NATIVE PLANT REVEGETATION GUIDE FOR COLORADO

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Colorado Natural Areas Program
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INTRODUCTION

Every day portions of Colorado's landscape are disturbed as roads and trails are constructed, trenches for utility lines are excavated, and fields are plowed or graded in anticipation of a new crop or new building. Natural disturbances occur too, including flood, fire, wind erosion, avalanches and landslides. Eventually most of these disturbances will be revegetated. But with what and when? Without special effort, it may be decades before plants become established. In other areas soil loss may occur before any plants can successfully colonize the disturbance, further lowering the chance for revegetation—even in the long term. In more moderate climates, and on sites with better soils, plants may begin to grow as soon as the disturbance ends—but these may not be native species. Some will be noxious weeds, which will use the disturbed zone as a staging area to spread into adjacent healthy landscapes where they will be difficult to control. Others may be well-adapted to grow in barren landscapes, but will not persist.

For decades, land management agencies have been developing reclamation plans for reseeding and replanting disturbances. The historic focus was on providing vegetation to stabilize eroding areas and to heal unsightly scars on the landscape. Many of the plants used historically were readily available, inexpensive, fast growing, and aggressive agronomic species—just the strategy for quick and effective revegetation. However most were not native species. In recent years more agencies and landowners have become interested in propagating attractive and diverse plant communities by using native species for revegetation projects. This guide is intended to assist them in successfully planning and implementing such projects.

WHAT ARE "NATIVE" SPECIES?

When settlers first made their way to Colorado in the early 1800's, they brought with them seeds of plants from all over the world. Some were seeds planted in the Old World for food crops, windbreaks, landscaping, erosion control, and livestock forage. Many other seeds arrived accidentally, mixed with crop seeds, animal feed, or even in the ballast of ships. These came westward with shipments of agricultural goods, or they were dispersed along irrigation ditches, railroad tracks, wagon roads, and cattle trails. Today, either by accident or design, the introduction of nonnative plants to Colorado continues. Because of past and present human activities, Colorado's landscape is replete with "nonnative" species.

But what is a native plant? The contributors and reviewers of this guide spent a great deal of time wrestling with this question. In the end, it was easiest to start by defining which plants were nonnative. Although there are other perspectives, the group decided to use the definition from Colorado's Weed Management Act. The act defines a **nonnative plant species** as:

> ". . . a plant species which is not indigenous to the state of Colorado, nor to the native plant community in which it is found." *Title 35, Colorado Revised Statutes: Colorado Weed Management Act*.

This latter definition will be used in this guide. Conversely, a **native species** is defined as: "A plant species which *is* indigenous to the state of Colorado, or to the natural plant community in which it is found."

The terms alien, nonnative, exotic, and adventive are all expressions used to describe plants that have been introduced to Colorado. To keep things simple, this guide uses "nonnative" throughout.

WHY SHOULD WE BE CONCERNED ABOUT THE PRESENCE OF NONNATIVE PLANTS IN COLORADO?

Many, but not all, nonnative plants spread rapidly and outcompete native species for water, light and soil nutrients. Native plant species have evolved with local herbivores and diseases that regulate population numbers. In contrast, nonnative species frequently have no local predators acting to keep population sizes in check. Many nonnative agronomic species were bred in the Old World for rapid growth, prolific reproduction, and ability to tolerate both disease and a wide range of soil, moisture, and light conditions. Nonnative weeds have often had several thousand years evolution in the presence of human disturbances, resulting in enhanced growth, reproduction, and environmental tolerance, similar to what was purposedly bred into agronomic species of the Old World. While these characteristics are valuable for agricultural crops, they enable nonnative species to become aggressive invaders of native ecosystems. If left uncontrolled, these species often form extensive single-species stands where once there were diverse and productive native communities.

Nonnative species cover bare ground with dense greenery and sometimes with showy flowers, but may provide little in the way of habitat values or plant community diversity and structure. For example, a marsh full of purple loosestrife in bloom makes a beautiful impression from a distance. However, closer observation will reveal a lack of other plant species and a dearth of animal life. The same observation can be made about areas where knapweeds, thistles, leafy spurge and other nonnative plants have become established.

Plants such as knapweed and leafy spurge release toxins into the soil which inhibit the germination of native species. In addition, many nonnative species are not palatable to most North American animals. Such characteristics enable nonnative plant species to establish large monotypic stands that deplete the soil moisture and shade the ground, eliminating chances that native plants will germinate and grow.

HOW CAN NONNATIVE PLANTS BE COSTLY?

The impacts from infestations of aggressive nonnative plants are widespread and far reaching:

- Land infested by nonnative plants has low value for hunting, photography, or wildlife watching (Cook, 1991).
- Waterfowl habitat across North America has badly deteriorated due to purple loosestrife infestation. The dense stands reduce biotic diversity in wetlands by replacing native plant species, thereby eliminating the natural foods and cover essential to wetland wildlife (Malecki et al. 1993).
- Although planting Russian-olive as wildlife habitat has been encouraged for many years by public land managers, its presence actually degrades wildlife habitat. Studies reveal that this

species displaces native cottonwoods. The displacement of native trees has caused more than a 30 percent decline in nesting bird species (USFWS 1989). Furthermore, the small limbs and hard wood of Russian-olive are not appealing to cavity-nesters, and the trees do not support the insects that many birds require for food (Cook 1991).

Real Economic Losses From Nonnative Plant Infestation

Approximately 3.7 million acres (1.5 million hectares) of range and pasture land in the western United States are infested with knapweeds and leafy spurge infests over 2.5 million acres (1 million hectares) in North America (Steele 1991). Most domestic or wild animals cannot eat these species and knapweed is actually toxic to horses. In Montana and Wyoming, some areas are so completely covered with knapweed that the land has been abandoned and taken off tax rolls (Steele 1991). In North Dakota, mortgage companies will not lend on agricultural property infested with leafy spurge (Cook 1991).

In Colorado, leafy spurge has become thoroughly established in Larimer, Weld and Douglas counties, and is moving southward. Weed scientists predict that leafy spurge will soon be a dominant upland and lowland plant throughout the northern foothills and plains. The damage caused by nonnative plants includes degraded wildlife habitat, devalued crop and rangeland, injured or dead livestock, decreased water quality, lost tax revenue, diminished recreational experiences and the loss of irreplaceable native ecosystems.

The State of Colorado has recognized that nonnative species pose threats to natural landscapes and the economy. *Title 35, Colorado Weed Management Act* contends that it is the "duty of all persons to . . . manage undesirable plants . . ." and mandates that counties and municipalities adopt "undesirable plant management plans". This act further declares that the management plans apply to both state and privately owned lands.

Native Makes a Difference!

One way to combat the problem of invasive nonnative species is to use native plants for landscaping, revegetation, and reclamation. Using native plants for these projects decreases the introduction of nonnative plants into Colorado and maintains the integrity of native communities. Because they are adapted to the region, native plants often require less labor and expense to maintain once established. Native plants also provide many other benefits, including wildlife habitat, opportunities for environmental education, and a greater variety of scenery. The Colorado Native Plant Society Education Committee (1991) encourages the use of native species "both because of their adaptability and because we like the idea of Colorado looking like Colorado with a unique regional horticulture which sets us apart from other parts of the country". Colorado has a profusion of beautiful native grasses, wildflowers, shrubs, and trees which can be used for all planting purposes.

Objective and Scope of this Guide

This guide provides information on how to select, plant and maintain Colorado native plant species for a wide range of landscaping, revegetation and reclamation needs. It includes information on important ecological considerations for the variety of Colorado landscape types and natural communities in both upland and wetland habitats. Instructions for the design, planning, execution, and maintenance of revegetation projects are also presented. In addition to the information provided in the text, additional resources are provided in the appendices. Other

useful references and resources, including federal and state agencies, are dispersed throughout the document.

This guide does not contain suggestions for every possible revegetation situation or suggest a use for every plant species native to Colorado (there are more than 2500!). The emphasis instead is on providing a basic understanding of the range of natural communities in Colorado and the processes involved in establishing native species in those communities. Knowledge of this subject will continue to increase over time through implementation of these strategies and continued experimentation. It is our hope that this guide serves as a good place to begin and that updated editions result from the perfection of these or other techniques.

SYMBOLS USED IN THIS GUIDE

- ❖ Used to identify important components of a definition, technique, or other topic.

- ◔ Warning! This symbol indicates common pitfalls or disadvantages of a restoration technique.

BEFORE YOU BEGIN

This guide is intended to serve as a resource for choosing native tree, shrub, forb and grass species for reclamation, revegetation and landscape projects. However, **your best reference guide is the local landscape**. The landscape can tell you which native species occur, how they are distributed, what soils they prefer, and what conditions they can tolerate. The local landscape also provides an important potential source of seed for revegetation projects.

There are several ways local resources can be used for revegetation projects. One is to salvage the vegetation that was on the site before the onset of the disturbance. If you know in advance that a project is going to disturb the landscape and will require revegetation after its completion, try preserving some of the existing plants and seeds so they can be used in the revegetation process. For instance, while a pipeline trench is being excavated, blocks of the existing native sod can be removed and set aside to be replanted after the work is complete. If the native sod cannot be preserved for later use, it may be helpful to spread the topsoil that contains root systems and seeds on the area.

Another way to use existing local resources for revegetation projects is to use seed from native plants that occur near the reclamation site. (See collecting guidelines on page 82). Seeds can be collected by hand from plants near the area to be revegetated. This method requires some planning in terms of allowing time for seed collection, but it offers many benefits, including:

- ❖ Germination success and plant hardiness may be increased because the seed source is local, and therefore, well-adapted to local environmental conditions.
- ❖ This type of project promotes community service and “hands-on” involvement of the public in resource conservation issues.
- ❖ This method of seed acquisition is relatively inexpensive, requiring only the time needed for volunteer organization, seed collecting, and soil preparation.
- ❖ This method preserves local native gene pools and ecotypes.

HOW TO USE THIS GUIDE

STEP 1: What is the purpose of your planting project? The answer to this question will determine your choice of plant species, planting techniques, and methods for long term maintenance of the area.

POSSIBLE REASONS TO ESTABLISH NATIVE PLANTINGS

Designing an aesthetic landscape for a home, business or park

Reclaiming a heavily disturbed site

Blending a utility line trench with an otherwise natural setting

Planting an area that will sustain heavy foot traffic

Planting for weed control near a reservoir edge

Restoring the vegetation along newly constructed trail

Planting to prevent erosion

STEP 2: Read the **Plant Basics** section (beginning on page 7) which defines terms used throughout this manual. Understanding these terms will help you decide what kinds of plants and growth forms to select for specific projects and will help you discuss your project with experts.

STEP 3: Proceed to the **Natural Communities** section (beginning on page 11).

1. Determine your site's geographic setting. Choose from: Eastern Plains and Foothill Region, Rocky Mountain Region, or Western Plateau and Canyon Region.
2. Under the appropriate section, determine the vegetation type that best describes the site. Choose from grassland, shrubland, woodland, forest, riparian, or wetland (see box).
3. Finally, select the appropriate natural community, such as shortgrass prairie, mixed foothills shrubland, or piñon-juniper woodland.

➲ Some habitat types are especially challenging for revegetation projects. If your project is in or near alpine

VEGETATION TYPES

Grasslands (and Meadows) – Graminoids (grasses, rushes, and sedges) are the most common and obvious vegetation. Forbs (wildflowers) and a few shrubs or trees may be present.
Shrublands - Shrubs are the most common and the most obvious vegetation. Graminoids, forbs or bare ground may cover the understory. There may be a few trees present.
Woodlands – Trees are the most obvious vegetation, but they are widely spaced. Canopy cover is usually less than 40 percent. Graminoids, forbs or shrubs may be present in the understory.
Forests – Trees are the most obvious vegetation. They are closely spaced, and canopy cover is greater than 40 percent. Graminoids, forbs or shrubs make up the understory.
Wetland – The site has or is adjacent to standing water or has soils that are wet all or most of the year.
Riparian – The site is along the banks of a stream or river.

tundra or fens read the cautionary notes on pages 50 and 135.

➲ If you are carrying out a project in or near what you believe is a wetland or riparian habitat, be sure to read the **Wetland and Riparian Habitats** sections (beginning on page 111).

STEP 4: Choose plant species from the **Plant Finder** lists located in the **Natural Communities** section (beginning on page 11). Common species are listed for each natural community under the categories of graminoids, forbs and trees/shrubs, with the most common species in bold print. The **Upland Plant Characteristics Tables** in Appendix I (page 197) will help you determine which species are appropriate for your circumstances. They list characteristics for each species such as height, growth form, wildlife value, flower color, and maturity rate. In addition to using Appendix I**, it is always important to look at natural communities of the type you are trying to establish to get an idea of the relative abundance and arrangement of different species**. Some of the plants listed in the Plant Finder may not be commercially available, however, such species can still be used by collecting native seed /plant material or by contracting with a nursery to grow certain plants.

STEP 5: Read the **Revegetation Techniques** section (beginning on page 81). This section contains detailed information on planning and executing a revegetation project, including sources of plant material, seeding and planting methods and other advice. Not all of this information will be needed for every project. **If your project is small (of the "backyard" variety) you will not need to read the entire section in detail.** Instead, use the subject headings to locate topics of interest and information appropriate to the scale of your project.

PLANT NAMES

Common names are generally used in the text to make it easier for the reader, however, for the sake of accuracy, we have included scientific names in tables and lists. Appendix I (page 197) lists common names of major species from the Upland Plant Finder lists.

Some plants have more than one scientific name. This document uses Kartesz (1994) and the Kartez-based USDA-NRCS database (1997) as the primary source of scientific nomenclature, and Weber (1996a, 1996b) as the secondary source. Tables in the appendices list both names.

PLANT BASICS

The Plant Kingdom is extremely diverse. There are well over 200,000 different species of plants living today. Taxonomists divide these species into a variety of groups and sub-groups on the basis of shared characteristics. Plants discussed in this guide all belong to the large category of plants which reproduce by means of seeds. Plants which do NOT reproduce by seeds include ferns, mosses, and lichens; these plants are not included in this manual.

Two broadly defined groups of seed plants mentioned in this manual are **gymnosperms** and **angiosperms**.

Gymnosperms

- Woody plants with needle-like or scale-like (imbricate, overlapping) leaves.
- Do not produce flowers.
- Have fruits which are cones or berry-like cones. (The blue "berries" on junipers are really modified cones!)
- Includes pines, firs, Douglas-fir, spruces, junipers, and some that do not resemble the other taxa, e.g., Mormon-tea (*Ephedra* sp.).

Angiosperms

- Plants that produce flowers.
- Include species with obvious flowers such as wild rose and columbine, as well as those that are not so obvious, like grasses, bulrushes, and sedges.

Both gymnosperms and angiosperms may be either **deciduous** or **evergreen**

Deciduous

- Bears leaves only through the growing season, dropping them in the fall. Deciduous plants are bare during the winter.
- Quaking aspen, Rocky Mountain maple, and mountain mahogany are examples of deciduous plants.

Evergreen

- Bears green leaves throughout the winter.
- Pines, junipers, Oregon grape, and kinnikinnick are examples of evergreen plants.

Gymnosperms and angiosperms can be further categorized by **life cycle**, **growth form**, **reproductive strategy**, **maturity rate**, and other descriptive terms.

LIFE CYCLES

This manual uses only the general life cycle terms annual, biennial and perennial; more detailed and complicated descriptions of life cycles may be used by specialists.

Annual plants live for only one growing season. For annual species, the emphasis of growth is placed on production of seeds. Aboveground growth is rapid because the plant must flower and produce seed before it dies at the end of the season. As a consequence, annual species can be recognized by their relatively small root systems. Often annual plants are seeded at locations that need to be vegetated quickly, such as highly erosive slopes. While annuals grow quickly and provide cover, they do not provide a long-term solution to the challenge of revegetation. Furthermore, the seed that they produce may be stored in the soil. These plants will continue to appear, competing for nutrients, water and sunlight, long after the area has been planted with species that are more permanent and desirable. Many weeds and crop plants are annuals.

Biennial plants live for two years. During the first year they typically produce rosettes of basal leaves and store energy. They send up flowering stalks the second year, produce seeds and die. Native biennials are relatively uncommon, however, many invasive weeds are biennials, including musk thistle, scotch thistle, and some knapweed species.

Perennial plants live for many years. Normally they do not flower or reproduce until they are several years old. Perennials can afford to direct more energy to long-term establishment and typically have more extensive root systems. These species are usually the most desirable for native plantings.

GROWTH FORMS

Woody plants do not die back to ground level each winter as forbs, grasses, and grass-like plants do. On woody plants, buds are borne above ground level, giving these plants a “head start” to larger stature each spring. Trees and shrubs are woody plants.

Trees are woody perennial plants with a single main stem or trunk and radiating branches on the upper portion of the plant. They usually stand over 13 feet (4 m) tall at maturity.

Shrubs are woody perennials lacking a main stem, instead having several to many branches arising at ground level. They are usually less than 10 to 13 feet (3 to 4 m) tall.

Graminoids include grasses and grass-like plants such as sedges and rushes. **Sedges** resemble grasses but have solid stems which are often triangular. **Rushes** resemble grasses but have round, pliant, hollow, or pithy stems lacking joints.

