newly seeded areas can sometimes be raked or shoveled off in the first few days following a flood to allow recovery of the young vegetation. If the sediments are deep, they may require additional seeding and possibly mulching. Seed mixtures can be selected based on the texture of the flood-deposited sediment. Biweekly to monthly inspection and removal should continue throughout establishment when regular flows are anticipated (April through September).
- Planted woody trees and shrubs should be observed and documented for wildlife damage such as browse, trunk damage and other physical damage. If wildlife damage is observed, protection should be installed.
- Beaver protection installed at the time of installation may require straightening and debris removal after high water event. Over the long-term, beaver cages will require loosening or enlarging around growing trees to prevent loss of the trees from strangulation by the fencing.
- Irrigation of seeded/planted material during the early establishment period may be needed during especially hot summer drought periods.
- Social walking/biking trails through wetland areas should be discouraged through piling dead wood, boulders, and/or appropriate signage.
- Repair perimeter fencing, signage, and vandalism that may occur.

8.0 Post-construction Monitoring

Post-construction monitoring of revegetation progress is essential for determining the appropriate maintenance and corrective measures that may be required during establishment of vegetation at a site. The results of the monitoring provide the information necessary for adaptive management, which is key for effective revegetation due to climatic variability and other uncontrollable factors. Research has shown that if a revegetation project has problems, they typically show up in the first couple of years after plant installation (NRCS 1997).

A trained professional should conduct and evaluate monitoring recognizing that the site will progress through intermediate stages prior to full revegetation. A variety of techniques and methods for assessing revegetation are available, ranging from simple photo documentation, to comparison to reference sites, to more rigorous ecological evaluations, particularly for wetland sites. See BLM (1999) and Faber-Langendoen et al. (2006) as two resources for monitoring approaches at revegetation sites.

For upland and riparian areas, post-construction monitoring may be required from a federal, state, or local agency depending on project permits. If monitoring is required, the agency may have specific success criteria to meet. For wetland areas, post-construction monitoring is usually required as a condition of the Clean Water Act Section 404 permitting process. A permit granted by the USACE authorizing fill in wetlands or other waters typically specifies a series of performance measures (also referred to as success criteria or performance criteria) that the mitigation area must meet in order for the permit conditions to be

met.

Because of the importance of monitoring, adequate funding must be set aside during project development to support this phase of the project. Otherwise, the project may fail to comply with permit conditions (particularly 404 and stormwater construction permits, which require follow-up monitoring and reporting) and/or failure on-the-ground through lack of appropriate adaptive management.

The following post-construction monitoring phases are typical:

Should the contractor be responsible for the success of the vegetation?

Warranties are typically used to hold the original contractor responsible for the ultimate success of the vegetation. However, this is not necessarily the best or even the most cost effective method to ensure success. UDFCD will typically have the contractor perform initial efforts to vegetate the disturbed area. If these efforts turn out to be unsuccessful, UDFCD will work directly with a landscape specialist/contractor in an effort to reach adequate coverage of vegetation as quickly as possible.

- **Warranty Period Monitoring**: Warranty period monitoring of sites with substantial completion by early spring should begin in late May or early June to determine initial seedling establishment and composition and density of weed species. Monitoring in May can help determine a variety of conditions: whether seedling establishment is proceeding; whether the specified seed mix was in fact installed correctly at the proper rate; what the weed species are and when they are likely to require early summer mowing or later spot herbicide treatment; whether the bank protection measures are holding and establishing woody and herbaceous growth; whether the woody containerized vegetation appears to be healthy or in need of watering; and whether the trees and shrubs which were planted still appear to be the proper species as they leaf out. Evaluation of establishment at this time can sometimes lead to early corrective measures, such as reseeding of bare areas or rilling, mending or correcting poorly installed RECPs. Early growth of noxious biennial species which will flower in June or July should be noted and weed control efforts planned at this time.

  A second key warranty monitoring period typically occurs in August, when the area can again be checked for continued successful herbaceous establishment, woody vegetation survival and growth, and whether occasional watering and weed control efforts are being made. Plans can be made at this time for late season mowing and spot herbicide treatments, fall re-seeding and other corrective measures.

  Final warranty period inspection should occur at the end of warranty (1 year after substantial completion of construction and planting). At this time the site should be evaluated to determine if establishment meets the contract specification and plans. All temporary erosion control fencing, straw bales, tree protection or other temporary protective measures should be removed and disposed of offsite. Bare areas should be seeded with the seed mixture specified for that area in the plans.

- **Long-term Monitoring**: The next phase includes longer-term monitoring, typically by a revegetation specialist or wetland scientist with reporting to regulatory authorities. Monitoring methodologies may range from a quick visual inspection to an in-depth study of species composition, distribution, and density based on quantitative sampling techniques (Colorado Natural Areas Program 1998).

Representative issues that may need to be addressed during the course of post-construction monitoring include:

- Noxious weeds—weeds on the Colorado Noxious Weed A List should be noted and promptly and aggressively treated. Similarly, areas with infestations of Colorado Noxious Weed B or C List species with more than 10% cover should be promptly addressed; however, a tolerable range of what species can be present and/or the cover of an individual species can vary by state or local jurisdiction and by specific permitting requirements for an individual project. Using GPS to mark the locations of noxious weeds may be beneficial for short- and long-term monitoring.
- Browse damage (i.e., impacts from animals grazing on plants).
- Streambank or shoreline erosion.
- Irrigation needs or adjustments (irrigation is typically not needed for long-term maintenance of native areas).
- Replacement plantings.
- Water management in wetlands (if feasible).
- Removal of previously installed browse protection or temporary irrigation.

If animal damage or weed infestations appear to be significant issues, management plans can be prepared to address the problems over the long term.

9.0 Conclusion

Successful revegetation requires a multi-phase effort targeted to the relevant habitat condition. Drainage projects along the Front Range may encounter upland, riparian, and wetland habitat types, each having unique revegetation considerations. Successful revegetation projects will address proper site preparation, plant material selection and installation, mulching, maintenance and post-construction monitoring. Early involvement of a revegetation specialist can help improve the likelihood of a successful revegetation effort. Additionally, post-construction monitoring can help to identify problems that can be corrected while they are at a more manageable stage.