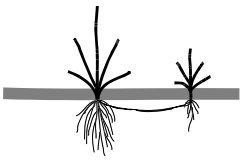
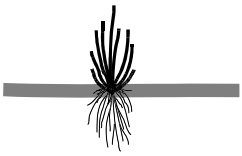
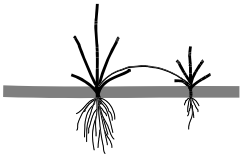
Grasses have jointed, hollow stems and clusters of small membranous flowers arranged in spikelets

Forbs are broad-leaved herbaceous plants that die back to the ground each year and are generally known as wildflowers.

REPRODUCTIVE STRATEGIES

Seed reproduction is found in all groups of gymnosperms and angiosperms. Seeds may be spread by wind, water, animals, or humans. Some seeds may require special treatment or conditions such as fire, freezing temperatures, or passage through the gut of animals in order to germinate.

Vegetative reproduction Many shrubs, grasses and a few trees, including quaking aspen, spread by root shoots or points on the roots from which new stems or trunks can emerge. Many aspen, even in groves that stretch for miles, are actually sprouting from the same root system! Often the parent plant must be cut, burned, or injured in some way before the root shoots will sprout. Most forbs and graminoids reproduce by seed, however, many perennials have developed additional strategies for propagation.

	STRATEGIES	APPLICATIONS
	**Rhizomatous** forbs and graminoids have underground stems and branches that spread in linear patterns. New plants grow from these rhizomes.	Rhizomatous graminoids are ideal for erosion control because their extensive networks of underground stems retain soil.
	**Bunch forming** forbs and graminoids grow in clusters and appear as round tufts on the landscape. New sprouts (tillers) grow only from the base of the plant, increasing the width of the bunch over time.	Bunch plants are recommended for aesthetic plantings because they provide visual interest and variety on the landscape.
	**Stoloniferous** forbs and graminoids have aboveground stems that spread, root and sprout new individuals.	Stoloniferous graminoids are useful for heavy-use areas and erosion control because they form durable sods.

SEASONAL GROWTH

Seasonal growth patterns are important considerations, especially for grass plantings. Two general patterns are recognized – **cool season** and **warm season**.

Cool season graminoids begin their growth in late winter and early spring and bloom in the early summer. They may enter dormancy during summer heat and resume growth or even bloom again in the fall if adequate moisture is available.

Planting a mixture of both warm and cool season grasses provides robust year-long cover and visual interest from spring to fall.

Warm season graminoids begin their growth in late spring or early summer and bloom in late summer or early fall, usually entering dormancy with the onset of winter.

NATURAL COMMUNITIES

In the broadest sense, a community can be defined as all the plants and animals living in a particular area. Plant communities are usually named for their most prominent and/or abundant members. Community classifications can range from general descriptions such as "grassland" or "forest" to more detailed designations which include species names. The term "natural communities" as used in this manual, refers to those plant species and communities which occurred in Colorado before European settlement and which retain the capability of maintaining themselves without human interference.

For the purposes of this guide, the state is divided into three floristic regions based on geography, elevation and climate (see Figure 2 on page 13). The **Eastern Plains and Foothills Region** occurs on the eastern side of the state below 8,000 feet (2438 m). The **Rocky Mountain Region** occurs in the center of the state on either side of the Continental Divide and includes the intermontane valleys (North Park, Middle Park, South Park and the San Luis Valley). The **Western Plateau and Canyon Region** occurs on the western side of the state below 8,000 feet (2438 m). Each region is divided into dominant vegetation types (grasslands, shrublands, woodlands and forests). Within each vegetation type, several natural plant communities are listed (for example, short-grass prairie or sagebrush shrubland). Vegetation types and natural communities have been generalized for this guide in order to emphasize the characteristic species which will help determine the environmental setting of your site. On the landscape, these types vary considerably in species composition and are too numerous to include in this document. The *native* landscape that surrounds your project site will be the best source of information for determining how to fine tune your revegetation project.

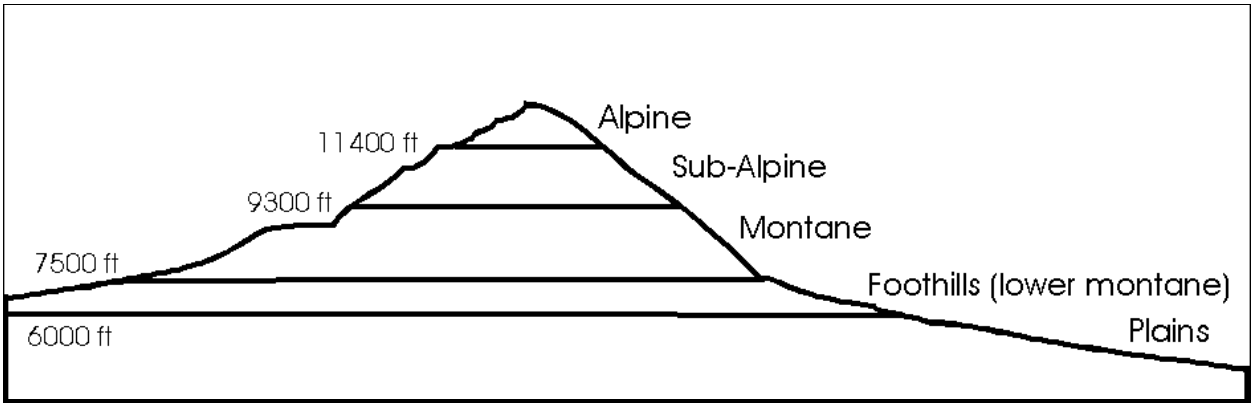


Figure 1. Life zones of Colorado.

Within each floristic region, the natural landscape can be subdivided into life zones, each zone being characterized by a given range of temperature, humidity, type and amount of precipitation, growing season length, amount and distribution of wind and soil conditions (Merriam 1899, Marr 1967). Five life zones defined by elevation occur in Colorado: alpine, subalpine, montane, foothills, and plains (see Figure 1). Divisions between zones are not always distinct; zones are often separated by transition areas (ecotones) between two or more distinct zones. The elevational limits shown above are general descriptions and may vary with topography, aspect, and latitude. For instance, because of differences in amounts of solar radiation which affect factors such as temperature, precipitation, and growing season, life zone boundaries tend to occur at higher elevations as you travel south. Life zones also tend to be higher on south-facing slopes than on adjacent north-facing slopes at the same latitude. Each floristic region contains at least

one life zone, and each life zone generally includes several natural communities. A few natural communities (wetland and riparian communities in particular) may cross life zones.

Natural communities tend to occur in predictable patterns on the landscape. The distribution of flora and fauna is for the most part determined by local resources and conditions. Important factors include water and nutrient availability, temperature, light, disturbance, and the presence of other organisms. Descriptive terms for habitats are frequently based on one or more of these factors. For instance, according to water availability, habitats may be characterized as “xeric” (dry) or “mesic” (moist). Or, depending on type and frequency of disturbance, communities may be classified as “successional or seral” (gradually changing in species composition) or “persistent or climax” (maintaining the same species composition over time in the absence of disturbance). Most other community characterizations are self-explanatory. Individual populations of a particular species may, over many generations, become genetically adapted to extremely localized conditions within a habitat type; these differentiated populations are known as “ecotypes”. The ecotype concept is important when discussing revegetation, because it points out that not all populations of a species are identical. For example, seeds of ponderosa pine adapted to the volcanic soils and high, dry conditions of Arizona's Colorado Plateau may not germinate or thrive when planted on coarse granitic soils of the Front Range, and adult trees may not possess the cold and wind tolerance needed on the east slope of the Front Range.

Natural community revegetation information in this manual is arranged as follows: Part I covers upland habitats, i.e. those communities occurring on ground which is not subject to regular flooding or saturation. Part II covers wetland and riparian communities, considered as a separate type within the surrounding upland community type. Each section also discusses appropriate methods and techniques for revegetation projects in specific communities. Plant community descriptions are taken largely from Marr 1967, Mutel and Emerick 1984, Galatowitsch 1988, and Benedict 1991.

FLORISTIC REGIONS OF COLORADO

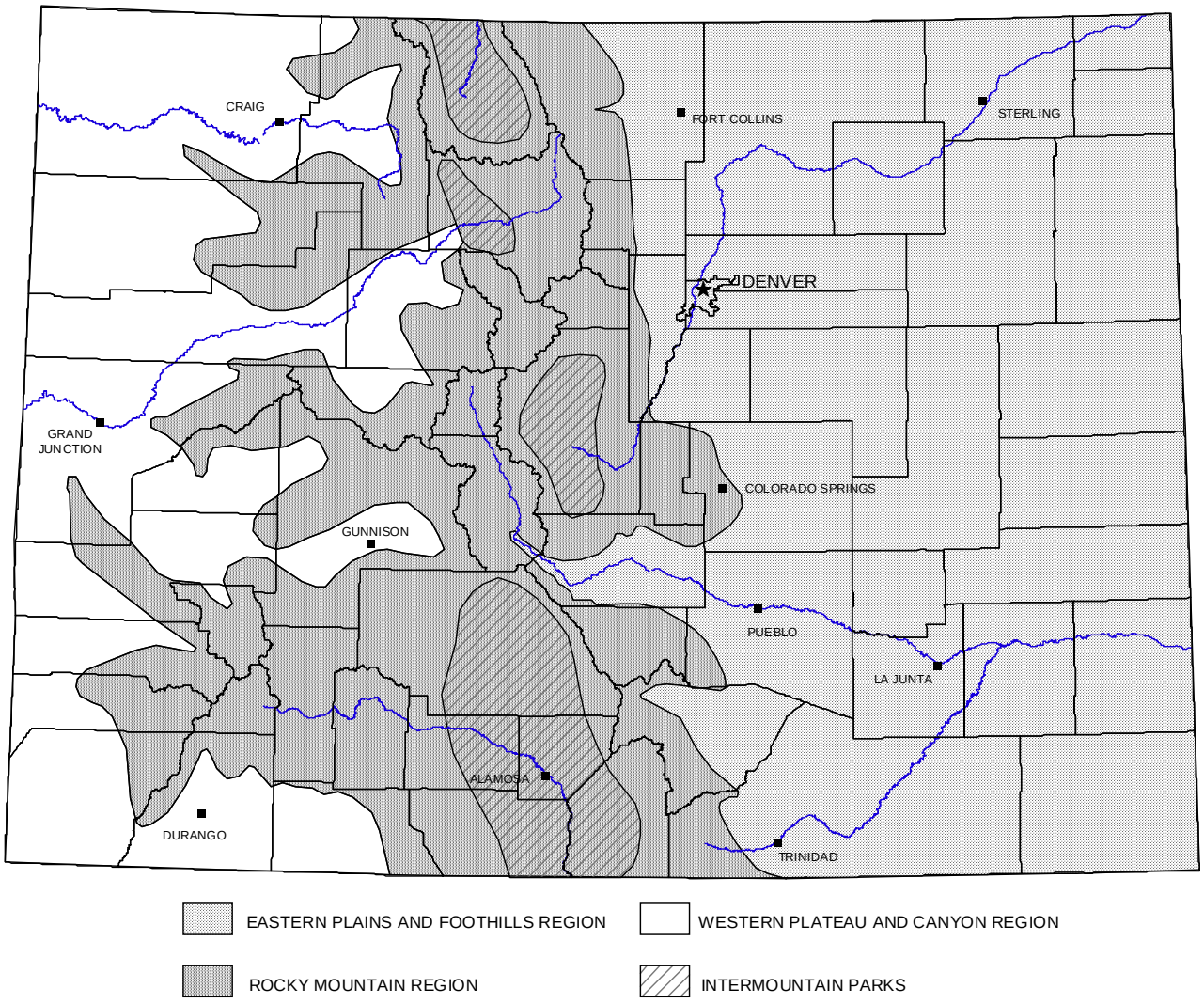
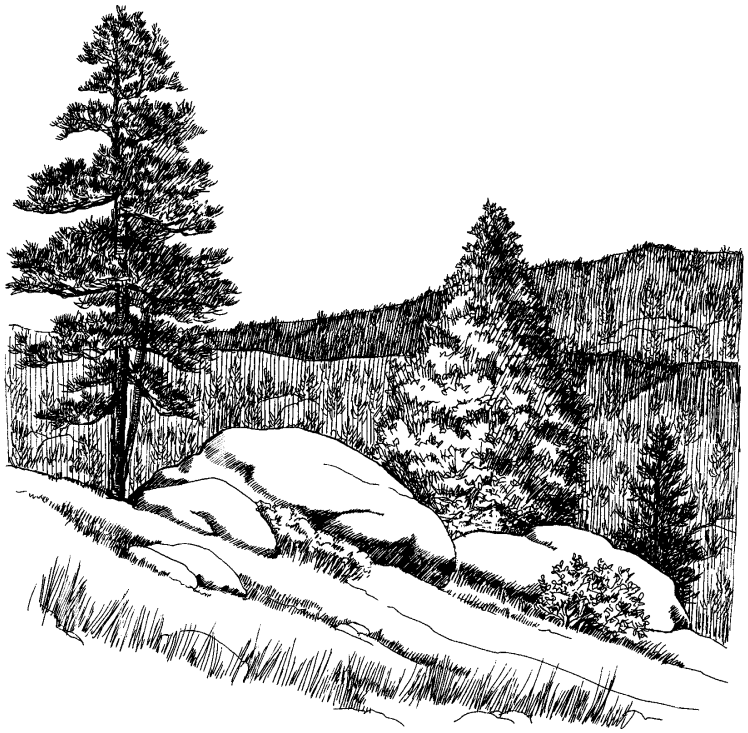
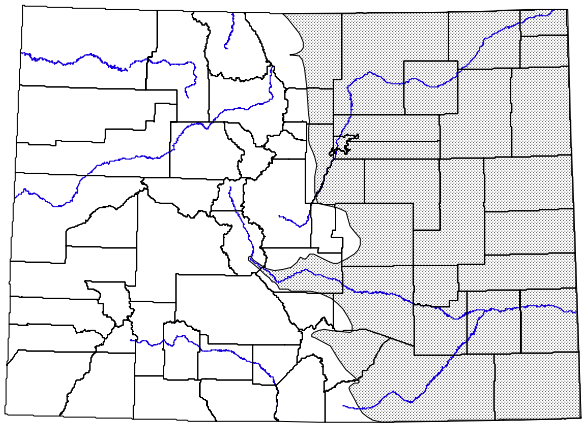


Figure 2. Floristic regions of Colorado.

PART I:
UPLAND COMMUNITIES



EASTERN PLAINS AND FOOTHILLS REGION



DESCRIPTION - The eastern plains form much of Colorado's landscape east of the Continental Divide, extending the length of Colorado from Wyoming to New Mexico and east to Nebraska and Kansas. Elevations on the plains rarely exceed 6,000 feet (1829 m) (Benedict 1991). Foothills, which occur at the eastern edge of the Rocky Mountains, form a transition zone between the plains and the mountains, extending from 6,000 (1829 m) to about 8,000 feet (2438 m) in elevation.

CLIMATE / SOIL - Annual precipitation on the plains ranges from 12 to 18 inches (30 to 46 cm) per year with much of the moisture occurring in the winter and early spring or late in the summer (Galatowitsch 1988; Mutel and Emerick 1984). The area is prone to long periods of drought. Many plains soils are alkaline and fine-textured; foothills soils are variable but tend to be coarser and have neutral chemistry.

TOPOGRAPHIC FEATURES - The eastern plains consist of relatively flat terrain with gentle hills, bluffs, and in some places, steep-sided mesas. Although glaciers never made it as far as the plains during the Pleistocene, their presence was felt east of the mountains. The Arkansas and South Platte Rivers were swollen with melted ice and ground-up rock and spread a blanket of sand and silt far beyond the current floodplains. Today, smaller, meandering drainages, wetlands, moist swales, playas, bottomlands, and depressions created by wind and water erosion are scattered throughout the plains. The foothills area is characterized by mesas, hogbacks, low ridges, and streams and creeks. Canyons and elevated plateaus (Mesa de Maya and the Palmer Divide) extend the foothills floristic region far out onto the plains.

VEGETATION – The eastern plains are dominated by grasslands. Shrublands and woodlands occupy small areas on the plains but are much more common in foothills areas. Although precipitation in the foothills region is very similar to that of the plains, the greater prevalence of rocky, moisture-retaining soils and irregular topography allow the dominance of woody plants. The impacts of fires in the foothills have been greatly reduced since intensive settlement of this region in the late 1800's. Consequently, the extent and density of many of the woody plant communities that were formerly thinned by fire have increased.

IF YOUR SITE IS:	GO TO PAGE:
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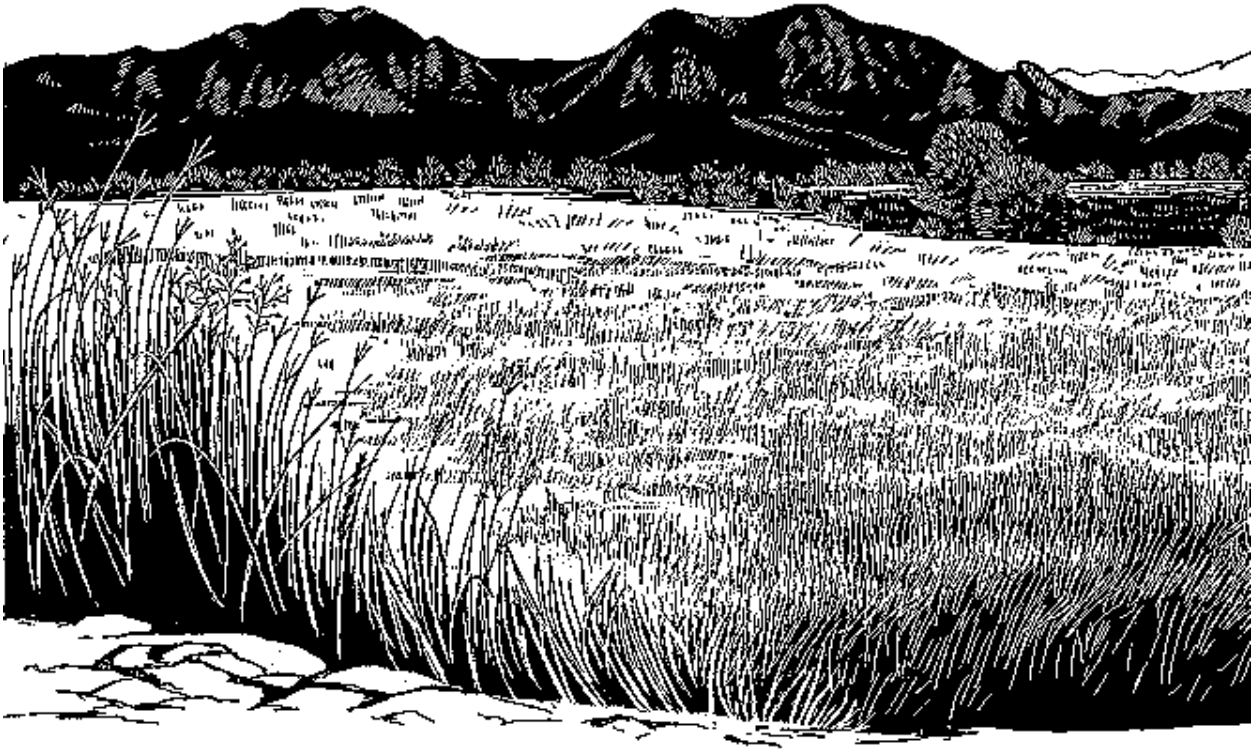
Shrublands	23
Woodlands	28
Wetland / Riparian	121



GRASSLANDS

Grasslands (or prairies) are the most common vegetation type on the eastern plains of Colorado. The Great Plains region that once covered central North America between the Rocky Mountains and central Iowa had three main components arranged in irregular north-south trending bands from southern Canada to central Texas (Sims et al. 1978). As precipitation decreases from east to west, height and species composition of the dominant prairie grasses changes. Tall-grass prairie covered the eastern band from 95º-100º west longitude; mid-grass prairie dominated the middle section between 100º and 105º west longitude, and short-grass prairie typified the arid western region between 105º and 110º west longitude. The plains of Colorado are in the short-grass zone, but fingers of mid-grass prairie extend into the short-grass prairie, and patches of tall grasses occur in riparian areas where conditions are sufficiently moist year-round.

Notes on grassland projects

True restoration of the prairie that once covered hundreds of thousands of square miles and sustained the complex interactions of hundreds of species is probably impossible on the small parcels that are available today. However, where native grasslands do occur, they can be maintained and their condition improved. Small created prairies can preserve native prairie plants and give visitors a feel for the former native prairie.

Depending on the degree of past disturbance, rehabilitation may be accomplished by removing grazing, introducing fire, interplanting native grasses and forbs, and/or removing aggressive nonnative plants.

Planting a prairie from scratch is a long-term project. It may take 3 to 5 years for the prairie to look like the vision you have of it.

Transplanting from the wild is difficult because many prairie plants have developed long, deep roots to promote survival during drought. Try salvaging plants from sites that are scheduled for development rather than trying to move plants from intact native prairies.

Mow prairie plantings the first year after planting to prevent weeds from going to seed.

If possible, burn occasionally to reduce litter accumulations and prevent invasion by shrubs and trees. Burning only a part of the prairie in any year will leave the remainder as a refuge for creatures living there.

For more information on prairie planting or restoration, see Brune 1991, Roundy et al. 1993, and Schramp 1978.

SHORT-GRASS PRAIRIE

Short-grass prairie covers much of the eastern plains, occurring on drought-prone, mildly alkaline, medium and fine-textured soils. The character of the short-grass prairie is shaped by aridity; average annual precipitation is between 10 and 16 inches (25-40 cm). Mid-grasses are able to survive during periods of moderate conditions, but are replaced by blue grama and buffalograss during and following events of stress such as drought or overgrazing. In the absence of such stress, mid-grasses such as needleandthread, sideoats grama, junegrass, and Sandberg bluegrass are common and even dominant, and the many associated forbs can turn the prairie into a colorful wildflower garden in wet summers. Western wheatgrass may form monotypic stands in swales and depressions on clay-rich soils. Few shrubs grow consistently in short-grass prairie because the soils are too dry and compacted to support them; yucca, cacti, fourwing saltbush and rabbitbrush are the most common woody plants on the prairie.

Plant Finder 1: Short-grass Prairie

(dominant species in bold type)

GRAMINOIDS	
Bouteloua gracilis	**blue grama**
Bouteloua hirsuta	hairy grama
Buchloe dactyloides	**buffalograss**
Carex filifolia	threadleaf sedge
Hilaria jamesii	galleta (southern plains)
Koeleria macrantha	junegrass
Muhlenbergia torreyi	ring muhly
Pascopyrum smithii	**western wheatgrass**
Poa secunda	Sandberg bluegrass
Sporobolus cryptandrus	sand dropseed
Stipa comata	needleandthread
FORBS	
Argemone polyanthemos	crested pricklypoppy
Artemisia carruthii	Carruth's sagewort
Artemisia frigida	**fringed sagewort**
Astragalus missouriensis	Missouri milkvetch
Heterotheca canescens	hoary false goldenaster
Cryptantha thyrsiflora	calcareous catseye
Dalea candida	white prairieclover
Dalea purpurea	purple prairieclover
Delphinium carolinium ssp. virescens	Carolina larkspur
Eriogonum effusum	spreading buckwheat
Erysimum asperum	plains wallflower
Gaillardia pinnatifida	red dome blanketflower
Gaura coccinea	scarlet beeblossom
Ipomoea leptophylla	bush morning glory
Liatris punctata	**dotted gayfeather**
Linum lewisii	Lewis' flax
Mirabilis linearis	narrowleaf four o'clock
Oenothera caespitosa	clumped evening primrose

Plant Finder 1: Short-grass Prairie

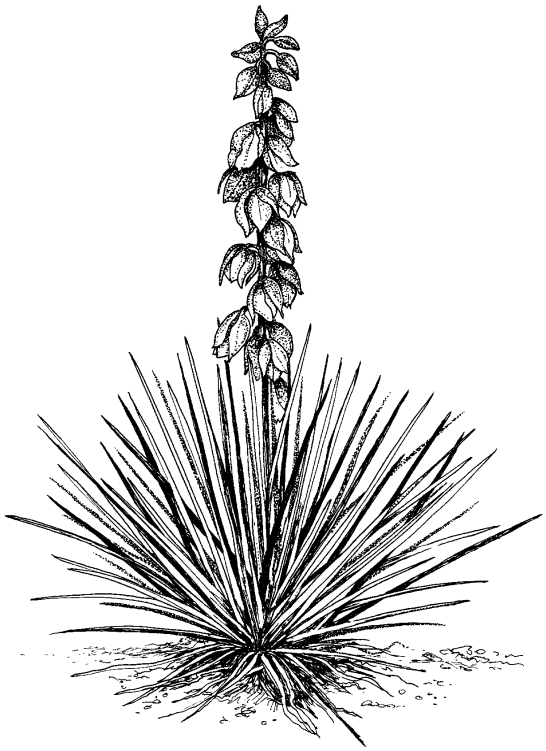
(dominant species in bold type)

FORBS (continued)

Psoralidium tenuiflorum	**slimflower scurfpea**
Ratibida columnifera	**upright prairie coneflower**
Solidago mollis	velvety goldenrod
Sophora sericea	silky sophora
Sphaeralcea angustifolia	copper globemallow
Sphaeralcea coccinea	**scarlet globemallow**
Tetraneuris acaulis	stemless hymenoxys
Zinnia grandiflora	Rocky Mountain zinnia (southern plains)

TREES AND SHRUBS (INCLUDING SUCCULENTS)

Atriplex canescens	fourwing saltbush
Chrysothamnus parryi	**Parry's rabbitbrush**
Coryphantha vivipara	scarlet hedgehog cactus
Echinocereus triglochidiatus	kingcup cactus
Echinocereus viridiflorus	nylon hedgehog cactus
Krascheninnikovia lanata	winterfat
Opuntia fragilis	brittle pricklypear
Opuntia macrorhiza	twistspine pricklypear
Opuntia phaeacantha	**Mojave pricklypear**
Opuntia polyacantha	hairspine pricklypear
Yucca glauca	**small soapweed**



Yucca glauca

MID-GRASS PRAIRIE

Mid-grass prairie is found on the western edge of the plains near the foothills and also in pockets in southeastern Colorado on sandy or loamy soils. Here, with generally greater annual precipitation and less stress from drought or overgrazing, grasses of medium height are able to survive.

Plant Finder 2: Mid-grass Prairie

(dominant species in bold type)

GRAMINOIDS	
Bouteloua curtipendula	sideoats grama
Bouteloua gracilis	**blue grama**
Hilaria jamesii	galleta (southern plains)
Koeleria macrantha	**prairie junegrass**
Pascopyrum smithii	**western wheatgrass**
Schizachyrium scoparium	**little bluestem**
Stipa comata	**needleandthread**
Stipa viridula	green needlegrass
FORBS	
Amorpha canescens	leadplant
Dalea candida	white prairieclover
Dalea purpurea	**purple prairieclover**
Eriogonum effusum	spreading buckwheat
Gaura coccinea	scarlet beeblossom
Liatris punctata	**dotted gayfeather**
Psoralidium tenuiflorum	**slimflower scurfpea**
Ratibida columnifera	**upright prairie coneflower**
Sphaeralcea coccinea	**scarlet globemallow**
Virgulus ericoides	white prairieaster
TREES AND SHRUBS	
Fallugia paradoxa	Apache plume (San Luis & Ark. Valley)
Krascheninnikovia lanata	winterfat
Rosa arkansana	prairie rose
Yucca glauca	**small soapweed**

TALL-GRASS PRAIRIE

Tall-grass prairie is extremely uncommon in Colorado, occurring only in very small pockets along the Front Range where natural and artificial subirrigation supplements soil moisture. It requires well-drained soils that stay moist; this is a difficult combination in the arid climate of eastern Colorado. Individual tall grass species can be found where localized environmental factors support their growth. If your project will include tall-grass prairie, you may want to contact a conservation professional before proceeding.

Plant Finder 3: Tall-grass Prairie

(dominant species in bold type)

GRAMINOIDS	
Andropogon gerardii	**big bluestem**
Bouteloua curtipendula	sideoats grama
Bouteloua gracilis	blue grama
Panicum virgatum	**switchgrass**
Pascopyrum smithii	western wheatgrass
Schizachyrium scoparium	little bluestem
Sorghastrum nutans	**yellow Indiangrass**
Spartina pectinata	prairie cordgrass
Sporobolus asper	dropseed
Sporobolus heterolepis	**prairie dropseed**
FORBS	
Artemisia frigida	fringed sagewort
Asclepias speciosa	showy milkweed
Cirsium flodmanii	Floodman's thistle
Dalea candida	Floodman's thistle
Dalea purpurea	**purple prairieclover**
Liatris punctata	dotted gayfeather
Psoralidium tenuiflorum	slimflower scurfpea
Ratibida columnifera	**upright prairie coneflower**
Solidago speciosa var. *pallida*	showy goldenrod
Thelesperma megapotamicum	Hopi tea greenthread
Virgulus ericoides	white prairieaster

FOOTHILLS GRASSLAND

Localized environmental conditions at the base of the foothills support grasslands at higher elevations than is typical of the eastern plains. Pockets of mid and tall-grass prairie species occur with foothills species on sites in the foothills where soils have a very high content of coarse rock fragments. The stones in and on the soil act as a mulch to concentrate soil moisture to levels needed by these species typical of wetter environments. Most commonly, foothills grasslands are composed of mid-grass species, and include occasional shrubs.

Plant Finder 4: Foothills Grassland

(dominant species in bold type)

GRAMINOIDS	
Andropogon gerardii	big bluestem
Bouteloua curtipendula	**sideoats grama**
Bouteloua gracilis	**blue grama**
Hilaria jamesii	galleta (southern foothills)
Koeleria macrantha	**prairie junegrass**
Muhlenbergia montana	**mountain muhly**
Panicum virgatum	switchgrass
Pascopyrum smithii	western wheatgrass
Schizachyrium scoparium	**little bluestem**
Sorghastrum nutans	yellow Indiangrass
Stipa comata	**needleandthread**
Stipa neomexicana	New Mexico needlegrass
FORBS	
Amorpha canescens	leadplant
Aster porteri	**Porter aster**
Dalea candida	white prairieclover
Dalea purpurea	purple prairieclover
Eriogonum effusum	spreading buckwheat
Gaura coccinea	scarlet beeblossom
Liatris punctata	**dotted gayfeather**
Psoralidium tenuiflorum	slimflower scurfpea
Ratibida columnifera	upright prairie coneflower
Solidago nana	baby goldenrod
Sphaeralcea coccinea	scarlet globemallow
Thelesperma megapotamicum	Hopi tea greenthread
TREES AND SHRUBS	
Cercocarpus montanus	**true mountain mahogany**
Krascheninnikovia lanata	winterfat
Rhus glabra	smooth sumac
Rhus trilobata	**skunkbush sumac**
Ribes cereum	**wax currant**
Rosa arkansana	prairie rose
Yucca glauca	**small soapweed**

SHRUBLANDS

Shrublands come in many kinds, but all have shrubs – multiple-stemmed, woody plants – as their dominant plants. Shrublands occur naturally in specialized habitats, often in areas too cold or too dry for trees but where soil conditions will support shrubs' deep root systems. Shrubs will also invade many types of grassland communities in the absence of fire or where grazing by wild and domestic animals has weakened the competitive ability of grasses. In eastern Colorado, greasewood and saltbush shrublands occur in alkaline depressions with clayey soils and a high water table ("flats"). Deep sandy soils support sand sage shrublands, and rocky hillsides and foothills support mixed shrubland communities.

Notes on shrubland projects

Shrublands may be considered transitional communities – possibly grasslands transitioning to forests in the absence of fire. There are still some procedures to follow which will help the success of your restoration project.

Resist the tendency to remove all the rocks and boulders from the soil in which you want to grow your shrubland. Rocks on the surface of the soil concentrate rainfall around their margins and provide hospitable sites for moisture-hungry shrubs to grow. Subsurface rock also increases the available soil moisture at depth by allowing moisture percolation and concentrating it between rocks. Rocks without fine soil between them can be a problem, since shrub roots have a hard time becoming established in very rocky soils. Total rock content of the soil should be between 5 and 20 percent with a sand or sandy loam matrix and up to 50 percent for a fine textured matrix.

Plant shrubs and forbs first. Grass competition must be restricted by use of mulch cloth or other techniques to protect young shrubs or forbs from often fatal competition with grasses.

Whenever possible, control weeds before planting to avoid damaging plantings with herbicide applications.

For more information on shrubland projects, see Barrow 1996 and Roundy et al. 1993.

SALINE BOTTOMLAND SHRUBLANDS

These communities occur on alkaline flats and slight depressions where periodic saturation has caused salts to accumulate as a white crust on the soil surface. Only a few specially adapted species of plants can tolerate these extremely alkaline soils.

Plant Finder 5: Greasewood Flats (Eastern Plains)

(dominant species in bold type)

GRAMINOIDS	
Bouteloua gracilis	blue grama
Buchloe dactyloides	**buffalograss**
Distichlis spicata	**inland saltgrass**
Hordeum jubatum	**foxtail barley**
Muhlenbergia asperifolia	alkali muhly
Puccinelia nuttaliana	Nuttal alkaligrass
Spartina gracilis	alkali cordgrass
Sporobolus airoides	**alkali sacaton**
TREES AND SHRUBS	
Atriplex canescens	Fourwing saltbush
Chrysothamnus nauseosus	rubber rabbitbrush
Sarcobatus vermiculatus	**greasewood**

Plant Finder 6: Shadscale and Saltbush Flats (Eastern Plains)

(dominant species in bold type)

GRAMINOIDS	
Bouteloua gracilis	blue grama
Buchloe dactyloides	**buffalograss**
Pascopyrum smithii	**western wheatgrass**
Sporobolus airoides	alkali sacaton
Sporobolus cryptandrus	**sand dropseed**
FORBS	
Ambrosia psilostachya	**western ragweed**
Sphaeralcea coccinea	scarlet globemallow
TREES AND SHRUBS	
Atriplex canescens	**fourwing saltbush**
Atriplex confertifolia	**shadscale saltbush**

SAND SAGEBRUSH PRAIRIE

Sand sagebrush prairie occupies sandy soils of the plains, primarily in the northeastern and southeastern corners of the state but also in other isolated areas where sandy soils occur. The porous nature of sand allows deeper water infiltration, giving deep-rooted shrubs the opportunity to grow more abundantly here. Unlike most prairies which are named for the dominant grasses, this prairie type is named for the most obvious species, sand sagebrush *(Artemisia filifolia).* Taller bunch grasses are common in this community, although they tend to drop out in heavily grazed areas. Wind erosion is common, often resulting in localized depressions or "blowouts". These blowouts are usually sparsely vegetated due to constantly shifting sands. Where vegetation occurs, it is composed of grass species with roots and rhizomes long enough to stabilize the sand.