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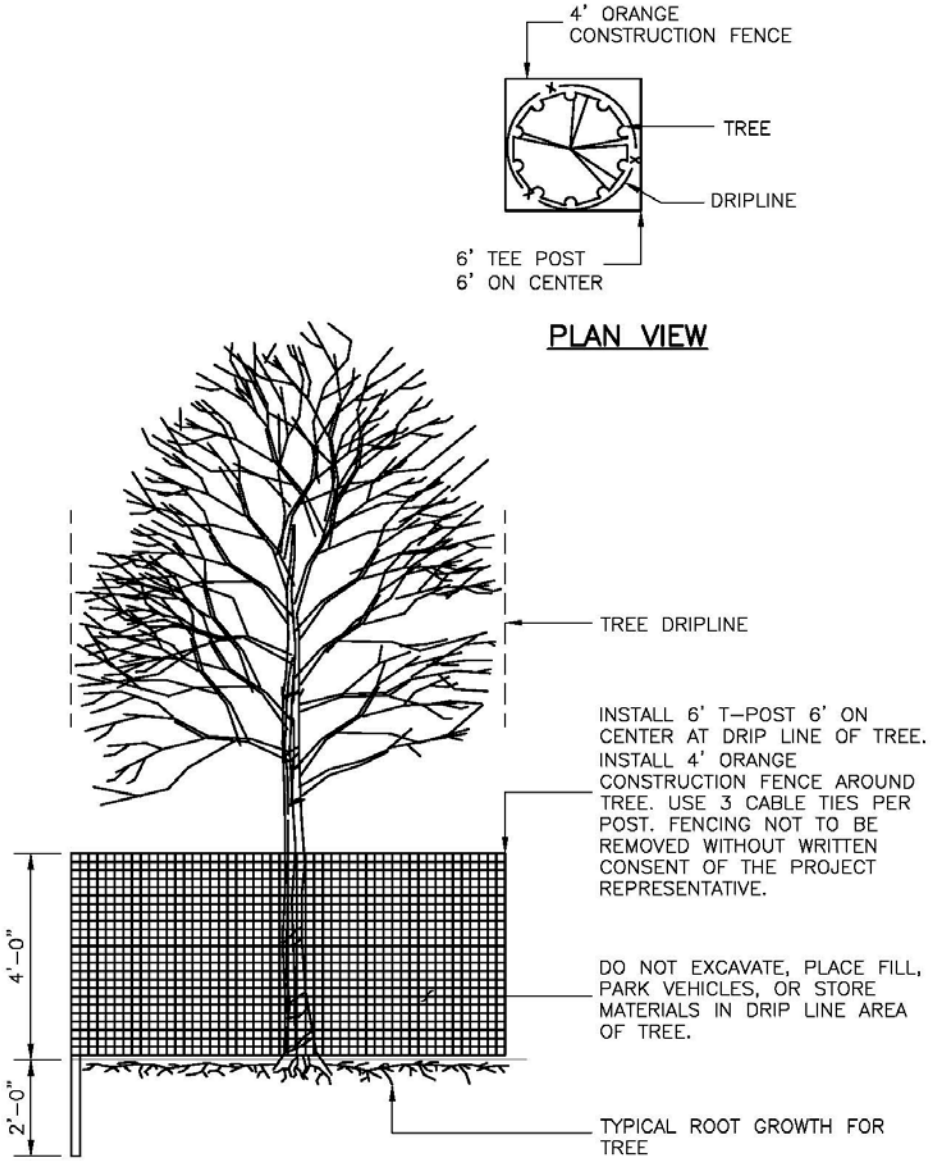
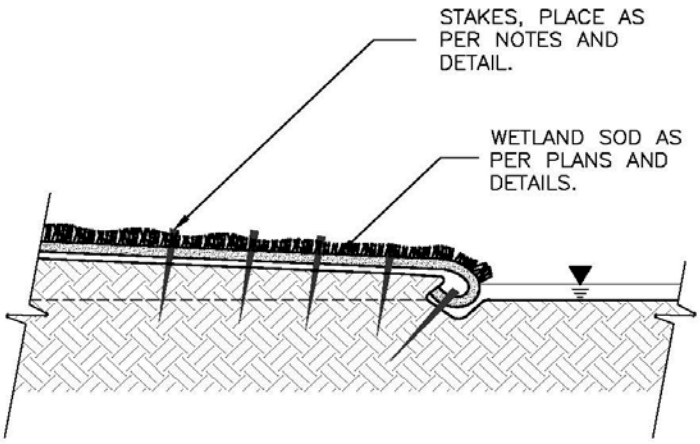
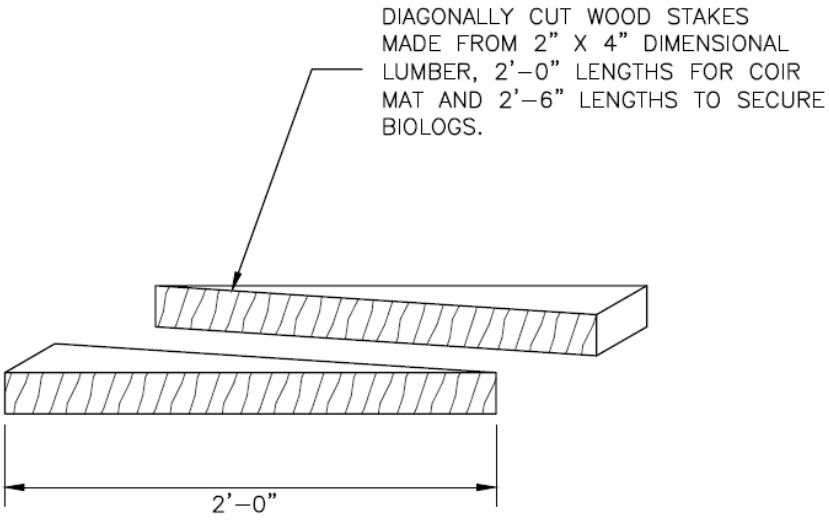


Figure 13-3. Tree protection

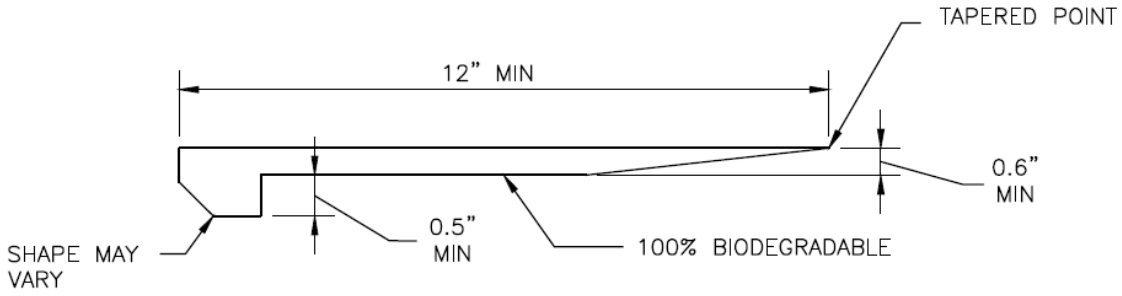


NOTES
1. KEEP ALL WETLAND SOD MOIST AND SHADED UNTIL INSTALLED.
2. FOLLOW FINAL GRADING AND TOPSOIL PLACEMENT.
3. INSTALL FABRIC (4M COIR MAT) AND ANY WILLOW LIVE STAKES PER PLAN.
4. APPLY WETLAND SOD AS SOON AS IT IS AVAILABLE FROM SUPPLIER.
5. ABUT EDGES OF SOD SECTIONS AND SECURELY PIN IN PLACE WITH 8" STEEL LANDSCAPE STAPLES IF NEEDED TO SECURE UNTIL STAKED.
6. STAKE SOD 18" O.C. ON ALL EDGES AND THROUGHOUT THE BODY OF SOD WITH WOODEN STAKES. LEAVE 2–3" OF THE STAKE SHOWING ABOVE THE MAT.
7. ANY PREVIOUS STAKES IN SOD AREA TO BE POUNDED DOWN TO SURFACE PRIOR TO SOD PLACEMENT AND STAKING.
8. IN BACKWATER AREAS AND OTHER AREAS (NOTED ON PLAN) WHERE VELOCITIES APPROACH ZERO, STAKES MAY NOT BE NECESSARY.

Figure 13-4. Wetland sod installation with staking

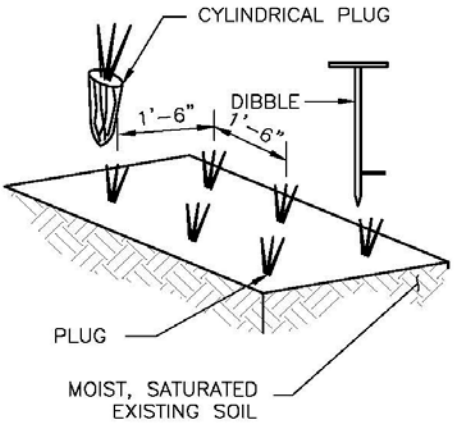


CUT WOOD



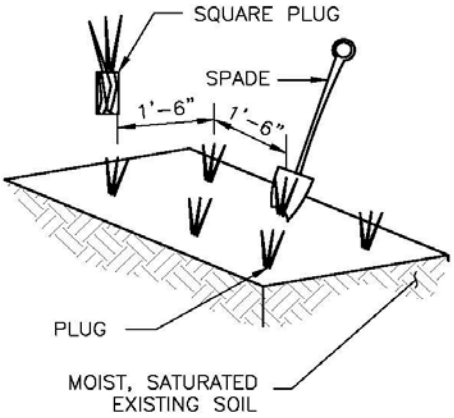
PROPRIETARY

Figure 13-5. Stakes



NOTES
1. DROP WOODEN DIBBLE STICK WITH APPROPRIATELY SIZED STEEL END INTO SOIL APPROXIMATELY 1'-6" FROM OTHER PLUGS.
2. STEP ON STEEL FOOT PLATE TO CREATE DEEPER HOLE. REMOVE DIBBLE STICK.
3. REMOVE WETLAND PLUG FROM CONTAINER AND PLANT ROOTS DOWN.
4. TAMP ON SOIL AROUND PLANT TO SECURE.

CYLINDRICAL CONTAINER PLUGS



NOTES
1. DROP SPADE INTO SOIL APPROXIMATELY 1'-6" FROM OTHER PLUGS.
2. STEP ON SPADE AND MOVE BACK AND FORTH TO CREATE AN OPEN POCKET LARGE ENOUGH FOR THE ROOT MASS TO BE INSTALLED FULLY WITHOUT HAVING TO BEND THE ROOTS.
3. REMOVE WETLAND PLUG FROM CONTAINER AND PLANT ROOTS DOWN SO THAT THE TOP OF THE ROOTS ARE JUST BELOW THE SOIL SURFACE IN THE HOLE.
4. TAMP ON SOIL AROUND PLANT TO SECURE.