Plant Finder 7: Sand Sagebrush Prairie

(dominant species in bold type)

GRAMINOIDS	
Andropogon hallii	**sand bluestem**
Bouteloua curtipendula	sideoats grama
Bouteloua gracilis	**blue grama**
Bouteloua hirsuta	hairy grama
Calamovilfa longifolia	**prairie sandreed**
Muhlenbergia pungens	**sandhill muhly**
Oryzopsis hymenoides	Indian ricegrass
Redfieldia flexuosa	blowout grass
Schizachyrium scoparium	little bluestem
Sporobolus cryptandrus	**sand dropseed**
Stipa comata	**needleandthread**
FORBS	
Heterotheca villosa	hairy goldenaster
Corydalis aurea	scrambledeggs
Cymopterus acaulis	plains springparsley
Dalea villosa	**silky prairieclover**
Eriogonum annuum	**annual buckwheat**
Gilia longiflora	flaxflowered gilia
Helianthus petiolaris	prairie sunflower
Ipomoea leptophylla	bush morning glory
Mentzelia nuda	**bractless blazingstar**
Mirabilis glaber	four-o'clock
Psoralidium lanceolatum	**lemon scurfpea**
Rumex venosus	veiny dock
Tradescantia occidentalis	**prairie spiderwort**
TREES AND SHRUBS	
Artemisia filifolia	**sand sagebrush**
Opuntia phaeacantha	Mojave pricklypear
Yucca glauca	**small soapweed**

Plant Finder 8: Sand Dune Blowouts

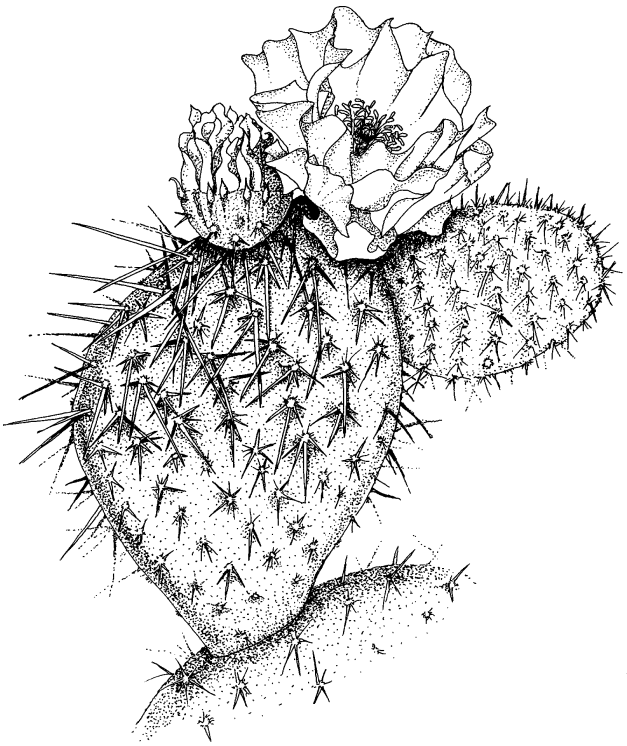
(dominant species in bold type)

GRAMINOIDS

Andropogon hallii	sand bluestem
Muhlenbergia pungens	**sandhill muhly**
Pascopyrum smithii	western wheatgrass
Redfieldia flexuosa	**blowout grass**
Sporobolus cryptandrus	sand dropseed
Stipa comata	**needleandthread**

FORBS

Asclepias arenaria	**sand milkweed**
Astragalus ceramicus var. *filifolius*	painted milkvetch
Dalea villosa	silky prairieclover
Heliotropium convolvulaceum	phlox heliotrope
Oenothera caespitosa	**clumped evening primrose**
Polanisia jamesii	James' clammyweed
Psoralidium lanceolatum	**lemon scurfpea**



Opuntia spp.

MIXED FOOTHILLS SHRUBLAND

These mixed shrublands occur on canyon slopes and on hillsides in the foothills zone. In the northern counties, shrublands consist primarily of skunkbush sumac *(Rhus trilobata),* mountain mahogany *(Cercocarpus montanus),* currant *(Ribes cereum),* and in some places bitterbrush *(Purshia tridentata).* In the southern counties, the composition of the shrublands changes, and Gambel's oak *(Quercus gambelii)* becomes the dominant component.

Plant Finder 9: Shrublands

(dominant species in bold type)

GRAMINOIDS	
Andropogon gerardii	big bluestem
Bouteloua curtipendula	**sideoats grama**
Bouteloua gracilis	**blue grama**
Carex pensylvanica var. heliophila	**sun sedge**
Danthonia parryi	Parry oatgrass
Muhlenbergia montana	**mountain muhly**
Pascopyrum smithii	western wheatgrass
Schizachyrium scoparium	**little bluestem**
Stipa comata	**needleandthread**
Stipa neomexicana	New Mexico needlegrass
FORBS	
Artemisia frigida	**fringed sagewort**
Erigeron flagellaris	trailing fleabane
Liatris punctata	**dotted gayfeather**
Solidago velutina	velvety goldenrod
TREES AND SHRUBS	
Brickellia californica	brickellbush
Cercocarpus montanus	**true mountain mahogany**
Chrysothamnus viscidiflorus	green rabbitbrush
Prunus virginiana	**black chokecherry**
Ptelea trifoliata	common hoptree (Arkansas Valley only)
Purshia tridentata	antelope bitterbrush
Quercus gambelii	**Gambel's oak (south of Denver)**
Rhus trilobata	**skunkbush sumac**
Ribes cereum	**wax currant**
Rosa woodsii	**Wood's rose**
Symphoricarpos rotundifolius	**roundleaf snowberry**

WOODLANDS

Woodlands occur in the foothills zone and where canyons on the plains create foothills-like conditions. They are characterized by having one or more species of small trees – oneseed juniper, Rocky Mountain juniper, piñon pine, or limber pine – dominant in the topmost layer of vegetation. Because these trees require more moisture and deeper soils than shrubs or grasses, woodland communities are restricted to rocky, mesic sites in draws and north-facing escarpments below 6000 feet (1829 m), and dry slopes among ponderosa pine and Douglas-fir communities above 6000 feet. Fire converts woodland communities to grasslands or shrublands; very old woodland communities are rare except in rocky areas which are protected from fire.

Notes on woodland projects

Woodland sites alternate over time between woodland, shrubland, and grassland vegetation, depending on the climate and the frequency and intensity of the fire regime. After intense fire, grasses replace all or some of the trees. Over time, shrubs replace grasses. Eventually, trees again become the dominant vegetation.

In natural settings, unless the soil has been seriously disturbed or weeds are abundant, woodlands will regenerate without intervention. Erosion control and weed management may be sufficient to restore woodlands after disturbance. Planting in woodland sites can be very difficult due to rocky soils. Short-term reestablishment of visually dominant amounts of woody cover is likely to require nursery stock planting and mulching, caging, and irrigation of those plants.

For more information on woodlands, see Shaw et al. 1994, Covington 1996, and Howell 1986.

PIÑON PINE-JUNIPER WOODLANDS

Piñon pine-juniper woodlands occur in draws, on escarpments and mesas, and on rocky hillsides. These woodlands are best developed between 5,000 and 7,000 feet (1524-2134 m), but localized environmental conditions may allow them to occur at lower elevations on the plains and up to 9,000 feet (2743 m) in the montane zone. Sites occupied by piñon-juniper woodlands are typically warm, dry and windy. Annual precipitation ranges from 12 to 18 inches (30-46 cm). Trees tend to be short and widely spaced. Either piñon or juniper may dominate; generally juniper is more abundant at the lower end of the elevational range. Piñon pine, being better adapted to cold conditions is typically more abundant at higher elevations. In southern counties, the community includes one-seeded juniper and piñon in the overstory and wavyleaf or Gambel's oak, apache plume, and candelabra cactus in the understory. North of Colorado Springs, Rocky Mountain juniper may replace one-seeded juniper and piñon pine becomes less common; understory species include skunkbush, rabbitbrush, bitterbrush, and mountain mahogany. Throughout the range of this community type, grass and forb cover is inversely proportional to the density of the piñon and juniper.

Plant Finder 10: Piñon Pine-Juniper Woodland

(dominant species in bold type)

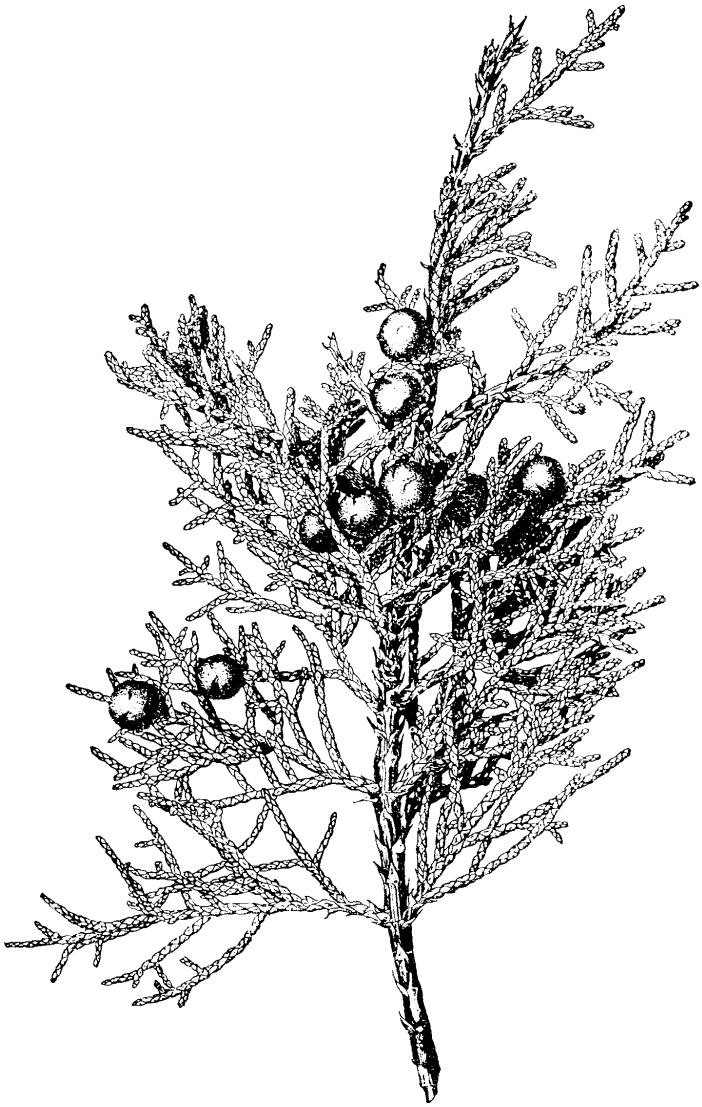
GRAMINOIDS	
Bouteloua curtipendula	sideoats grama
Bouteloua gracilis	**blue grama**
Elymus elymoides	bottlebrush squirreltail
Lycurus phleoides	common wolfstail
Oryzopsis hymenoides	**Indian ricegrass**
Oryzopsis micrantha	littleseed ricegrass
Poa fendleriana	**muttongrass**
Schizachyrium scoparium	little bluestem
Stipa comata	**needleandthread**
Stipa neomexicana	New Mexico needlegrass
FORBS	
Arenaria hookeri	**Hooker's sandwort**
Castilleja linariifolia	**Wyoming Indian paintbrush**
Heterotheca villosa	**hairy goldenaster**
Hymenopappus filifolius	fineleaf hymenopappus
Mirabilis multiflora	Colorado four o'clock (south of Denver)
Solidago velutina	velvety goldenrod
Tetraneuris acaulis	stemless hymenoxys
TREES AND SHRUBS	
Amelanchier alnifolia	Saskatoon serviceberry
Artemisia tridentata	big sagebrush
Cercocarpus montanus	**true mountain mahogany**
Chrysothamnus nauseosus	rubber rabbitbrush
Holodiscus dumosus	rock spirea
Juniperus monosperma	**oneseed juniper**

Plant Finder 10: Piñon Pine-Juniper Woodland

(dominant species in bold type)

TREES AND SHRUBS (continued)

Juniperus scopulorum	Rocky Mountain juniper
Pinus edulis	**piñon pine (south of Denver)**
Pinus flexilis	limber pine (northeast Colorado)
Purshia tridentata	**antelope bitterbrush**
Quercus gambelii	**Gambel's oak (south of Denver)**
Rhus trilobata	skunkbush sumac
Ribes cereum	**wax currant**
Symphoricarpos rotundifolius	roundleaf snowberry



Juniperus scopulorum

PONDEROSA PINE WOODLAND AND SAVANNA

Ponderosa pine savannas occur primarily on dry, fire-prone south-facing slopes and have grassy understories with few shrubs. Woodlands typically occur on rockier sites less prone to fire and have dense shrub understories. In the eastern part of the state, these communities are found at the base of the foothills and on mesa tops on the plains.

Plant Finder 11: Ponderosa Pine Woodlands and Savanna

(dominant species in bold type)

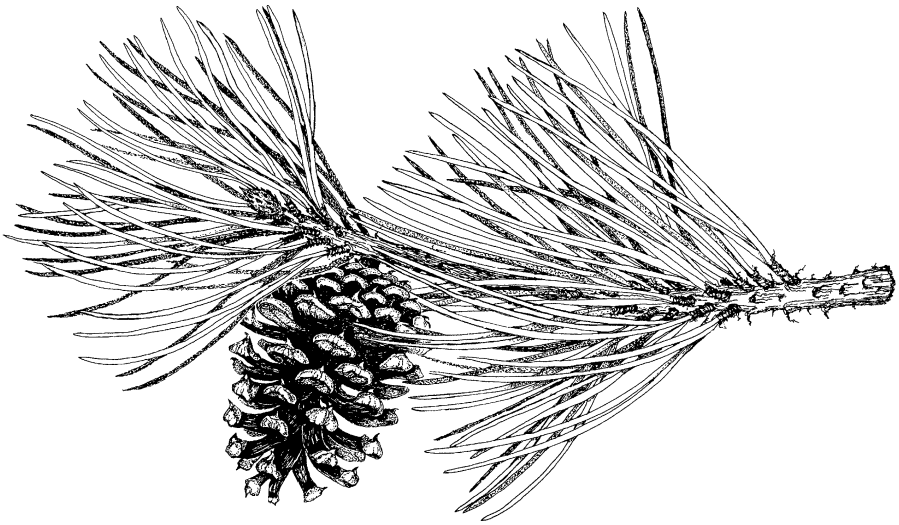
GRAMINOIDS	
Blepharoneuron tricholepis	**pine dropseed**
Bouteloua curtipendula	sideoats grama
Bouteloua gracilis	**blue grama**
Carex pensylvanica var. *heliophila*	sun sedge
Danthonia spicata	poverty oatgrass
Festuca arizonica	**Arizona fescue**
Koeleria macrantha	**prairie junegrass**
Leucopoa kingii	spike fescue
Leymus ambiguus	Colorado wildrye
Muhlenbergia montana	**mountain muhly**
Poa fendleriana	mutton bluegrass
Poa secunda	Sandberg bluegrass
Schizachyrium scoparium	little bluestem
Stipa pinetorum	pine needlegrass
Stipa scribneri	Scribner's needlegrass
FORBS	
Antennaria rosea	rosy pussytoes
Arnica fulgens	foothill arnica
Artemisia frigida	**fringed sagewort**
Artemisia ludoviciana	**white sagebrush**
Campanula rotundifolia	**bluebell bellflower**
Eremogone fendleri	desert sandwort
Heterotheca villosa	**hairy goldenaster**
Galium boreale	northern bedstraw
Geranium caespitosum	**pineywoods geranium**
Penstemon virens	green beardtongue
Potentilla fissa	bigflower cinquefoil
Sedum lanceolatum	**spearleaf stonecrop**
TREES AND SHRUBS	
Arctostaphylos uva-ursi	**kinnikinnick**
Berberis fendleri	Colorado barberry (south of Denver)
Ceanothus fendleri	Fendler's ceanothus
Cercocarpus montanus	**true mountain mahogany**
Jamesia americana	cliffbush
Juniperus communis	common juniper
Juniperus scopulorum	**Rocky Mountain juniper**

Plant Finder 11: Ponderosa Pine Woodlands and Savanna

(dominant species in bold type)

TREES AND SHRUBS (continued)

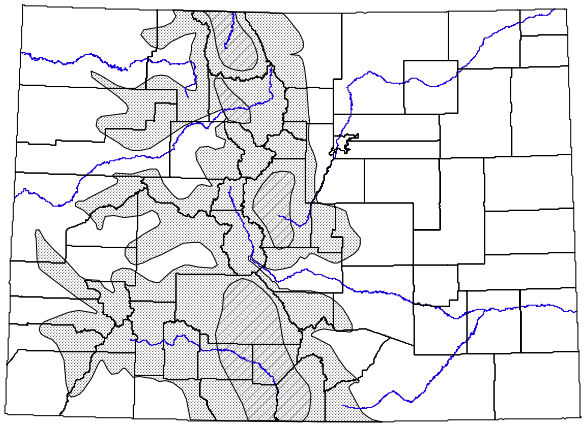
Mahonia repens	**Oregon grape**
Physocarpus monogynus	mountain ninebark
Pinus ponderosa	**ponderosa pine**
Pseudotsuga menziesii	**Douglas fir**
Purshia tridentata	**antelope bitterbrush**
Quercus gambelii	**Gambel's oak (south of Denver)**
Rhus trilobata	skunkbush sumac



Pinus ponderosa

Quercus gambelii

ROCKY MOUNTAIN REGION



DESCRIPTION – This region lies between the plains and foothills to the east and the plateaus, canyons and lowlands to the west. The southern Rocky Mountains of Colorado are a complex group of well-defined ranges which have been carved by glaciers and eroded by streams to form steep, rugged canyons and ridges. This section also describes the vegetation of the great intermountain basins or "parks" (North Park, Middle Park, South Park) and the San Luis Valley, which are geographically part of the mountain region, but which may also share climatic and floristic characteristics with the eastern and western regions of Colorado.

CLIMATE / SOIL – Annual precipitation in the Colorado Rocky Mountains ranges from 18 to over 40 inches (45 to 100 cm) per year, with the high elevations of the Park Range and San Juan Mountains receiving the most moisture. At least 40 percent of the annual precipitation originates with Pacific air masses and falls in the form of snow. Soils are variable, depending on geologic substrate, precipitation, aspect and slope, and contribute to the diversity of plant communities found in the region. In general, soils developed from granitic and metamorphic rocks are coarser than soils developed from the less extensive sedimentary rocks in the region. The steeper slopes and higher precipitation in this region result in higher rates of erosion, keeping soils generally younger and shallower than is the case east or west of the region.

TOPOGRAPHIC FEATURES – Vertical relief characterizes the Rocky Mountain region of Colorado. Colorado's average elevation is 6,800 feet (2073 m); the state contains 54 peaks higher than 14,000 feet (4267 m) and more than 1000 peaks over 10,000 feet (3048 m) high, three elevated plateaus and more than 20 named mountain ranges. Most of the mountain ranges were glaciated during the Pleistocene, which put the finishing touches on peaks and valleys already millions of years in the making. Four of North America's great rivers (the Colorado, the Platte, the Rio Grande and the Arkansas) originate within these mountains.

Steep slopes are the rule in the Rocky Mountain region, with three exceptions. Glaciers broadened the bottoms of many mountain valleys a thick layer of river deposits leveled them. The four great parks within the region (North, Middle, and South Park and the San Luis Valley) also have relatively flat floors. Surprisingly, a good deal of gentle terrain is also found at upper

elevations and even at the *tops* of the mountains, a reminder that at various times since the current Rocky Mountains were uplifted, erosional planing created surfaces later elevated, dissected by streams, broken by faults, and carved by glaciers. Broad summits at various elevations in the Front and Rampart ranges are examples of these ancient surfaces.

VEGETATION – The topographic diversity which defines the Rocky Mountain region gives rise to a parallel diversity of vegetation. Mountain environments are characterized primarily by coniferous forests: Ponderosa pine forests, Douglas-fir, and Engelmann spruce and subalpine fir forests. Aspen forests cover large areas where conifers have been removed by wind, landslide, avalanche or fire. Pockets of grassland often persist on deep soils and shrublands are found where warm, shallow soils are inhospitable to tree establishment. At the highest elevations, treeless alpine tundra and bare rock form the landscape. The Rocky Mountain region is also where most of the naturally-occurring wetlands of Colorado are found.

GRASSLANDS

Grasslands are a minor but important part of the Rocky Mountain region's vegetation. They occupy specialized habitats where the climate is too cold or dry and/or the soils are too shallow to support the growth of trees and shrubs. In general, grasslands are small, providing openings within the forested zone, but the entire floor of South Park is a montane grassland. Two major types of grasslands have been distinguished on the basis of elevation. Montane grasslands occur between approximately 8,000 and 10,000 feet (2438-3048 m) and subalpine grasslands occupy favorable habitats between approximately 10,000 feet and treeline.

Notes on grassland projects

Many mountain grasslands in Colorado have been altered by over a century of use and fire suppression. Restoration can increase the diversity of plants, animals and community types in a given area.

Depending on the degree of past disturbance, restoration may be as simple as removing grazing and introducing fire. In more disturbed situations, interplanting missing native grasses and forbs, and/or removing aggressive nonnative plants may also be necessary.

Transplanting from the wild is difficult because mountain envirmonments are stressful on plants weakened by relocation. Grassland plants have developed long, deep roots to promote survival during drought. Try salvaging plants from sites that are scheduled for development rather than trying to move plants from intact native grasslands.

Where possible, burn occasionally to reduce litter accumulations and prevent invasion by shrubs and trees. Burning only a part of the grassland in any year will leave the remainder as a refuge for creatures living there.

For more information on grassland planting or restoration, see Brune 1991, and Roundy et al. 1993.

MONTANE AND SUBALPINE GRASSLANDS

Small mountain grasslands and meadows are interspersed between the various forest communities and occur primarily on flat or gently sloping terrain with shallow to deep fine-grained soils. Large expanses of grassland or meadow communities are concentrated in parts of North, Middle, and South parks, the Wet Mountain Valley, the perimeter of the San Luis Valley and parts of the upper Rio Grande Basin (Benedict 1991). These grasslands range from moist to dry depending on exposure, their proximity to the water table and soil characteristics. Meadows with seasonally or permanently saturated soils or standing water are discussed in the wetland section (beginning on page 111). Mountain grasslands are usually dominated by bunch grasses such as fescues, oatgrass, Junegrass and mountain muhly, but wildflowers are abundant and diverse, making Colorado's grasslands the state's most photogenic plant community. Because mountain grasslands occur under conditions (including cold sinks or shallow soils) which do not favor the growth of woody plants, trees and shrubs are not recommended for revegetation projects.

Plant Finder 12: Montane Grasslands

(dominant species in bold type)

GRAMINOIDS	
Bouteloua gracilis	**blue grama**
Carex geyeri	elk sedge
Danthonia parryi	**Parry's oatgrass**
Festuca arizonica	**Arizona fescue**
Festuca idahoensis	Idaho fescue
Koeleria macrantha	**prairie junegrass**
Muhlenbergia montana	**mountain muhly**
Poa fendleriana	**muttongrass**
Stipa lettermanii	Letterman's needlegrass
FORBS	
Achillea lanulosa	**western yarrow**
Antennaria umbrinella	**umber pussytoes**
Arnica parryi	Parry's arnica
Artemisia frigida	**fringed sagewort**
Erigeron flagellaris	trailing fleabane
Geranium richardsonii	Richardson's geranium
Heterotheca villosa	hairy goldenaster
Hymenoxys richardsonii	**pingue hymenoxys**
Ipomopsis aggregata	**skyrocket gilia**
Linum lewisii	Lewis' flax
Oxytropis lambertii	Lambert's locoweed
Penstemon strictus	Rocky Mountain penstemon
Potentilla pulcherrima	beautiful cinquefoil
Senecio neomexicanus	New Mexico groundsel

Plant Finder 13: Subalpine Grasslands

(dominant species in bold type)

GRAMINOIDS

Carex geyeri	elk sedge
Ceratochloa carinata	California brome
Danthonia intermedia	timber oatgrass
Deschampsia cespitosa	**tufted hairgrass**
Elymus elymoides	bottlebrush squirreltail
Elymus trachycaulus	slender wheatgrass
Festuca idahoensis	**Idaho fescue**
Festuca rubra	red fescue
Festuca saximontana	Rocky Mountain fescue
Festuca thurberi	**Thurber's fescue**
Phleum alpinum	**alpine timothy**
Poa alpina	alpine bluegrass
Poa secunda	**Sandberg bluegrass**
Stipa viridula	green needlegrass
Trisetum spicatum	spike trisetum

FORBS

Achillea lanulosa	**western yarrow**
Agoseris aurantiaca	orange agoseris
Aquilegia coerulea	Colorado blue columbine
Arnica parryi	Parry's arnica
Campanula rotundifolia	**bluebell bellflower**
Castilleja rhexifolia	Indian paintbrush
Erigeron peregrinus	**subalpine fleabane**
Helianthella quinquenervis	**fivenerve sunflower**
Lathyrus lanszwertii* var. *leucanthus	**aspen peavine**
Lupinus argenteus	**silvery lupine**
Mertensia lanceolata	prairie bluebells
Oxytropis lambertii	**Lambert's locoweed**
Penstemon whippleanus	Whipple's penstemon
Senecio dimorphophyllus	groundsel
Thalictrum fendleri	**Fendler meadow-rue**
Thermopsis montana	**golden banner**
Vicia americana	**American vetch**

SHRUBLANDS

Shrublands come in many kinds, but all have shrubs – multiple-stemmed, woody plants – as their dominant plants. Shrublands occur naturally in specialized habitats, often in areas too cold or too dry for trees but where soil conditions will support shrubs' deep root systems. Shrubs will also invade many types of grassland communities in the absence of fire or where grazing by wild and domestic animals has weakened the competitive advantage of grasses. In the Rocky Mountain region, greasewood and saltbush shrublands occur in level areas where clay soils and a high water table create saline or alkaline conditions. Sagebrush shrublands can occur on a variety of well-drained soils with more nearly neutral soil pH and can be found over a wide range of elevations.

Notes on shrubland projects

Shrublands may be considered transitional communities – possibly grasslands transitioning to forests in the absence of fire. There are several procedures to follow which will help the success of your restoration project.

Resist the tendency to remove all the rocks and boulders from the soil in which you want to grow your shrubland. Rocks on the surface of the soil concentrate rainfall around their margins and provide hospitable sites for moisture-hungry shrubs to grow. Subsurface rock also increases the available soil moisture at depth by allowing moisture percolation and concentrating it between rocks. Rocks without fine soil between them can be a problem since shrub roots have a hard time becoming established in very rocky soils. Total rock content of the soil should be between 5 and 20 percent with a sand or sandy loam matrix and up to 50 percent for a fine textured matrix.

Plant shrubs and forbs first. Grass competition must be restricted by use of mulch cloth or other techniques to protect young shrubs or forbs from often fatal competition with grasses.

Whenever possible, control weeds before planting to avoid damaging plantings with herbicide applications.

For more information on shrubland projects, see Barrow 1996 and Roundy et al. 1993.

SAGEBRUSH SHRUBLANDS

Sagebrush shrublands are most extensive in western Colorado, but also cover certain areas of the Rocky Mountain region. Two major types may be distinguished on the basis of elevation and soils.

BASIN BIG SAGEBRUSH

Basin big sagebrush shrublands occur at lower elevations on deep soils of floodplains and arroyos; they occur throughout western and southern Colorado. This type is dominated by basin big sagebrush (*Artemisia tridentata* ssp. *tridentata),* a tall shrub up to seven feet (2 m) in height. Understory vegetation tends to be sparse but other shrub species are common associates.

Plant Finder 14: Basin Big Sagebrush

(dominant species in bold type)

GRAMINOIDS	
Bouteloua curtipendula	sideoats grama
Hilaria jamesii	galleta (southern Colorado)
Leymus cinereus	**Great basin wildrye**
Oryzopsis hymenoides	**Indian ricegrass**
Pascopyrum smithii	**western wheatgrass**
Poa fendleriana	muttongrass
Poa secunda	**Sandberg bluegrass**
Sporobolus cryptandrus	sand dropseed
FORBS	
Arenaria hookeri	Hooker's sandwort
Balsamorhiza sagittata	**arrowleaf balsamroot**
Heterotheca villosa	hairy goldenaster
Gaillardia aristata	common gaillardia
Sphaeralcea coccinea	**scarlet globemallow**
Wyethia amplexicaulis	mulesears wyethia
TREES AND SHRUBS	
Artemisia tridentata* ssp. *tridentata	**basin big sagebrush**
Artemisia tridentata ssp. *wyomingensis*	Wyoming big sagebrush
Atriplex canescens	fourwing saltbush
Chrysothamnus nauseosus	**rubber rabbitbrush**
Chrysothamnus viscidiflorus	green rabbitbrush
Sarcobatus vermiculatus	**greasewood**

MOUNTAIN BIG SAGEBRUSH

Mountain big sagebrush communities occur at higher elevations on convex sites and on shallower soils than basin big sagebrush communities. Mountain big sagebrush is the dominant plant species of this type, but it may be replaced by black sagebrush at lower elevations on rocky soils and it intermixes with basin big sagebrush growing in similar size on many sites. Mountain big sagebrush communities may include a variety of shrubs and an abundance of wild flowers. It occurs at upper elevations adjacent to aspen, oak-serviceberry, and coniferous forest. Examples of this plant community are found in North Park, Middle Park, the western slope of the Park Range, the upper Gunnison Basin, the Vail Valley, and the Beaver Meadows area on the eastern side of Rocky Mountain National Park. In these areas, the similar Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis)* may be dominant or co-dominant locally.

Plant Finder 15: Mountain Big Sagebrush

(dominant species in bold type)

GRAMINOIDS	
Agropyron spicatum	bluebunch wheatgrass
Bouteloua curtipendula	sideoats grama
Festuca saximontana	Rocky Mountain fescue
Hilaria jamesii	**galleta (southern Colorado)**
Koeleria macrantha	**prairie junegrass**
Melica sp.	onion grass
Oryzopsis hymenoides	**Indian ricegrass**
Pascopyrum smithii	western wheatgrass
Poa fendleriana	**muttongrass**
Poa secunda	**Sandberg bluegrass**
Stipa lettermanii	Letterman's needlegrass
Stipa nelsonii	Nelson's needlegrass
FORBS	
Agastache urticifolia	nettleleaf giant hyssop
Arenaria hookeri	Hooker's sandwort
Astragalus miser	timber milkvetch
Balsamorhiza sagittata	**arrowleaf balsamroot**
Erigeron speciosus	showy daisy
Helianthella uniflora	oneflower helianthella
Heterotheca villosa	**hairy goldenaster**
Delphinium nuttallianum	**Nuttall's larkspur**
Gaillardia aristata	common gaillardia
Lupinus argenteus	**silvery lupine**
Lupinus caudatus	tailcup lupine
Penstemon caespitosus	mat penstemon
Wyethia amplexicaulis	mulesears wyethia
TREES AND SHRUBS	
Amelanchier utahensis	Utah serviceberry
Artemisia arbuscula ssp. *longiloba*	alkali sagebrush
Artemisia nova	black sagebrush
Artemisia tridentata* ssp. *tridentata	**basin big sagebrush**

Plant Finder 15: Mountain Big Sagebrush

(dominant species in bold type)

TREES AND SHRUBS (continued)

Artemisia tridentata* ssp. *vaseyana	**mountain big sagebrush**
Artemisia tridentata* ssp. *wyomingensis	**Wyoming big sagebrush**
Atriplex confertifolia	shadscale saltbush
Chrysothamnus parryi	Parry rabbitbrush
Purshia tridentata	**antelope bitterbrush**
Symphoricarpos rotundifolius	**roundleaf snowberry**
Tetradymia canescens	spineless horsebrush

WOODLANDS

Open woodlands of limber and bristlecone pines occupy dry, rocky, wind-swept sites in the Rocky Mountain region. Limber pine can be found on a variety of windy, exposed sites as low as Pawnee Buttes in northeastern Colorado, but they are generally found above 9,000 feet (2743 m). Limber pine is most common in northern Colorado; bristlecone pine is limited to southern and central Colorado. In central parts of the state where the ranges overlap, bristlecone usually occurs at higher elevations. Bristlecone and limber pine woodlands occupy sites with harsh climatic conditions; high winds, low temperatures, and periodic drought are common. Trees growing in these conditions tend to be stunted, gnarled, multiple-trunked and widely spaced. The understory is nearly always sparse, with a low diversity of shrubs and herbaceous plants.

Notes on woodland projects

Woodland sites are similar to alpine sites in the challenges they present to revegetation project planners. The conditions are generally too dry and windy for plantings to succeed without special measures.

In moister, less windy sites, plants listed in the Plant Finder can perform well if seeded in the fall and provided with a durable mulch cover such as bonded fiber matrix or well-anchored excelsior mat.

In moderately windy sites, establishment must be done via planting rather than seeding. Mulches in these sites must be more carefully applied and must be better anchored than those in sheltered sites.

For more information on woodlands, see Shaw et al. 1994, Covington 1996, and Howell 1986.