SQUARE CONTAINER PLUGS

NOTES
1. UPON ARRIVAL CHECK THAT WETLAND PLUGS ARE HEALTHY, MOIST, AND FREE OF INJURIES OR INSECT DAMAGE.
2. KEEP WETLAND PLUGS MOIST AND SHADED BEFORE PLANTING.
3. SOILS SHOULD BE MOIST TO SATURATED BEFORE PLANTING.
4. WATER THE PLANTED AREA AFTER PLANTING IF NEEDED.
5. INSTALL WATERFOWL PREDATION CONTROL AS NEEDED.

Figure 13-6. Wetland plug planting

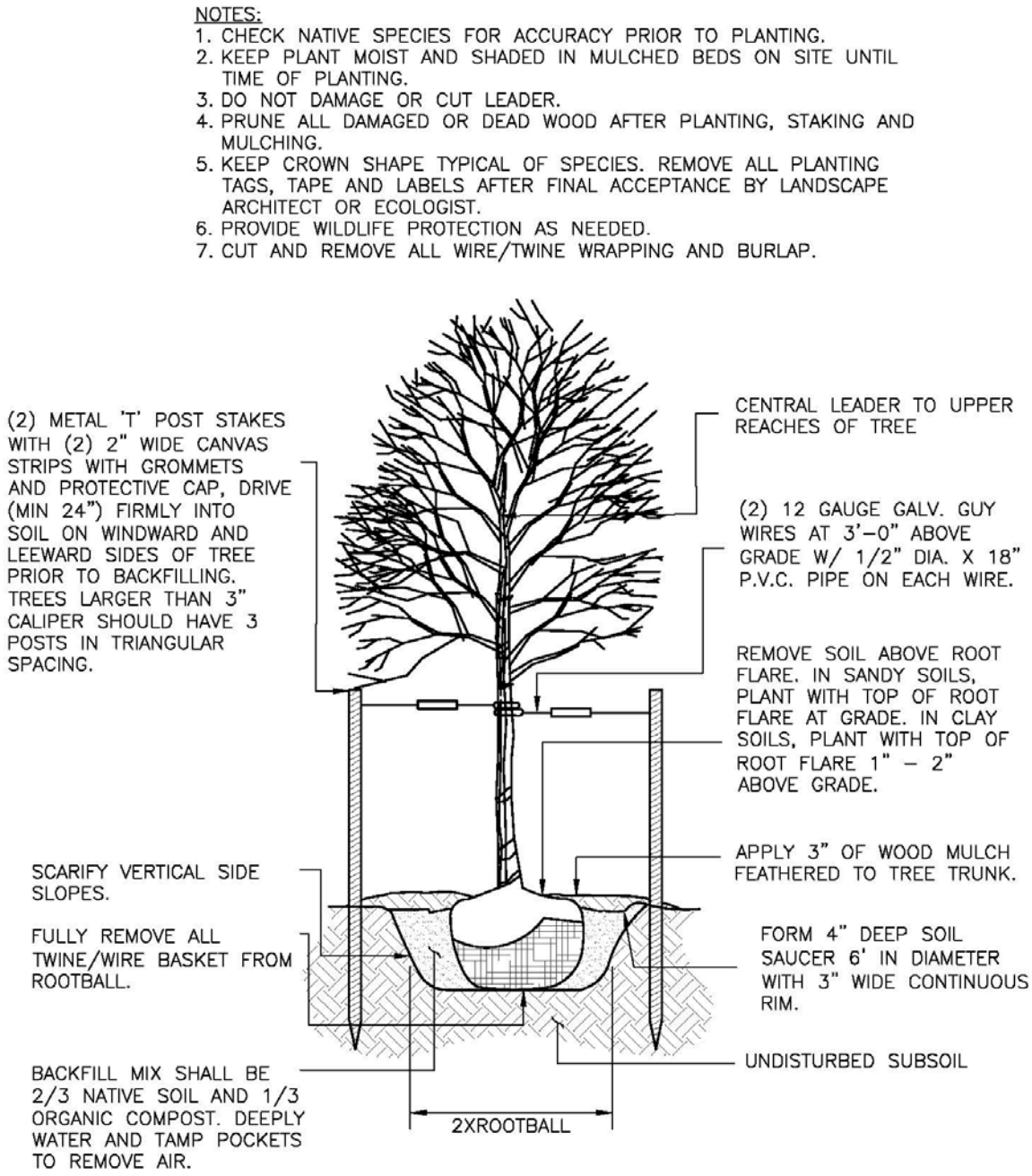


Figure 13-7. Deciduous tree planting

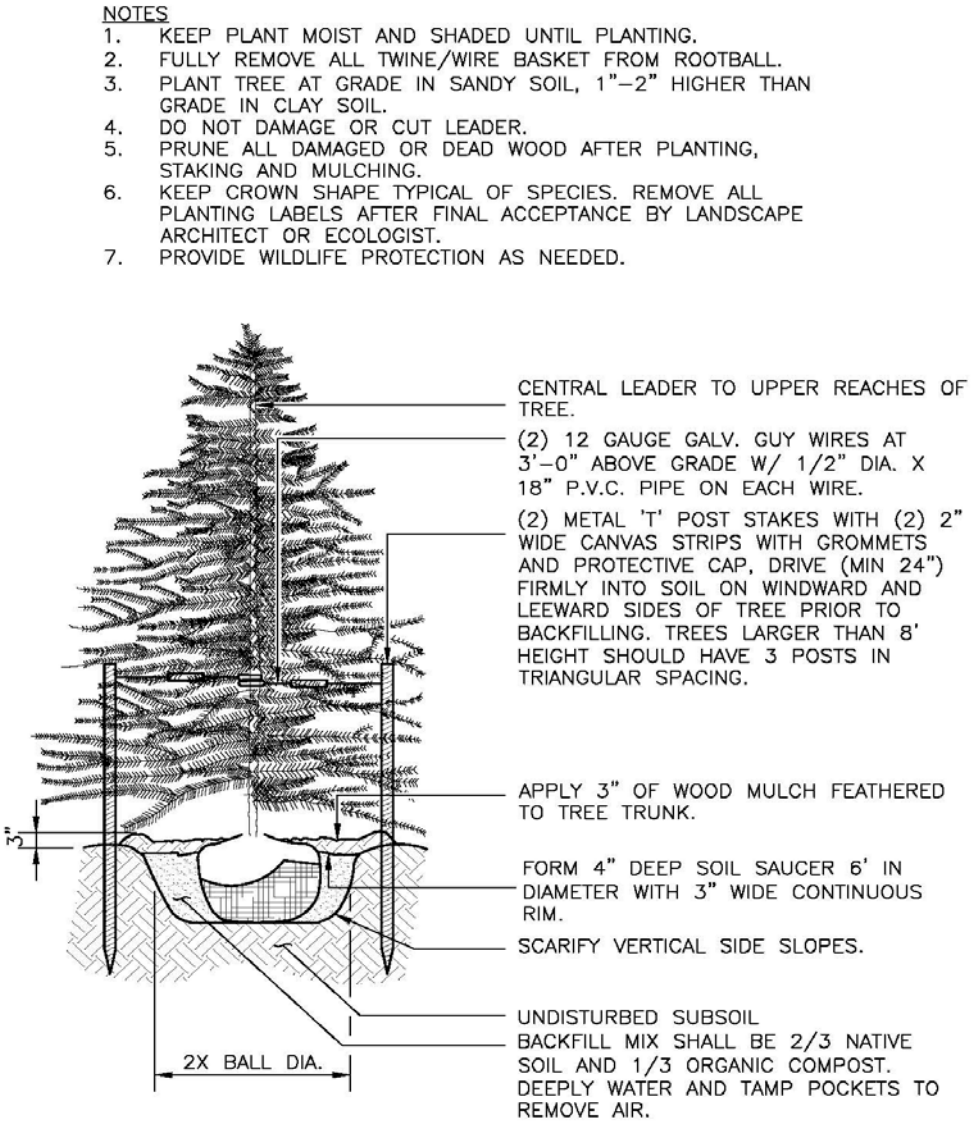


Figure 13-8. Upland evergreen tree planting

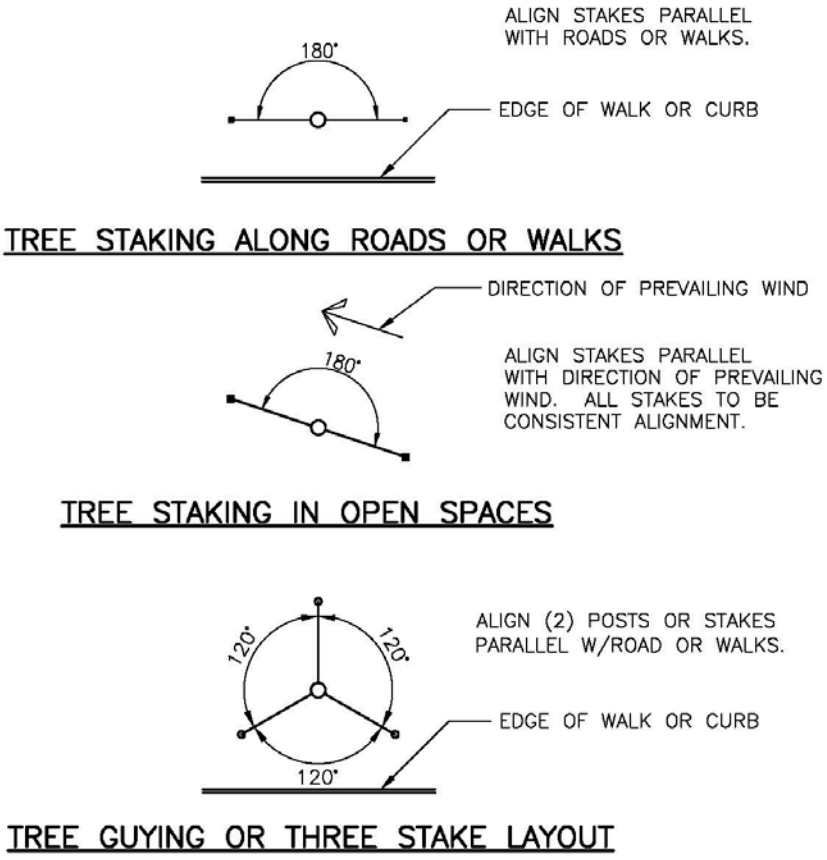


Figure 13-9. Tree stake layout

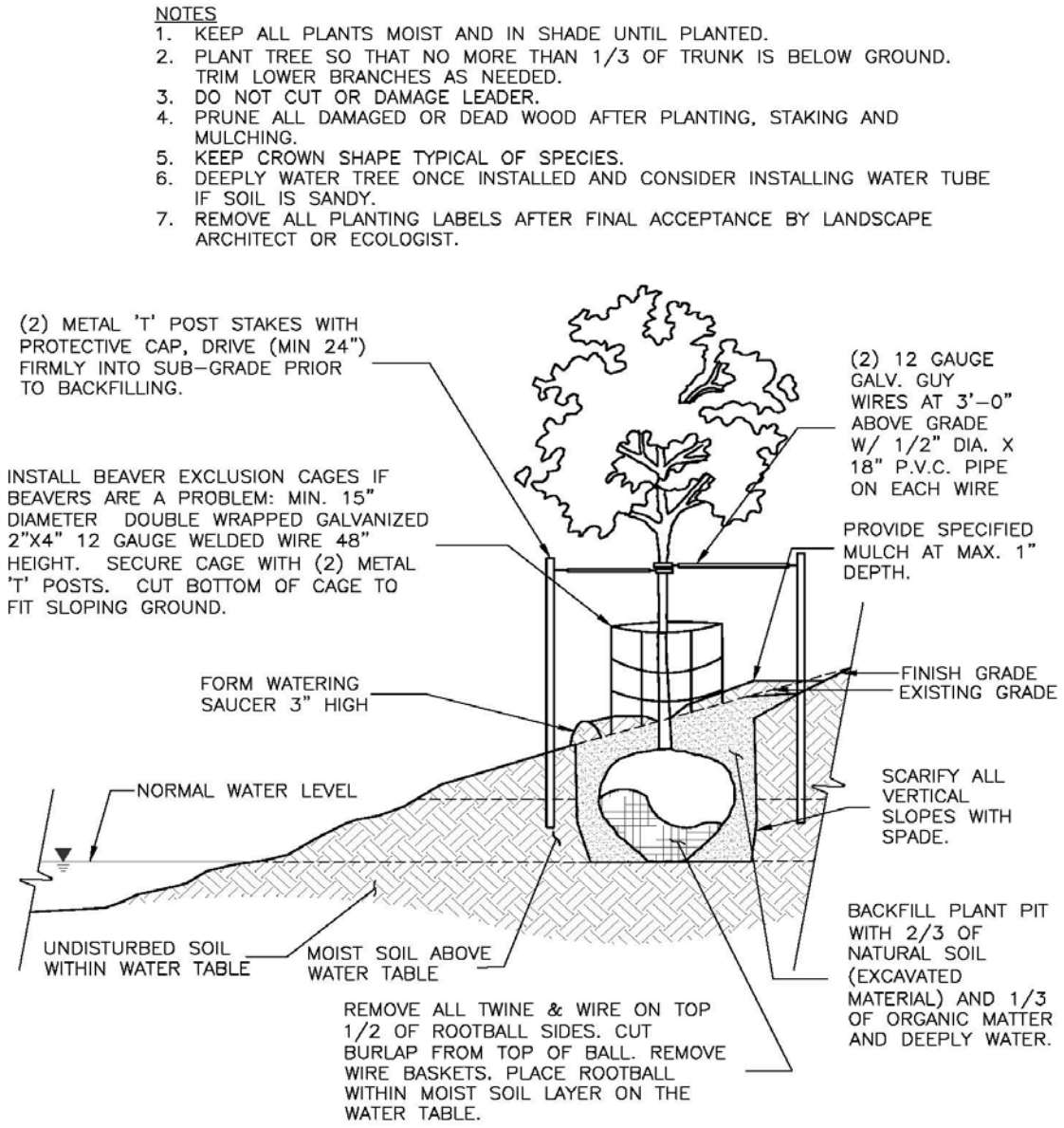