Pinus contorta

Plant Finder 16: Limber and Bristlecone Pine Woodlands

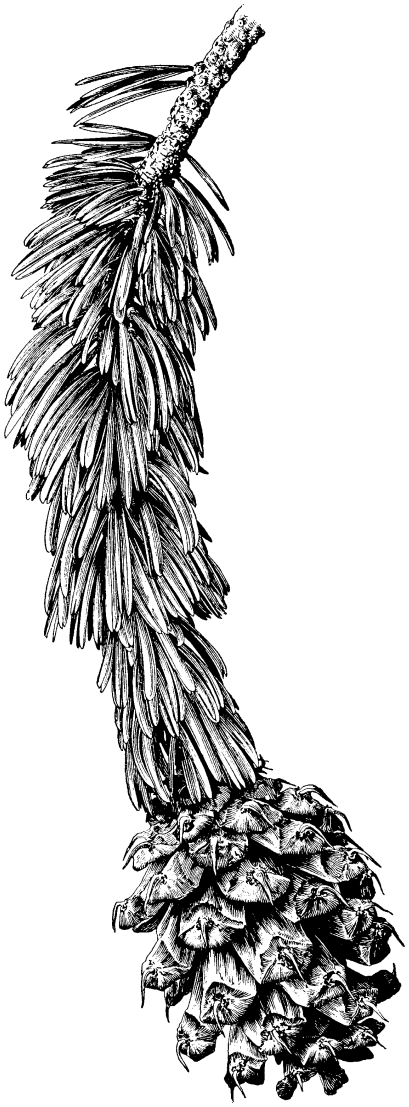
(dominant species in bold type)

GRAMINOIDS	
Danthonia intermedia	timber oatgrass
Festuca arizonica	Arizona fescue
Festuca thurberi	Thurber's fescue
Poa alpina	**alpine bluegrass**
Trisetum spicatum	**spike trisetum**
FORBS	
Cilaria austromontana	**matted saxifrage**
Erysimum capitatum	sanddune wallflower
Heuchera parvifolia	littleleaf alumroot
Sedum lanceolatum	**spearleaf stonecrop**
Trifolium attenuatum	Rocky Mountain clover
Trifolium dasyphyllum	alpine clover
TREES AND SHRUBS	
Arctostaphylos uva-ursi	**kinnikinnick**
Juniperus communis	**common juniper**
Pinus aristata	**bristlecone pine**
Pinus flexilis	**limber pine**
Ribes montigenum	**gooseberry currant**

Sedum lanceolatum

FORESTS

Forest communities are the principal vegetation type in the Rocky Mountain region, occurring on all slopes, aspects and soil types. The upper and lower elevational limits (upper and lower "treeline") of forests in Colorado are defined primarily by climatic factors. At upper treeline, trees give way to tundra because the growing season is too short and the soils too cold to support woody plant growth. Lower treeline is defined by a variety of factors, including precipitation and the presence of cold air sinks. Between upper and lower treeline, most of Colorado's forests are coniferous; that is, dominated by pine, spruce, and/or fir trees. Several distinct types of coniferous forest have been defined on the basis of elevation. Douglas-fir forest occurs at lower elevations; spruce-fir forest at higher elevations. Aspen forest occupies smaller areas throughout the region, usually on mesic soils where catastrophic disturbance (fire, avalanche, blowdown) has removed the conifers, while lodgepole forest takes over after disturbance on dry soils.



Pinus aristata

Notes on forest projects

In natural settings, forests will regenerate after disturbance without intervention if soil erosion or weed infestation are not severe. Erosion control and weed management may be sufficient to promote natural regeneration.

The complex vertical structure of forests may affect the type of equipment that can be used for forest projects.

Forests require many decades of growth before maturing. As a result, forest restoration projects may require long-term monitoring.

For more information on forest projects, see Alexander 1987, Shaw et al. 1994, Crane 1982, and Covington 1996.

DOUGLAS-FIR FORESTS

Forests dominated by Douglas-fir are found from 6,000 to 9,500 feet (1829-2896 m) throughout Colorado. In the foothills, Douglas-fir forests are confined to rocky soils on cool north-facing slopes and in shaded canyons, but in the montane zone, they may be found on slopes of all aspects. Tree canopy density varies with site temperature and moisture availability. Dense forests often permit only diffuse light to reach the forest floor. As a consequence, understory vegetation is sparse and consists of scattered shade-tolerant shrubs, forbs and graminoids.

In northern Colorado, Douglas-fir may occur in pure stands or share the canopy with a few ponderosa pine, Rocky Mountain juniper, or Engelmann spruce. In southern Colorado the forest is much more mixed; Douglas-fir, white fir, southwestern white pine, ponderosa pine, and Engelmann spruce may vie for dominance in these middle-elevation forests.

Plant Finder 17: Douglas-fir Forest

(dominant species in bold type)

GRAMINOIDS	
Bromopsis porteri	nodding brome
Carex geyeri	**elk sedge**
Festuca arizonica	Arizona fescue
Koeleria macrantha	**prairie junegrass**
Leucopoa kingii	**spike fescue**
Muhlenbergia montana	mountain muhly
Poa nervosa	Wheeler bluegrass
FORBS	
Antennaria rosea	rosy pussytoes
Arnica cordifolia	heartleaf arnica
Artemisia franserioides	**ragweed sagebrush**
Campanula rotundifolia	**bluebell bellflower**
Cerastium strictum	mouseears chickweed
Geranium viscosissimum	sticky geranium
Mertensia lanceolata	prairie bluebells
Potentilla concinna	red cinquefoil
Senecio eremophilus* var. *kingii	**King's groundsel**
Solidago spathulata var. *neomexicana*	New Mexico goldenrod
TREES AND SHRUBS	
Abies concolor	**white fir (southern counties)**
Acer glabrum	Rocky Mountain maple
Amelanchier alnifolia	Saskatoon serviceberry
Arctostaphylos uva-ursi	**kinnikinnick**
Jamesia americana	cliffbush
Juniperus communis	**common juniper**
Juniperus scopulorum	**Rocky Mountain juniper**
Mahonia repens	**Oregon grape**
Paxistima myrsinites	boxleaf myrtle
Physocarpus monogynus	**mountain ninebark**

Plant Finder 17: Douglas-fir Forest

(dominant species in bold type)

TREES AND SHRUBS (continued)

Pinus ponderosa	**ponderosa pine**
Pinus strobiformis	southwestern white pine (southerncounties)
Pseudotsuga menziesii	**Douglas fir**
Ribes cereum	wax currant
Rosa woodsii	**Wood's rose**
Rubus deliciosus	delicious raspberry
Rubus idaeus	grayleaf red raspberry
Symphoricarpos rotundifolius	roundleaf snowberry

LODGEPOLE PINE FORESTS

In Colorado, lodgepole pine is an upper montane and subalpine species whose range overlaps that of Engelmann spruce and subalpine fir, except that lodgepole pine does not occur naturally west of the Sangre de Cristo Mountains and south of the Gunnison River (Crane 1982). In general lodgepole pine replaces Engelmann spruce and subalpine fir after catastrophic fires on dry sites, where it forms dense stands. Few herbaceous plants and shrubs are able to tolerate the deep shade of these "doghair thickets". Because lodgepole pine does not reproduce in the shade of existing forest, it usually gives way over time to spruce and fir. Lodgepole pine can persist indefinitely, however, on cold sites with thin, extremely dry soils.

Plant Finder 18: Lodgepole Pine Forest

(dominant species in bold type)

GRAMINOIDS	
Carex geyeri	**elk sedge**
Koeleria macrantha	prairie junegrass
Poa lettermanii	Letterman's bluegrass
Trisetum spicatum	spike trisetum
FORBS	
Arnica cordifolia	**heartleaf arnica**
Campanula rotundifolia	bluebell bellflower
Epilobium angustifolium	fireweed
Lupinus argenteus	silvery lupine
Potentilla diversifolia	varileaf cinquefoil
TREES AND SHRUBS	
Abies lasiocarpa	**subalpine fir**
Arctostaphylos uva-ursi	**kinnikinnick**
Juniperus communis	**common juniper**
Mahonia repens	**Oregon grape**
Picea engelmannii	**Engelmann spruce**
Pinus contorta	**lodgepole pine**
Pseudotsuga menziesii	Douglas fir
Rosa woodsii	Wood's rose
Salix scouleriana	**Scouler's willow**
Shepherdia canadensis	**russet buffaloberry**
Vaccinium myrtillus	**whortleberry**
Vaccinium scoparium	**grouse whortleberry**

ASPEN FORESTS

Aspen forests are distributed on moist deep soils and scattered shallow soils in all mountain zones except the alpine. At lower elevations, aspen forests reach into the upper foothills zone along ravines where conditions are cool and moist; in the montane and subalpine, aspen may form large groves on slopes and narrow borders on valley bottoms. Aspen are typically seral species that become established on sites disturbed by fires, floods, avalanches, landslides or human activity. Persistent aspen stands are found in northern Colorado, in South Park, and west of the continental divide. Moist aspen groves typically have a rich diversity and a dense cover of herbaceous and shrub species in the understory. Drier sites have a grassy understory of Thurber fescue, slender wheatgrass, and blue wild rye.

Plant Finder 19: Aspen Forest

(dominant species in bold type)

GRAMINOIDS	
Bromopsis porteri	nodding brome
Bromopsis pumpelliana	pumpelly brome
Carex geyeri	**elk sedge**
Elymus glaucus	blue wildrye
Elymus trachycaulus	slender wheatgrass
Festuca thurberi	**Thurber's fescue**
FORBS	
Achillea lanulosa	western yarrow
Agastache urticifolia	nettleleaf giant hyssop
Arnica cordifolia	heartleaf arnica
Aster engelmannii	Engelmann's aster
Delphinium barbeyi	**tall larkspur**
Galium boreale	northern bedstraw
Geranium richardsonii	**Richardson's geranium**
Heracleum sphondylium	cow parsnip
Lathyrus lanszwertii var. *leucanthus*	aspen peavine
Ligusticum porteri	**Porter's licoriceroot**
Osmorhiza chilensis	sweet cicely
Senecio serra	tall ragwort
Thalictrum fendleri	**Fendler's meadowrue**
Thermopsis montana	**golden banner**
Vicia americana	American vetch
TREES AND SHRUBS	
Amelanchier alnifolia	**Saskatoon serviceberry**
Juniperus communis	common juniper
Mahonia repens	Oregongrape
Populus tremuloides	**quaking aspen**
Prunus virginianus	**black chokecherry**
Rubacer parviflorus	thimbleberry
Symphoricarpos rotundifolius	**roundleaf snowberry**

ENGELMANN SPRUCE - SUBALPINE FIR FORESTS

Forests of Engelmann spruce and subalpine fir form extensive stands in the subalpine zone (9300-11,400 feet/2835-3475 m) of the Rocky Mountain region and extend down into the montane zone in cool ravines. These fairly homogeneous expanses of forest are occasionally interrupted by stands of lodgepole pine (in northern Colorado) or aspen, grasslands, meadows or wetlands. The understory in spruce-fir forests is often dense but with moderate to low diversity of vascular plants and relatively high diversity of non-vascular plants—mosses and lichens as well as various fungi involved with the decay of fallen wood. In the southern mountains, corkbark fir may occur with or replace subalpine fir.

Plant Finder 20: Engelmann Spruce - Subalpine Fir Forest

(dominant species in bold type)

GRAMINOIDS	
Bromopsis pumpelliana	pumpelly brome
Carex geyeri	**elk sedge**
Poa nervosa	Wheeler bluegrass
Poa reflexa	**nodding bluegrass**
FORBS	
Achillea lanulosa	western yarrow
Antennaria rosea	rosy pussytoes
Arnica cordifolia	**heartleaf arnica**
Campanula rotundifolia	bluebell bellflower
Epilobium angustifolium	**fireweed**
Galium boreale	northern bedstraw
Geranium richardsonii	**Richardson's geranium**
Pedicularis spp.	lousewort
Polemonium pulcherrimum* ssp. *delicatum	**Jacob's ladder**
Pyrola spp.	wintergreen
Solidago parryi	Parry's goldenrod
TREES AND SHRUBS	
Abies arizonica	**corkbark fir (southern Colorado)**
Abies lasiocarpa	**subalpine fir (northern Colorado)**
Lonicera involucrata	twinberry honeysuckle
Paxistima myrsinites	boxleaf myrtle
Picea engelmannii	**Engelmann spruce**
Pinus flexilis	limber pine
Ribes coloradense	Colorado currant
Ribes lacustre	prickly currant
Ribes montigenum	gooseberry currant
Ribes wolfii	Wolf's currant
Rubacer parviflorus	**thimbleberry**
Shepherdia canadensis	russet buffaloberry
Vaccinium myrtillus	**whortleberry**
Vaccinium scoparium	**grouse whortleberry**

ALPINE TUNDRA

Alpine tundra extends from treeline (approximately 11,400 feet/3475 m) to the mountain tops. The cold, extremely windy climate produces harsh growing conditions. As a result, plants are mostly small, low, perennial and adapted to a short growing season. Geomorphic processes (frost action, glaciation, mass wasting), snow retention, wind dessication and permafrost have produced soil and topographic conditions that vary considerably over short distances and strongly influence vegetation patterns. Plant communities, reflecting the underlying variations in environmental conditions, are arranged in a complex mosaic of closely interspersed types.

Tips for alpine projects

Due to the high elevation, harsh environmental conditions, and difficult access, planting in the alpine zone presents special complications.

- Short growing seasons and cold temperatures limit plant growth rates, slowing establishment and visible progress of revegetation.
- Few high altitude native plant materials are available from commercial suppliers.
- Very little information regarding the germination requirements of native high-altitude species is available. High altitude species are even less likely than lower altitude native species to conform to the desired "garden model" of rapid germination and vigorous establishment.

The severe environmental conditions of high elevations can devastate carefully acquired/propagated plant materials. Among the most harmful factors are wildlife browsing (including pocket gophers), summer freezes, snowmold and frost-heaving especially during spring when young seedlings trapped in a frozen surface soil layer are often ripped out of the ground by ice crystals growing from below.

- Below treeline and in the moister, less windy alpine communities, plants listed in the Plant Finders can perform well if seeded in the fall and provided with a durable mulch cover such as bonded fiber matrix or well-anchored excelsior or other organic mats.

- In moderately windy sites, establishment must be done via planting rather than seeding. Appropriate species for such sites are not ordinarily available (e.g., Bellardi kobresia *(Kobresia myosuroides)*, or blackroot sedge *(Carex elynoide*s)) and must be propagated by special order. Mulches in these sites must be more carefully applied than those in sheltered sites.

- In the most exposed alpine sites (fellfields), prospects of successful revegetation within a decade are small. Success is likely to result from custom propagation of fellfield native species, careful positioning relative to microtopography, and subtle use of microtopographic objects such as rocks to produce a moderate, but not overly protected microsite for the plantings.

For more information, see Proceedings of the High Altitude Revegetation Workshops, Willard 1972.

➲ In consideration of the difficulty of alpine revegetation, readers are strongly advised to avoid disturbing alpine areas whenever possible. For instance, if your project involves a trail, consider the possibility of using cairns rather than removing vegetation to build the trail. You should consult an experienced restoration specialist for alpine projects.

ALPINE MEADOWS

Alpine meadows are common on level to gently rolling sites with fairly deep, well-drained, fine-textured soils. Dry meadows (turfs) occur in areas where snow does not accumulate in the winter or melts early, typically on windward slopes and ridges. Meadows in more mesic areas are found on gentle slopes or in shallow basins.