Figure 13-10. Deep tree planting for B&B cottonwood species

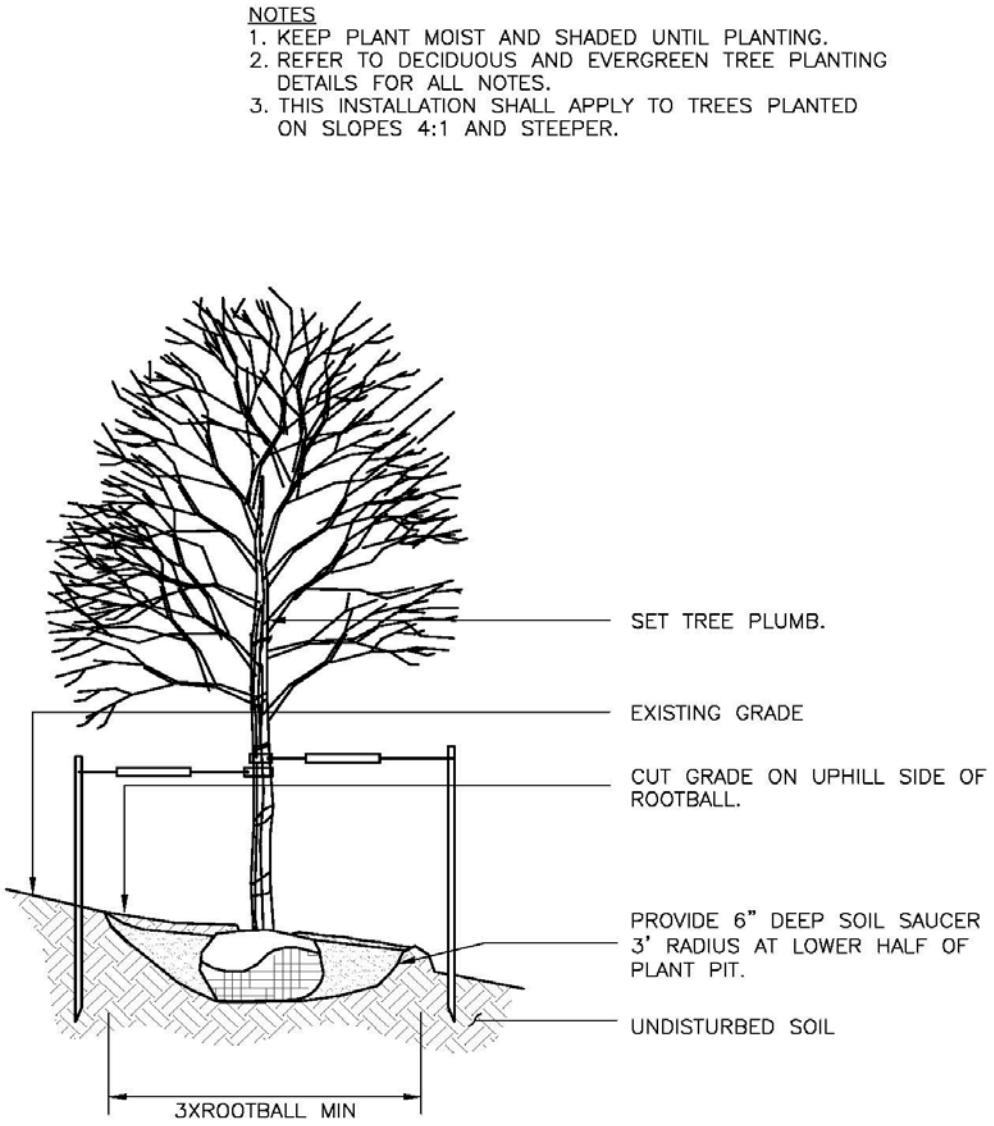


Figure 13-11. Tree planting on slope

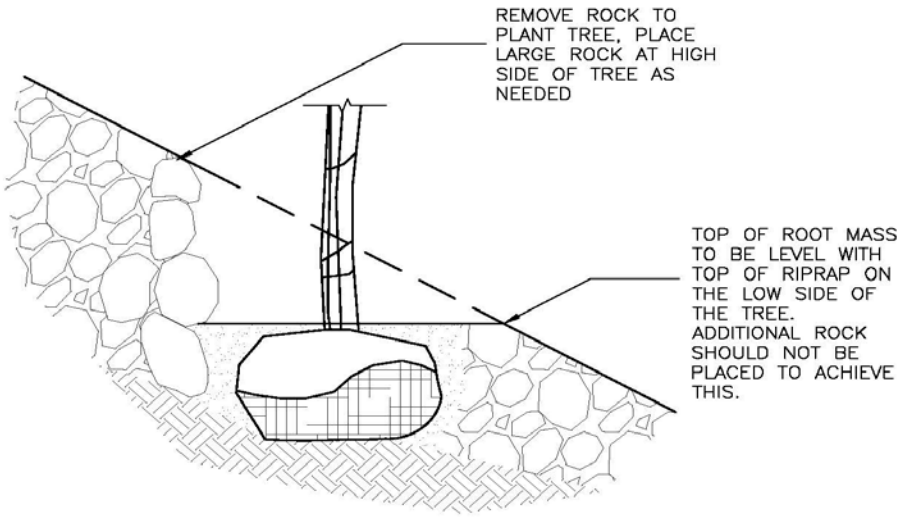


Figure 13-12. Tree planting on riprap slope

NOTES
1. KEEP PLANT MOIST AND SHADED UNTIL PLANTING.
2. FOR ROOT BOUND CONTAINER PLANTS, MAKE 4–5" DEEP VERTICAL CUTS INTO ROOT BALL EDGE AND PLANT IMMEDIATELY.
3. DO NOT CUT LEADER, PRUNE ALL DAMAGED OR DEAD WOOD AFTER PLANTING, STAKING AND MULCHING, KEEP CROWN SHAPE TYPICAL OF SPECIES, REMOVE ALL PLANTING LABELS AFTER FINAL ACCEPTANCE BY LANDSCAPE ARCHITECT OR ECOLOGIST.
4. PROVIDE WILDLIFE PROTECTION AROUND PLANTED SHRUB AS NEEDED.

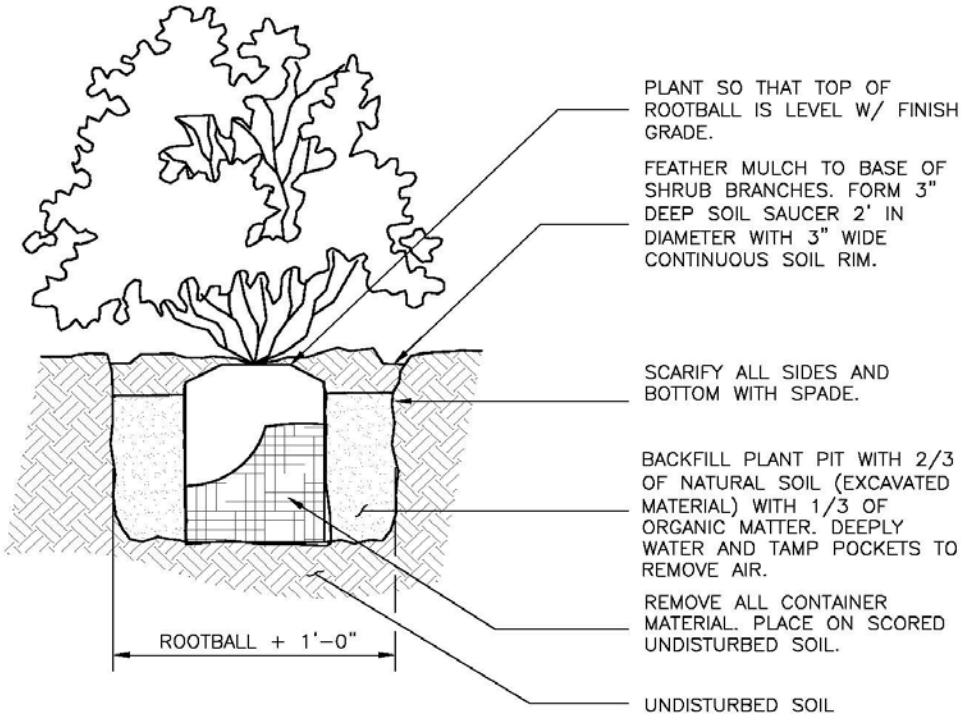
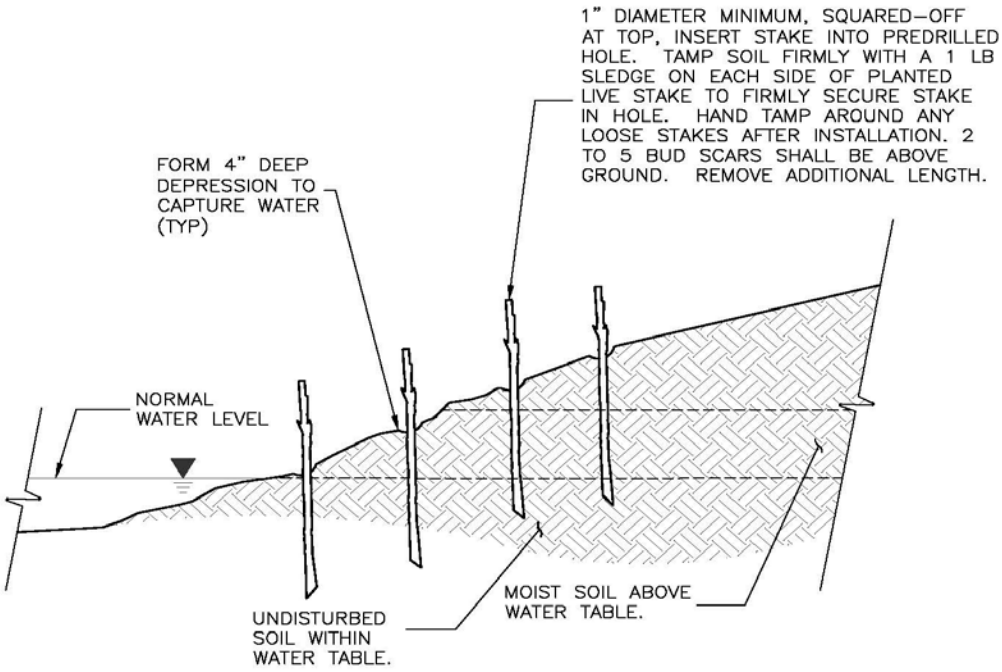


Figure 13-13. Shrub planting container



NOTES
1. HARVEST AND PLANT WILLOW LIVE STAKES DURING DORMANT SEASON
2. WILLOW STAKE SHALL HAVE CUT END ON AN ANGLE TO SIGNIFY PLANTING END.
3. USE HEALTHY, STRAIGHT, AND LIVE WOOD AT 2 TO 3 YEARS OLD.
4. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS.
5. PLACE CUTTINGS IN WATER IMMEDIATELY AFTER HARVESTING.
6. SOAK CUTTINGS FOR 24 HOURS (MIN.) PRIOR TO INSTALLATION.
7. STORE CUT WILLOWS WITH LOWER ENDS IN WATER FOR NO LONGER THAN 7 DAYS BEFORE PLANTING.
8. LENGTH OF STAKES SHALL BE 2' (MIN.). PRE–DRILL HOLES WITH STEEL REBAR.
9. PLANT AT LEAST 3/4 LENGTH OF STAKE INTO MOIST SOIL.