Plant Finder 21: Mesic Alpine Meadows

(dominant species in bold type)

GRAMINOIDS

Carex norvegica	Norway sedge
Danthonia intermedia	timber oatgrass
Deschampsia cespitosa	**tufted hairgrass**
Elymus trachycaulus subsp. *andinus*	slender wheatgrass (alpine race)
Festuca brachyphylla	alpine fescue
Luzula spicata	spiked woodrush
Poa alpina	alpine bluegrass
Poa glauca	timberline bluegrass
Trisetum spicatum	spike trisetum

FORBS/SHRUBS

Achillea lanulosa	western yarrow
Agoseris glauca	wild dandelion
Aquilegia caerulea	Colorado blue columbine
Aquilegia saximontana	Rocky Mountain columbine
Artemisia arctica	arctic wormwood
Artemisia scopulorum	**alpine sagewort**
Aster foliaceous	alpine leafybract aster
Erigeron melanocephalus	blackhead fleabane
Erigeron simplex	onestem fleabane
Geum rossii* var. *turbinatum	**alpine avens**
Polygonum bistortoides	American bistort
Polygonum viviparum	alpine bistort
Hymenoxys grandiflora	graylocks hymenoxys
Penstemon whippleanus	Whipple's penstemon
Polemonium viscosum	sticky Jacob's ladder
Salix brachycarpa	barrenground willow
Salix arctica	**arctic willow**
Salix reticulata* ssp. *nivalis	**snow willow**
Sibbaldia procumbens	**creeping sibbaldia**
Solidago spathulata	alpine goldenrod
Trifolium dasyphyllum	**alpine clover**

Plant Finder 22: Dry Alpine Meadows

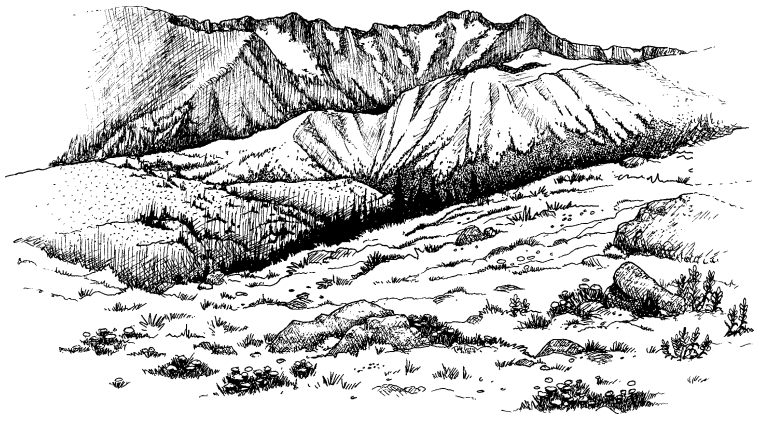
(dominant species in bold type)

GRAMINOIDS

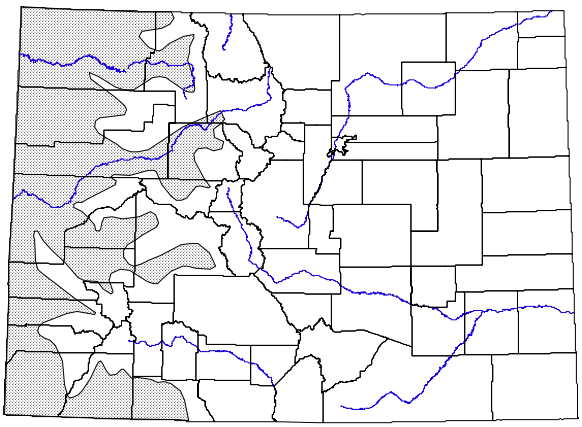
Carex elynoides	**blackroot sedge**
Carex rupestris	**Drummond sedge**
Danthonia intermedia	timber oatgrass
Elymus scribneri	spreading wheatgrass
Festuca brachyphylla	**Colorado fescue**
Kobresia myosuroides	**Bellardi kobresia**
Phleum commutatum	**alpine timothy**
Poa alpina	**alpine bluegrass**
Poa glauca	timberline bluegrass

FORBS

Campanula uniflora	arctic bellflower
Castilleja occidentalis	**western Indian paintbrush**
Claytonia megarhiza	**alpine springbeauty**
Dryas octopetala	mountain dryad
Erigeron pinnatisectus	featherleaf fleabane
Eritrichum aretioides	alpine forget-me-not
Hymenoxys grandiflora	old man of the mountain
Mertensia lanceolata	prairie bluebells
Oreoxis alpina	alpine oreoxis
Primula angustifolia	alpine primrose
Silene acaulis	**moss campion**
Thalictrum alpinum	alpine meadowrue



WESTERN PLATEAU AND CANYON REGION



DESCRIPTION – This region lies west of the Continental Divide and below 8,000 feet (2438 m). Like the Rocky Mountain region, it is geographically and vegetationally complex. The unifying theme in this region is the relatively flat-lying layers of sedimentary rocks forming extensive highlands. The Colorado River and its major tributaries (the San Juan, Dolores, White, Yampa and Gunnison rivers) have cut deep canyons into the layers of rock. The region shares floristic affinities with the Colorado Plateau, the San Juan Basin and the Uintah Basin regions of Arizona, Utah and New Mexico.

CLIMATE / SOIL – This region does not have a dominant precipitation season. Sixty percent of the annual precipitation occurs from October to April in the form of snow. The western plateau and canyon region receives very little summer precipitation, although some areas in southern Colorado are influenced by summer monsoon moisture from the southwest. Annual precipitation ranges from 6 to 18 inches (15-45 cm). Shallow and impermeable soils in many areas limit the effectiveness of the snow and rain that does fall.

TOPOGRAPHIC FEATURES – This region is distinguished from the Rocky Mountain and Eastern Plains and Foothills Regions by plateaus with more or less flat tops and very steep sides. Broad river valleys and deep, spectacular canyons frequently interrupt the generally level terrain. High escarpments such as the Vermilion Bluffs, the Book Cliffs and the Mesa Verde also provide topographic relief.

VEGETATION – The combination of dry climate and shallow, impermeable soils on slopes that are often steep imposes severe limitations on plant growth. The perennial vegetation of the region is generally very sparse, though weedy annuals can form a dense understory. Major communities include bunchgrass grasslands, saline bottomland shrublands, sagebrush shrublands, mixed mountain shrublands, and piñon-juniper and pine woodlands.

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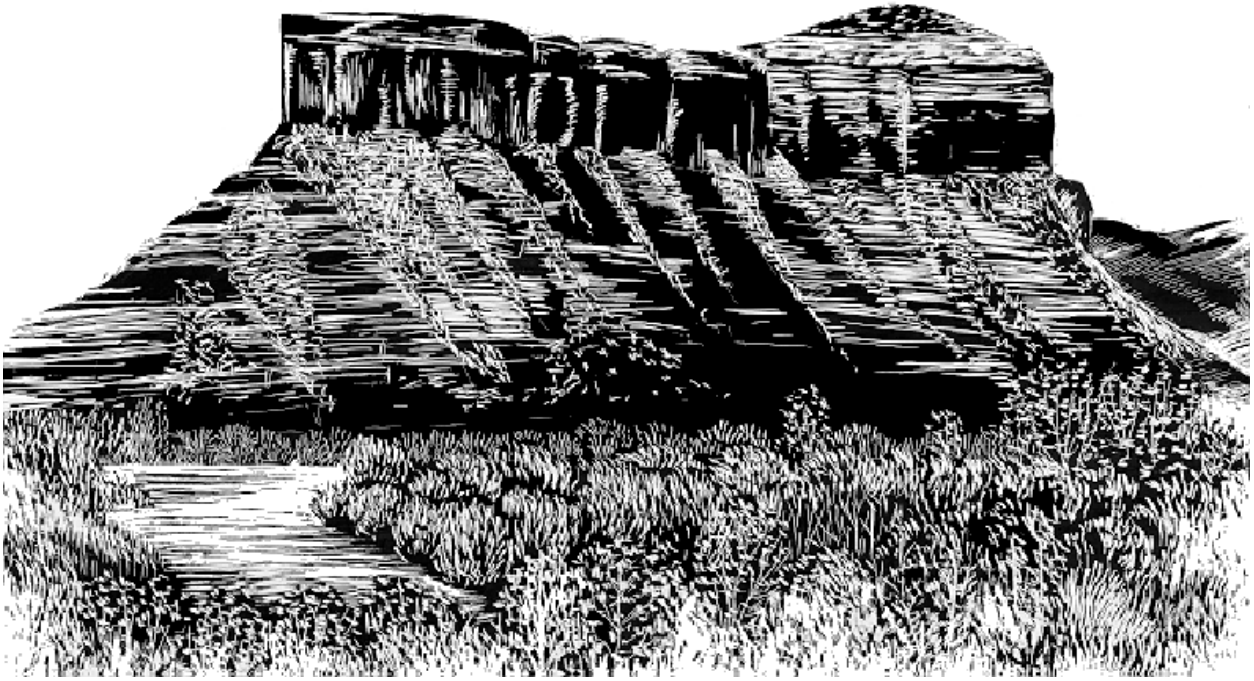


GRASSLANDS

Grasslands and meadows occur primarily on fine-grained or deep soils on moderate to low slopes or on steeply sloping sites, and may be small patches interspersed among shrubland, woodland or forest communities. These areas range from mesic to dry depending on soil characteristics and the availability of ground water.

Grasslands on rocky, windswept mesa sides above 6,500 feet (1981 m) are dominated by bunchgrasses, especially bluebunch wheatgrass, Indian ricegrass, and Junegrass. Shrub cover is generally minimal. Other grasslands typically occur on flat sandstone benches below 6,500 feet (1981 m). Galleta, Indian ricegrass, needleandthread grass, Indian ricegrass and blue grama are the most common species.

Notes on grassland projects

Depending on the degree of past disturbance, rehabilitation may be accomplished by removing grazing, introducing fire, interplanting native grasses and forbs, and/or removing aggressive nonnative plants.

Transplanting from the wild is difficult because many grassland plants have developed long, deep roots to promote survival during drought. Try salvaging plants from sites that are scheduled for development rather than trying to move plants from intact native grasslands.

Mow grasslands the first year after planting to prevent weeds from going to seed.

Western slope grasslands evolved without frequent fire or intense grazing. Burn these grasslands only often enough to prevent invasion by shrubs and trees.

For more information on grassland projects, see Brune 1991, Roundy et al. 1993, and Schramp 1978.

Plant Finder 23: Grasslands (West Slope)

(dominant species in bold type)

GRAMINOIDS

Agropyron spicatum	**bluebunch wheatgrass**
Agropyron spicatum* var. *inerme	**beardless bluebunch wheatgrass**
Bouteloua gracilis	blue grama
Hilaria jamesii	**galleta (southern Colorado)**
Koeleria macrantha	prairie junegrass
Leymus ambiguus	Colorado wildrye
Oryzopsis hymenoides	**Indian ricegrass**
Stipa comata	**needleandthread**
Stipa nelsonii	Nelson needlegrass

FORBS

Ipomopsis aggregata	skyrocket gilia
Lupinus brevicaulis	shortstem lupine
Oxytropis sericea	silvery locoweed
Phlox hoodii	spiny phlox

SHRUBS

Chrysothamnus viscidiflorus	green rabbitbrush
Gutierrezia sarothrae	broom snakeweed
Krascheninnikovia lanata	winterfat
Tetradymia canescens	**spineless horsebrush**
Yucca harrimaniae	Spanish bayonet

Bouteloua gracilis

SHRUBLANDS

Shrublands come in many kinds, but all have shrubs – multiple-stemmed, woody plants – as their dominant plants. Shrublands occur naturally in specialized habitats, often in areas too cold or too dry for trees but where soil conditions will support shrubs'deep root systems. Shrubs will also invade many types of grassland communities in the absence of fire or where grazing by wild and domestic animals has weakened the competitive ability of grasses. In western Colorado, shrubland communities separate out by elevation and soil type. The "adobe badlands" so common at the lowest elevations near Grand Junction and in the northwestern and southwestern corners of the state support mat saltbush shrublands. Greasewood and fourwing saltbush shrublands occur in alkaline depressions with clayey soils and a high water table ("flats") in the same areas. Deeper, coarser soils at middle elevations support sagebrush shrublands, and hillsides near lower treeline support mixed mountain shrubland communities.

Notes on shrubland projects

Shrublands may be considered transitional communities – possibly grasslands transitioning to forests in the absence of fire. There are several procedures to follow which will help the success of your restoration project.

Resist the tendency to remove all the rocks and boulders from the soil in which you want to grow your shrubland. Rocks on the surface of the soil concentrate rainfall around their margins and provide hospitable sites for moisture-hungry shrubs to grow. Subsurface rock also increases the available soil moisture at depth by allowing moisture percolation and concentrating it between rocks. Rocks without fine soil between them can be a problem since shrub roots have a hard time becoming established in very rocky soils. Total rock content of the soil should be between 5 and 20 percent with a sand or sandy loam matrix and up to 50 percent for a fine textured matrix.

Plant shrubs and forbs first. Grass competition must be restricted by use of mulch cloth or other techniques to protect young shrubs or forbs from often fatal competition with grasses.

Whenever possible, control weeds before planting to avoid damaging plantings with herbicide applications.

For more information on shrubland projects, see Barrow 1996 and Roundy et al. 1993.

MAT SALTBUSH SHRUBLANDS

Mat saltbush shrubland usually occurs on the driest sites below 6,000 feet (1829 m), usually on soils derived from shales of the Mancos and Green River formations. It is sometimes hard to recognize this community because the total vegetation cover often does not exceed 10 percent. The soils are heavy clays rich in calcium sulfate, selenium and sodium, and create conditions outside the tolerance limits of most plants. Gardner's and mat saltbush seem best adapted to these harsh growing conditions.

Plant Finder 24: Mat Saltbush Shrublands

(dominant species in bold type)

GRAMINOIDS	
Hilaria jamesii	**galleta (southern Colorado)**
Leymus salinus	saline wildrye
Oryzopsis hymenoides	**Indian ricegrass**
Sporobolus airoides	alkali sacaton
FORBS	
Gilia ophthalmoides	eyed gilia
Phacelia splendens	patch scorpionweed
Sphaeralcea coccinea	**scarlet globemallow**
Stanleya pinnata	**pinnate princesplume**
TREES AND SHRUBS	
Atriplex corrugata	**mat saltbush**
Atriplex gardneri	**Gardner's saltbush**
Frankenia jamesii	James' seaheath (southern Colorado)
Krascheninnikovia lanata	winterfat

SALINE BOTTOMLAND SHRUBLANDS

Saline bottomland shrubland usually occurs below 7,500 feet (2286 m); it is common on broad valley floors from Wyoming to the New Mexico border and west into Utah. On moist alkaline soils developed from stream deposits, greasewood forms pure stands. As alkalinity and depth of alluvium decrease, greasewood is found with shadscale and other saltbush species (Benedict 1991; Mutel and Emerick 1984). Shadscale saltbush is found primarily on elevated moderately coarse, moderately alkaline alluvium. Other species of saltbush, primarily Gardner's and mat, occur on more alkaline soils, often developed from shales.

Plant Finder 25: Greasewood Flats (West Slope)

(dominant species in bold type)

GRAMINOIDS	
Bouteloua gracilis	blue grama
Distichlis spicata	inland saltgrass

Plant Finder 25: Greasewood Flats (West Slope)

(dominant species in bold type)

GRAMINOIDS (continued)

Hordeum jubatum	foxtail barley
Leymus cinereus	**basin wildrye**
Muhlenbergia asperifolia	alkali muhly
Pascopyron smithii	western wheat
Puccinelia nuttaliana	Nuttall's alkaligrass
Sporobolus airoides	alkali sacaton

SHRUBS

Atriplex canescens	fourwing saltbush
Chrysothamnus nauseosus	**rubber rabbitbrush**
Chrysothamnus viscidiflorus	green rabbitbrush
Sarcobatus vermiculatus	**greasewood**

Plant Finder 26: Shadscale Shrublands

GRAMINOIDS

Hilaria jamesii	**galleta (southern Colorado)**
Leymus salinus	Salina wildrye
Muhlenbergia asperifolia	alkali muhly
Oryzopsis hymenoides	Indian ricegrass
Pascopyrum smithii	western wheatgrass (northwestern Colorado)
Sporobolus airoides	alkali sacaton

FORBS

Sphaeralcea cocinnea	scarlet globemallow
Stanleya pinnata	pinnate princesplume

TREES AND SHRUBS

Artemisia spinescens	bud sagebush
Atriplex canescens	fourwing saltbush
Atriplex confertifolia	shadscale saltbush
Atriplex gardneri	Gardner's saltbush
Krascheninnikovia lanata	winterfat
Sarcobatus vermiculatus	greasewood

SAGEBRUSH SHRUBLANDS

Sagebrush shrublands are one of the most extensive vegetation types in western Colorado. Two major types can be distinguished on the basis of elevation and soils.

BASIN BIG SAGEBRUSH

Basin big sagebrush shrublands occur at lower elevations on deep soils of floodplains and arroyos; they are especially well developed in the Piceance Basin. This type is dominated by big sagebrush (*Artemisia tridentata),* a tall shrub up to eight feet (2.5 m) in height. Understory vegetation tends to be sparse, but other shrub species are common associates.

Plant Finder 27: Basin Big Sagebrush (West Slope)

(dominant species in bold type)

GRAMINOIDS	
Bouteloua curtipendula	sideoats grama
Elymus elymoides	bottlebrush squirreltail
Hilaria jamesii	galleta (southern Colorado)
Leymus cinereus	**basin wildrye**
Oryzopsis hymenoides	Indian ricegrass
Pascopyrum smithii	**western wheatgrass**
Poa fendleriana	muttongrass
Poa secunda	Sandberg bluegrass
Sporobolus cryptandrus	**sand dropseed**
FORBS	
Arenaria hookeri	Hooker's sandwort
Balsamorhiza sagittata	arrowleaf balsamroot
Heterotheca villosa	hairy goldenaster
Gaillardia aristata	common gaillardia
Petradoria pumila	grassy rockgoldenrod
Tetraneuris ivesiana	Ive's fournerved daisy
TREES AND SHRUBS	
Artemisia tridentata* ssp. *tridentata	**big sagebrush**
Atriplex canescens	fourwing saltbush
Chrysothamnus nauseosus	**rubber rabbitbrush**
Sarcobatus vermiculatus	greasewood

MOUNTAIN BIG SAGEBRUSH

Mountain sagebrush communities occur at higher elevations and on shallower soils than Basin big sagebrush communities. Mountain big sagebrush is the dominant plant species of this type, but it may be replaced by black sagebrush at lower elevations on rocky soils or by alkali sagebrush on heavy clay soils. Mountain sagebrush communities may include a variety of shrubs and an abundance of wildflowers. This type is widespread in northwestern Colorado, the Gunnison Basin and Glade Park.