Figure 13-14. Willow live stakes planting

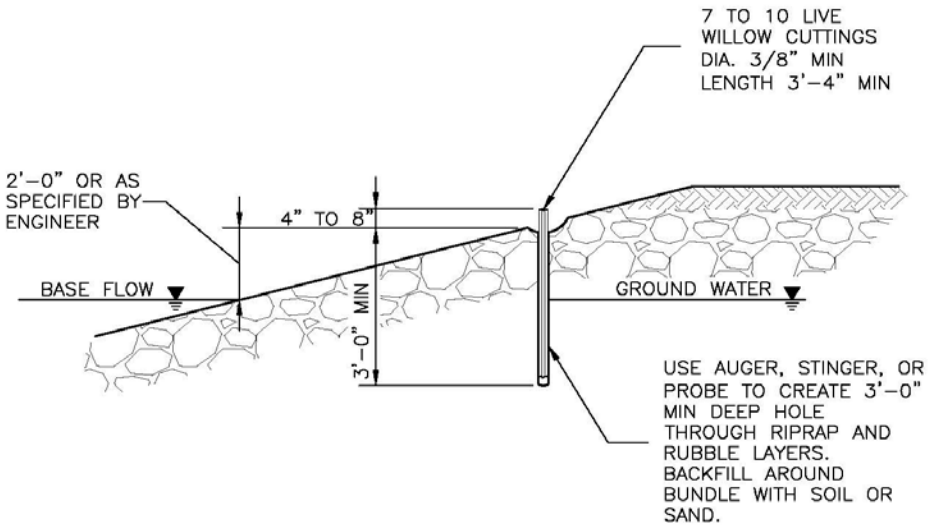


Figure 13-15. Willow bundle installation

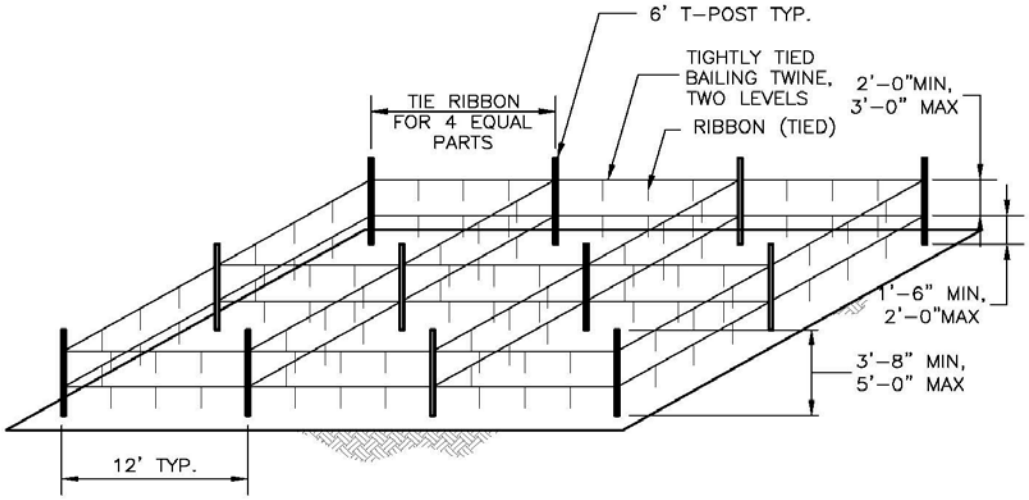


Figure 13-16. Waterfowl grazing control

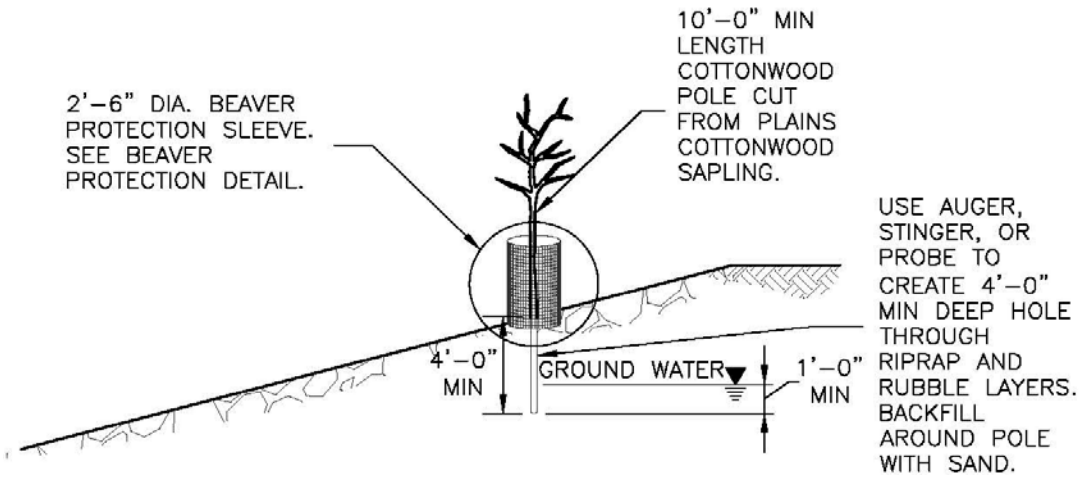


Figure 13-17. Cottonwood poling

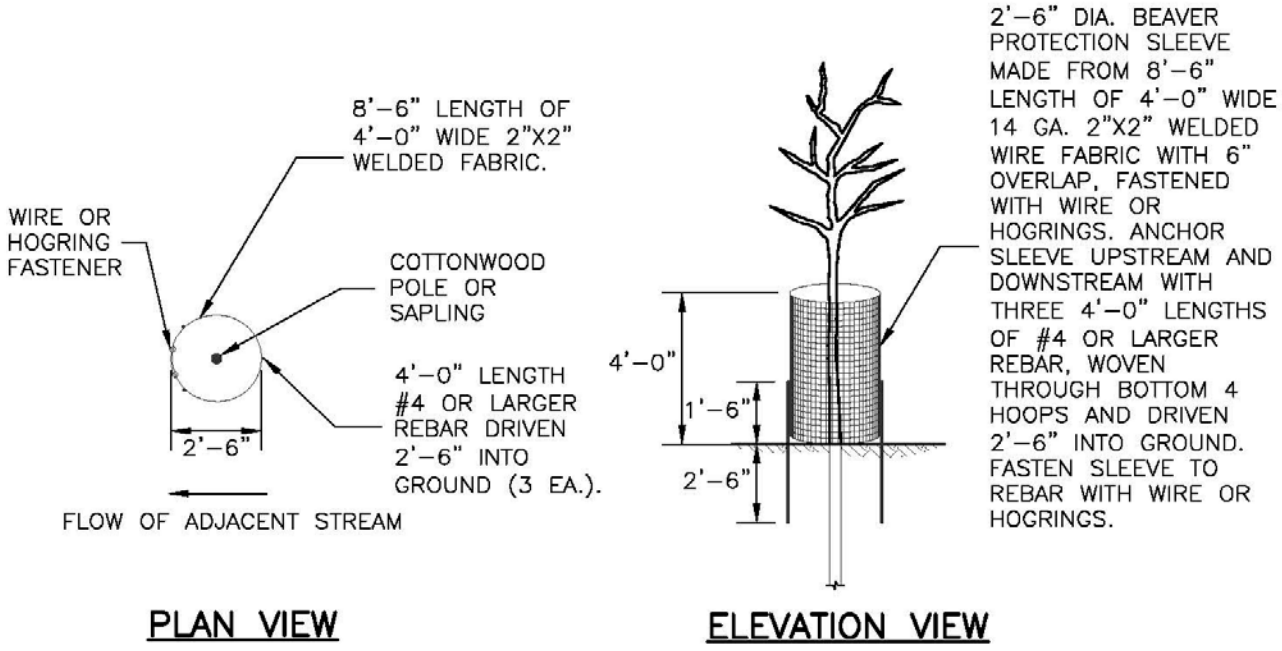


Figure 13-18. Beaver protection

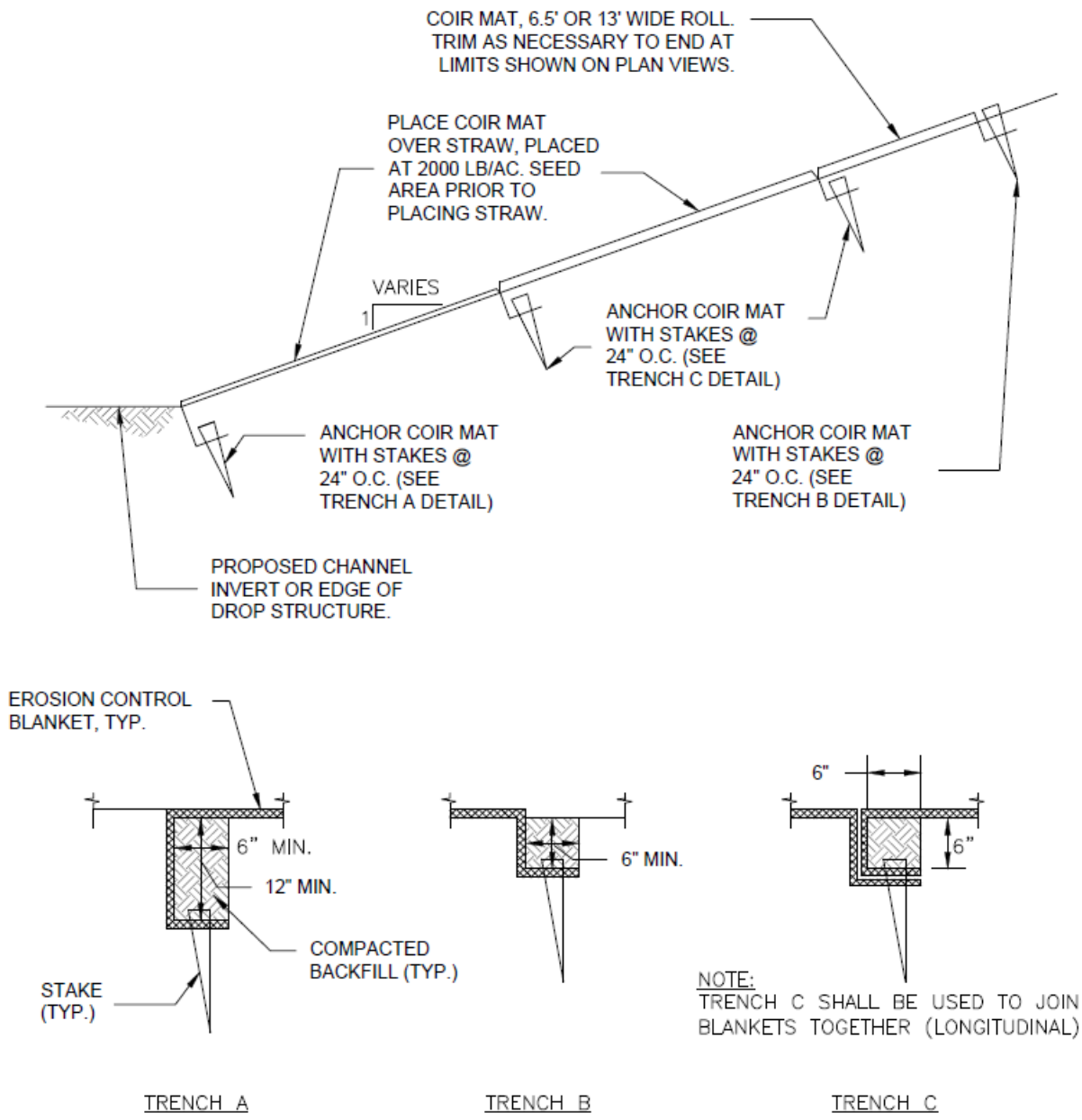


Figure 13-19. Coir mat placement and trenching detail

Appendix A. Seed Mix Tables

Upland Native Seed Mixes (drill seed rates)

Table A-1. Upland area seed mix – loamy to clay soils

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Lb/ac (PLS[1])
Grasses					
Blue grama	*Bouteloua gracilis*	Warm	Sod	25	1.8
Sand dropseed	*Sporobolus cryptandrus*	Warm	Bunch	20	0.2
Sideoats grama	*Bouteloua curtipendula*	Warm	Sod	20	6.3
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	15	8.2
Buffalograss	*Bouteloua dactyloides*	Warm	Sod	10	10.7
Inland saltgrass	*Distichlis spicata*	Warm	Sod	5	0.6
Herbaceous/Wildflowers					
Pasture sage	*Artemisia frigida*			1	0.01
Blanket flower	*Gaillardia aristata*			1	0.5
Prairie coneflower	*Ratibida columnifera*			1	0.1
Purple prairieclover	*Dalea (Petalostemum) purpurea*			1	0.3
Blue flax	*Linum lewisii*			1	0.4
TOTAL PLS POUNDS/ACRE				**100**	**29.11**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-2. Upland area seed mix – sandy soil

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Lb/ac (PLS[1])
Grasses					
Switchgrass	*Panicum virgatum*	Warm	Sod/Bunch	15	2.3
Prairie sandreed	*Calamovilfa longifolia*	Warm	Sod	10	2.2
Sideoats grama	*Bouteloua curtipendula*	Warm	Sod	10	3.1
Blue grama	*Bouteloua gracilis*	Warm	Sod	10	0.7
Indian ricegrass	*Oryzopsis hymenoides*	Cool	Bunch	10	4.3
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	10	5.5
Little bluestem	*Schizachyrium scoparium*	Warm	Bunch	10	2.3
Sand dropseed	*Sporobolus cryptandrus*	Warm	Bunch	10	0.1
Green needlegrass	*Stipa viridula*	Cool	Bunch	10	3.3
Herbaceous/Wildflowers					
Pasture sage	*Artemisia frigida*			1	0.1
Blanket flower	*Gaillardia aristata*			2	0.9
Tansy aster	*Maceranthera tanacetifolia*			2	0.2
TOTAL PLS POUNDS/ACRE				**100**	**25**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-3. Upland/transitional area seed mix – alkali soil

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Lb/ac (PLS[1])
Blue grama	*Bouteloua gracilis*	Warm	Sod	20	1.5
Sideoats grama	*Bouteloua curtipendula*	Warm	Sod	15	4.7
Slender wheatgrass	*Elymus trachycaulus*	Cool	Bunch	15	5.7
Alkali sacaton	*Sporobolus airoides*	Warm	Sod/Bunch	15	0.5
Inland saltgrass	*Distichlis spicata*	Warm	Sod	15	1.7
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	10	5.5
Sand dropseed	*Sporobolus cryptandrus*	Warm	Bunch	10	0.1
TOTAL PLS POUNDS/ACRE				**100**	**19.7**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Riparian Native Seed Mixes

Table A-4. Riparian seed mix – loamy to clay soils

(Recommended for middle to upper terraces and slopes above the 5-year flood elevations.)

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Lb/ac (PLS[1])
Grasses					
Blue grama	*Bouteloua gracilis*	Warm	Sod	20	1.5
Sand dropseed	*Sporobolus cryptandrus*	Warm	Bunch	20	0.2
Switchgrass	*Panicum virgatum*	Warm	Sod/Bunch	20	3.2
Sideoats grama	*Bouteloua curtipendula*	Warm	Sod	15	4.7
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	10	5.5
Green needlegrass	*Nasella viridula*	Cool	Bunch	10	3.3
Wildflowers					
Smooth aster	*Aster laevis*			1	0.1
Louisiana sage	*Artemisia ludovisciana*			1	0.1
Showy goldeneye	*Heliomeris multiflora (aka Viguiera)*			1	0.1
Blanket flower	*Gaillardia aristata*			1	0.5
Prairie coneflower	*Ratibida columnifera*			1	0.1
TOTAL POUNDS PLS/ACRE				**100**	**19.3**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-5. Riparian area seed mix – sandy soil

(Recommended for middle to upper terraces and slopes above 5-year flood elevations.)

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Lb/ac (PLS[1])
Sand dropseed	*Sporobolus*	Warm	Bunch	20	0.2
Switchgrass	*Panicum virgatum*	Warm	Sod/Bunch	20	3.1
Blue grama	*Bouteloua gracilis*	Warm	Sod	15	1.1
Canada wildrye	*Elymus canadensis*	Cool	Bunch	10	5.2
Sand bluestem	*Andropogon hallii*	Warm	Bunch	10	5.3
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	10	5.5
Yellow Indiangrass	*Sorghastrum nutans*	Warm	Sod	10	3.5
Wildflowers					
Blanket flower	*Gaillardia aristata*			1	0.5
Rocky Mountain	*Penstemon strictus*			1	0.1
Purple prairie clover	*Dalea purpurea*			1	0.3
Mexican hat	*Ratibida columnifera*			1	0.1
Western yarrow	*Achillea millefolium*			1	0.02
TOTAL PLS POUNDS/ACRE				**100**	**24.92**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-6. Riparian area seed mix – alkali soil

(Recommended for middle to upper terraces and slopes above the 5-year flood elevations.)

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Lb/ac (PLS[1])
Alkali sacaton	*Sporobolus airoides*	Warm	Bunch	25	0.9
Blue grama	*Bouteloua gracilis*	Warm	Sod	25	1.8
Inland saltgrass	*Distichlis spicata*	Warm	Sod	25	2.9
Streambank wheatgrass	*Elymus lanceolatus*	Cool	Sod	10	3.9
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	10	5.5
Buffalograss	*Bouteloua dactyloides*	Warm	Sod	5	5.4
TOTAL PLS POUNDS/ACRE				**100**	**20.4**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-7. Riparian/creek edge seed mix – moist to wet soils

(Recommended for riparian streambank/low terraces below the 5-year flood elevation.)

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Lb/ac (PLS[1])
Grasses					
Inland saltgrass	*Distichlis stricta*	Cool	Sod	15	1.7
Creeping spikerush	*Eleocharis palustris*	Cool	Sod	15	1.5
Baltic rush	*Juncus balticus*	Cool	Sod	15	0.1
Switchgrass	*Panicum virgatum*	Warm	Sod	12	1.9
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	8	4.4
Green needlegrass	*Nasella viridula*	Cool	Bunch	10	3.3
Prairie cordgrass	*Spartina pectinata*	Warm	Sod	10	3.1
Wooly sedge	*Carex lanuginosa*	Cool	Sod	5	1.0
Nebraska sedge	*Carex nebrascensis*	Cool	Sod	5	0.6
Wildflowers					
Wild Bergamot	*Monarda fistulosa*			1	0.1
Yarrow	*Achillea millefolium*			1	0.02
Blue vervain	*Verbena hastata*			2	0.1
Nuttall's sunflower	*Helianthus nuttallii*			1	0.2
TOTAL PLS POUNDS/ACRE					**18.02**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Wetland Native Seed Mixes

Table A-8. Wetland seed mix – loamy to sandy soils
(Recommended for detention ponds and less eroding wetland areas.)

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Wetland Indicator*	Lb/ac (PLS[1])
Grasses and Herbaceous Species						
American Sloughgrass	*Beckmannia syzigachne*	Cool	Sod	15	OBL	0.8
Prairie cordgrass	*Spartina pectinata*	Warm	Sod	15	FACW	4.6
Switchgrass	*Panicum virgatum*	Warm	Sod/Bunch	15	FAC	2.3
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	10	FACU	5.5
Fowl mannagrass	*Glyceria striata*	Cool	Sod	10	OBL	3.3
Hardstem bulrush	*Scirpus acutus*			10	OBL	1.6
Baltic rush	*Juncus balticus*			10	OBL	0.1
Creeping spikerush	*Eleocharis palustris*			10	OBL	1.0
Wildflowers						
Blue vervain	*Verbena hastata*			2.5	FACW	0.1
Nuttall's sunflower	*Helianthus nuttallii*			2.5	FAC	0.5
TOTAL PLS POUNDS/ACRE				**100**		**19.8**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-9. Wetland seed mix – clay and alkali soils
(Recommended for detention ponds and wetland areas.)

Common Name	Scientific Name	Growth Season	Growth Form	% Mix	Wetland Indicator*	Lb/ac (PLS[1]
Grasses and Herbaceous Species						
Alkali sacaton	*Sporobolus airoides*	Warm	Bunch	10	FAC	0.4
Inland saltgrass	*Distichlis spicata*	Warm	Sod	10	FACW	1.2
Nuttall's alkaligrass	*Puccinellia nuttalliana*	Cool	Bunch	10	OBL	0.2
Prairie cordgrass	*Spartina pectinata*	Warm	Sod	10	FACW	3.0
Slender wheatgrass	*Elymus trachycaulus spp.*	Cool	Bunch	10	FACU	3.8
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	10	FACU	5.5
Fowl mannagrass	*Glyceria striata*	Cool	Sod	10	OBL	3.3
Hardstem bulrush	*Scirpus acutus*			10	OBL	1.6
Baltic rush	*Juncus balticus*			10	OBL	0.1
Creeping spikerush	*Eleocharis palustris*			10	OBL	1.0
TOTAL PLS POUNDS/ACRE						**20.1**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Note: Wildflowers species not recommended for clay or alkali soils.

Wetland Indicator Key for Tables A-8 and A-9:

FAC = Facultative – Equally occurs in both wetlands and uplands.
FACU = Facultative Upland – Occurs mostly in uplands, but can occur in wetlands about 1/3 of the time.
FACW = Facultative Wetlands – Occurs mostly in wetlands, but can occur in uplands about 1/3 of the time.
OBL = Obligate Wetlands – Almost always occurs in wetlands.
UPL = Uplands – Almost always occurs in uplands.

Temporary Native Seed Mixes

Note: A sterile annual grass such as a wheat X wheatgrass hybrid may be used as temporary grass cover in areas that are likely to be disturbed again. A sterile annual cover crop is generally less expensive and quicker to establish than a temporary native grass seed mix. The native grass seed mixes as shown below offer an alternative to seeding with annual sterile grasses and can be used in areas where there may be limited future disturbance therefore warranting a temporary seed mix that can become permanent.

Table A-10. Upland area temporary seed mix – loamy to clay soils

Common Name	Scientific Name	Growth Season	Growth Form	% of Seed Mix	Lb/ac (PLS[1])
Slender wheatgrass	*Elymus trachycaulus spp.*	Cool	Bunch	20	5
Green needlegrass	*Nasella viridula*	Cool	Bunch	20	4.4
Western wheatgrass	*Pascopyrum smithii*	Cool	Sod	20	7.3
Arizona fescue	*Festuca arizonica*	Cool	Bunch	20	1.5
Sideoats grama	*Bouteloua curtipendula*	Warm	Bunch/Sod	20	4.2
TOTAL PLS POUNDS/ACRE				**100**	**22.4**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-11. Upland area temporary seed mix – sandy soil

Common Name	Scientific Name	Growth Season	Growth Form	% of Seed Mix	Lb/ac (PLS[1])
Sand lovegrass	*Eragrostis trichodes*	Warm	Bunch	20	0.5
Sand bluestem	*Andropogon hallii*	Warm	Sod	20	7.1
Prairie sandreed	*Calamovilfa longifolia*	Warm	Sod	15	2.2
Sand dropseed	*Sporobolus cryptandrus*	Warm	Bunch	15	0.1
Needle and Thread	*Hesperostipa comata spp. comata*	Cool	Bunch	15	5.2
Red three-awn	*Aristida purpurea var. longiseta*	Warm	Bunch	15	2
TOTAL PLS POUNDS/ACRE				**100**	**17.1**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-12. Upland area temporary seed mix –combination of soil types

Common Name	Scientific Name	Growth Season	Growth Form	% of Seed Mix	Lb/ac (PLS[1])
Slender wheatgrass	*Elymus trachycaulus spp.*	Cool	Bunch	25	6.3
Canada wildrye	*Elymus canadensis*	Cool	Bunch	15	5.2
Little bluestem	*Schizachyrium scoparium*	Warm	Bunch	15	2.3
Thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Cool	Sod	15	3.9
Sixweeks fescue	*Vulpia octoflora*	Cool	Annual/ Bunch	15	0.6
Bottlebrush squirreltail	*Elymus elymoides*	Cool	Bunch	15	3.1
TOTAL PLS POUNDS/ACRE				**100**	**21.4**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate

Table A-13. Moist to wet area temporary seed mix – combination of soil types

Common Name	Scientific Name	Growth Season	Growth Form	% of Seed Mix	Lb/ac (PLS[1])
Streambank wheatgrass	*Elymus lanceolatus ssp. psammophilus*	Cool	Sod	20	5.1
Slender wheatgrass	*Elymus trachycaulus spp.*	Cool	Bunch	15	3.8
Switchgrass	*Panicum virgatum*	Warm	Sod/Bunch	15	1.5
American	*Beckmannia syzigachne*	Cool	Sod	15	0.5
Bluejoint reedgrass	*Calamagrostis canadensis*	Cool	Sod	15	0.3
Fowl mannagrass	*Glyceria striata*	Cool	Sod	10	2.2
Inland saltgrass	*Distichlis spicata*	Warm	Sod	10	0.8
TOTAL PLS POUNDS/ACRE				**100**	**14.2**

[1]PLS = Pure Live Seed – If broadcast seeding, double the rate