Plant Finder 28: Mountain Big Sagebrush (West Slope)

(dominant species in bold type)

GRAMINOIDS	
Agropyron spicatum	bluebunch wheatgrass
Bouteloua curtipendula	sideoats grama
Elymus trachycaulus	slender wheatgrass
Festuca saximontana	Rocky Mountain fescue
Hilaria jamesii	galleta (southern Colorado)
Koeleria macrantha	prairie junegrass
Oryzopsis hymenoides	**Indian ricegrass**
Pascopyrum smithii	western wheatgrass
Poa fendleriana	muttongrass
Poa secunda	Sandberg bluegrass
Stipa lettermanii	Letterman's needlegrass
FORBS	
Arenaria hookeri	Hooker's sandwort
Astragalus miser	timber milkvetch
Balsamorhiza sagittata	arrowleaf balsamroot
Delphinium nuttallianum	Nuttall's larkspur
Helianthella uniflora	onestem helianthella
Heterotheca villosa	hairy goldenaster
Lupinus caudatus	tailcup lupine
Penstemon caespitosus	mat penstemon
Phlox hoodii	spiny phlox
Tetraneuris acaulis	stemless hymenoxys
Wyethia amplexicaulis	mulesears wyethia
TREES AND SHRUBS	
Amelanchier utahensis	Utah serviceberry
Artemisis arbuscula ssp. *longiloba*	alkali sagebrush
Artemisia nova	**black sagebrush**
Artemisa tridentata ssp. *tridentata*	basin big sagebrush
Artemisia tridentata* ssp. *vaseyana	**mountain sagebrush**
Artemisia tridentata ssp.*wyomingensis*	Wyoming big sagebrush
Chrysothamnus viscidiflorus	**green rabbitbrush**
Prunus virginiana	black chokecherry
Purshia tridentata	antelope bitterbrush
Quercus gambelii	Gambel's oak
Symphoricarpos rotundifolius	**snowberry**
Tetradymia canescens	spineless horsebrush

MIXED MOUNTAIN SHRUBLAND

Mixed mountain shrublands occur at elevations between the piñon pine-juniper woodland and upper montane coniferous forest communities. The shrubland consists of Gambel's oak growing either in pure stands or with mountain mahogany, serviceberry and/or snowberry. The shrubs form a dense canopy restricting the understory to relatively few shade tolerant graminoids and forbs.

Plant Finder 29: Mixed Mountain Shrublands (West Slope)

(dominant species in bold type)

GRAMINOIDS	
Carex geyeri	**elk sedge**
Carex pensylvanica var. *heliophila*	sun sedge
Stipa nelsonii	Nelson's needlegrass
FORBS	
Lathyrus lanszwertii var. *leucanthus*	aspen peavine
Mertensia fusiformis	spindleroot bluebells
Petradoria pumila	grassy rockgoldenrod
Solidago missouriensis	Missouri goldenrod
Stenotus acaulis	stemless mock goldenweed
TREES AND SHRUBS	
Amelanchier alnifolia	**Saskatoon serviceberry**
Amelanchier utahensis	Utah serviceberry
Arctostaphylos patula	greenleaf manzanita (northwestern Colorado)
Arctostaphylos uva-ursi	kinnikinnick
Ceanothus martinii	Martin's ceanothus (northwestern Colorado)
Cercocarpus montanus	**true mountain mahogany**
Fendlera rupicola	cliff fendlerbush
Peraphyllum ramosissimum	squaw apple (southern counties)
Quercus gambelii	**Gambel's oak (southern counties)**
Rhus trilobata	skunkbush sumac
Symphoricarpos rotundifolius	**roundleaf snowberry**

WOODLANDS

Woodlands occur on rocky hillsides at middle elevations and often define lower treeline. They are characterized by having one or more species of small trees – Utah juniper, Rocky Mountain juniper or piñon pine – dominant in the topmost layer of vegetation. Because these trees require more moisture and deeper soils than shrubs or grasses do, woodland communities are restricted to rocky, mesic sites in draws and north-facing escarpments below 6,000 feet (1829 m), and dry slopes among ponderosa pine and Douglas-fir communities above 6,000 feet. Fire converts woodland communities to grasslands or shrublands; very old woodland communities are rare except in rocky areas which are protected from fire. Conversely, fire suppression over the past 150 years of settlement has resulted in the spread of piñon-juniper woodlands over vast areas of the West formerly occupied by grasslands and shrublands.

Notes on woodland projects

Woodland sites are similar to alpine sites in the challenges they present to revegetation project planners. The conditions are generally too dry and windy for plantings to succeed without special measures.

In moister, less windy sites, plants listed in the Plant Finder can perform well if seeded in the fall and provided with a durable mulch cover such as bonded fiber matrix or well-anchored excelsior mat.

In moderately windy sites, establishment must be done via planting rather than seeding. Mulches in these sites must be more carefully applied and must be better anchored than those in sheltered sites.

For more information on woodlands, see Shaw et al. 1994, Covington 1996, and Howell 1986.

PIÑON PINE-JUNIPER WOODLAND

Piñon pine-juniper woodland communities occur on shallow, rocky soils in warm, dry sites. They often occur on hillsides and mesa tops, and this community will invade sagebrush shrublands and Great Basin grasslands in the absence of fire. Gravelly substrates with high levels of calcium and alkaline salts provide the optimum growth medium (Mutel and Emerick 1984). Juniper tolerates drought and soil saturation better than piñon pine, so it is more abundant at lower elevations. Piñon pine is more cold tolerant and is more prevalent at higher elevations (Mutel and Emerick 1984). Understory species are less abundant where the woody overstory is dense, but the graminoid and forb flora is typically rich.

Plant Finder 30: Piñon Pine-Juniper Woodland (West Slope)

(dominant species in bold type)

GRAMINOIDS	
Agropyron spicatum	bluebunch wheatgrass
Bouteloua curtipendula	sideoats grama
Bouteloua gracilis	blue grama
Elymus elymoides	bottlebrush squirreltail
Hilaria jamesii	galleta (southern Colorado)
Leymus salinus	salina wildrye
Oryzopsis hymenoides	**Indian ricegrass**
Poa fendleriana	**muttongrass**
Poa secunda	**Sandberg bluegrass**
Stipa comata	needleandthread
FORBS	
Hymenopappus filifolius	thinleaf hymenopappus
Leucelene ericoides	**sand aster**
Petradoria pumila	**grassy rockgoldenrod**
Phlox longifolia	longleaf phlox
Solidago nemoralis	gray goldenrod
Stenotus armerioides	**thrift mock goldenweed**
Tetraneuris ivesiana	Ive's fournerved daisy
TREES AND SHRUBS	
Amelanchier utahensis	**Utah serviceberry**
Artemisia tridentata **ssp.** ***vaseyana***	mountain sagebrush
Brickellia californica	brickellbush
Cercocarpus intricatus	littleleaf mountain mahogany
Cercocarpus ledifolius	curlleaf mountain mahogany
Cercocarpus montanus	**true mountain mahogany**
Chrysothamnus viscidiflorus	green rabbitbrush
Juniperus osteosperma	**Utah juniper**
Lycium pallidum	pale wolfberry
Pinus edulis	**Piñon pine**
Purshia tridentata	antelope bitterbrush
Ribes cereum	wax currant
Symphoricarpos rotundifolius	roundleaf snowberry
Yucca baccata	banana yucca (southern counties)

PINE WOODLANDS

Pine woodlands are composed predominately of ponderosa pine. They typically consist of open stands on dry south-facing slopes with a shrub and herbaceous understory. These woodlands form the ecotone between the Rocky Mountain region and the Western Plateau and Canyon region, except in northwestern Colorado, where they are absent and replaced by pure stands of Douglas-fir and aspen. These communities are similar to the pine woodlands in the foothills east of the Rocky Mountain region.

Plant Finder 31: Pine Woodlands

(dominant species in bold type)

GRAMINOIDS

Blepharoneuron tricholepis	pine dropseed
Bouteloua gracilis	blue grama
Carex geyeri	**elk sedge**
Festuca arizonica	**Arizona fescue**
Festuca saximontana	Rocky Mountain fescue
Muhlenbergia montana	mountain muhly
Poa fendleriana	muttongrass
Poa secunda	Sandberg bluegrass
Stipa nelsonii	Nelson's needlegrass
Stipa pinetorum	pine needlegrass

FORBS

Antennaria rosea	rosy pussytoes
Artemisia ludoviciana	white sagebrush
Astragalus lonchocarpus	Hamilton's milkvetch
Brickellia grandiflora	tasselflower brickelbush
Campanula rotundifolia	bluebell bellflower
Gaillardia aristata	common gaillardia
Geranium caespitosum	pineywoods geranium
Ipomopsis aggregata	skyrocket gilia
Lotus wrightii	Wright's deervetch (southern counties)
Penstemon caespitosus	mat penstemon
Petradoria pumila	grassy rockgoldenrod

TREES AND SHRUBS

Arctostaphylos uva-ursi	**kinnikinnick**
Berberis fendleri	Colorado barberry
Ceanothus fendleri	Fendler's ceanothus
Juniperus communis	**common juniper**
Juniperus osteosperma	Utah juniper
Mahonia repens	**Oregon grape**
Paxistima myrsinites	boxleaf myrtle
Physocarpus monogynus	mountain ninebark
Pinus flexilis	limber pine
Pinus ponderosa	**ponderosa pine**
Pseudotsuga menziesii	Douglas-fir
Purshia tridentata	antelope bitterbrush
Quercus gambelii	**Gambel's oak**
Ribes inerme	whitestem gooseberry

REVEGETATION TECHNIQUES

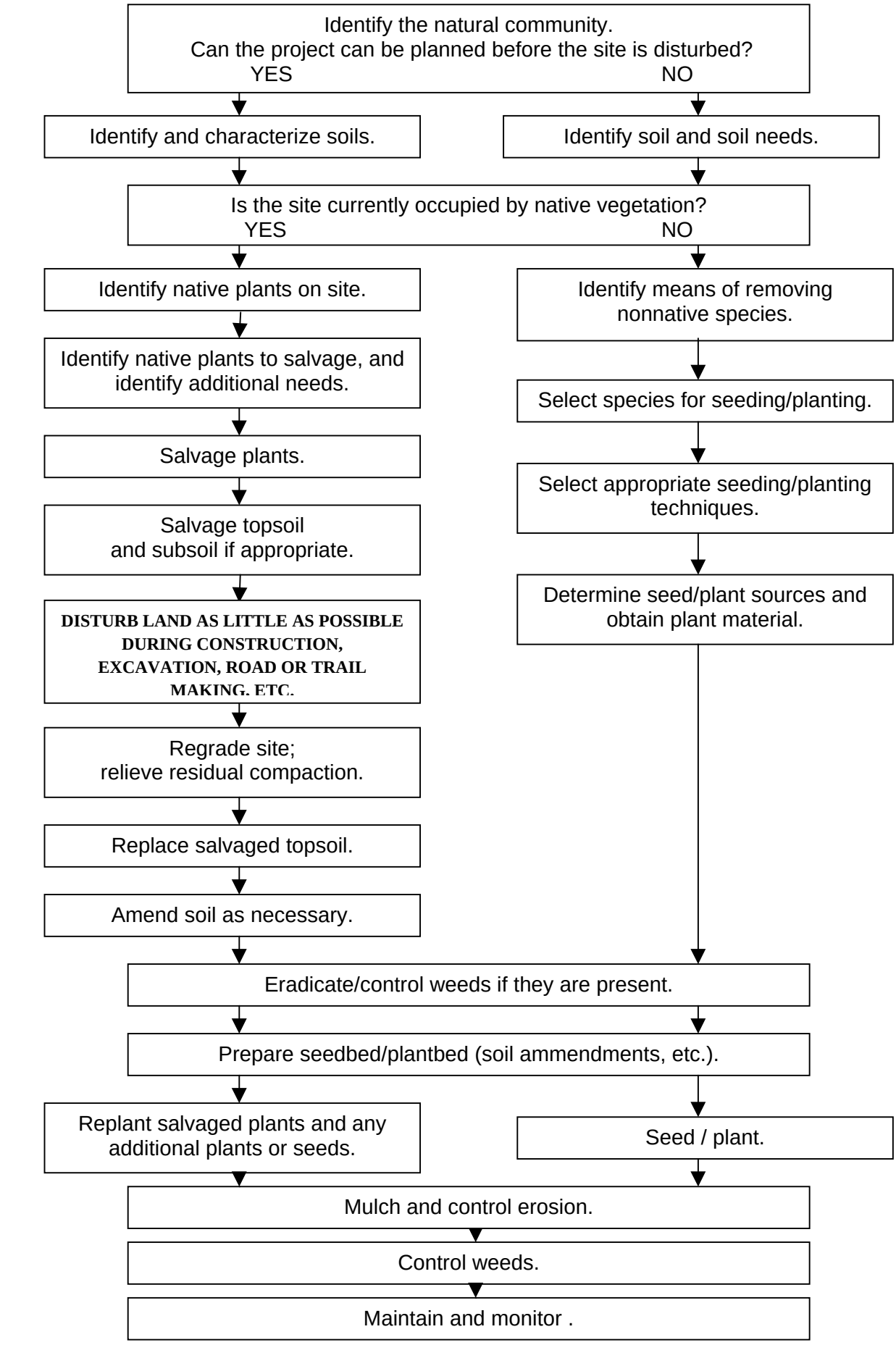
This section is divided into five steps:

WHEN TO CONSULT A PROFESSIONAL

The following sections will provide general guidelines for carrying out your project, however, this guide cannot include detailed information for every scenario. For large projects, or for those in particularly challenging environments, we advise working with experts. You may choose to work with a local resource agency or a private consultant. In either case, you should be as informed as possible about the techniques and plant species which will be used in your project.

STEP 1: PLANNING YOUR PROJECT

The flow-chart on the following page presents the steps which are required for successful completion of a revegetation project. The sequence will depend on the purpose of the project and the current condition of the site to be revegetated. The following sections provide more detailed information on each step.


Identify the natural community.
Can the project can be planned before the site is disturbed?
YES
NO
Identify and characterize soils.
Identify soil and soil needs.
Is the site currently occupied by native vegetation?
YES
NO
Identify native plants on site.
Identify native plants to salvage, and identify additional needs.
Salvage plants.
Salvage topsoil and subsoil if appropriate.
DISTURB LAND AS LITTLE AS POSSIBLE DURING CONSTRUCTION, EXCAVATION, ROAD OR TRAIL MAKING, ETC.
Regrade site; relieve residual compaction.
Replace salvaged topsoil.
Amend soil as necessary.
Identify means of removing nonnative species.
Select species for seeding/planting.
Select appropriate seeding/planting techniques.
Determine seed/plant sources and obtain plant material.
Eradicate/control weeds if they are present.
Prepare seedbed/plantbed (soil ammendments, etc.).
Replant salvaged plants and any additional plants or seeds.
Seed / plant.
Mulch and control erosion.
Control weeds.
Maintain and monitor .

STEP 2: SOIL CHARACTERIZATION

Soil is the medium for plant growth and is made up of minerals, dead organic matter, and living organisms such as soil microbes, mycorrhizae (the symbiotic association between specific fungi and the roots of some plants), worms, insects, and roots. Soils are often overlooked. However, an understanding of soil **texture, chemistry**, and **structure** is extremely important for successful reclamation.

➲ For small landscape projects, it is important to know the basic texture of the soil (clay, sand, loam, or a mixture), but it is rarely important to have laboratory tests made of soils on the site.

SOME SOIL TERMS:

Parent material is the rock from which soils are formed.

Subsoil is weathered parent material found beneath the soil layers. It is basically eroded rock and lacks the other elements, such as organic matter, that would make it suitable for plant growth.

Soil is made up of minerals (generally derived from the parent material), dead organic matter, and living organisms.

Topsoil refers to the uppermost layers of soil that include the most active biological components, nutrients and organic matter. If topsoil is missing, a site will be difficult to revegetate. In this case, amendments may be necessary to facilitate plant growth.

Amendments include organic matter and fertilizer or anything added to the soil or parent material to which will make it more suitable for plant growth (fertilizer is seldom used with native plants).

SOIL TEXTURE

Texture is determined by the size of the particles that make up the soil. Particles are divided into the three size categories: sand, silt, and clay. Sand is the largest particle, clay is the smallest. Soil types are based on the percentage of the soil composed of these particle sizes (Figure 3). For example, a soil that is 20 percent sand , 60 percent silt, and 20 percent clay is called a silty loam. Soil texture can be determined by using the flow chart in Figure 4.

Plants native to your site have evolved to survive in the local soils - even soils that might be considered “poor”. While some amendments may be required to aid in plant establishment, deep dark rich soil is not always the goal.

Texture influences how quickly water, nutrients and oxygen move into and through the soil as well as the quantity of water and nutrients a soil can hold (Table 1). In general, soils high in clay do not drain well. They retain nutrients but have a tendency to become waterlogged. Sandy soils drain well, but have low nutrient holding capacity. Loamy soils represent a balance between sand and clay and are preferred for agricultural use because they retain nutrients and also drain well. Adding organic matter to sandy soil can improve the nutrient and water holding capacity. The addition of organic matter to a clayey soil can improve water infiltration and percolation. Ultimately, the best solution is to choose plants adapted to the soil type.

Table 1: Soil Properties Dependent Upon Particle Size

Particle Type	Size (mm)	Water Retention	Nutrient Retention
Sand	0.05-2.0	Low water retention	Little to no nutrient retention
Silt	0.0002-0.05	Moderate water retention	Moderate nutrient retention
Clay	<0.002	High water retention	High nutrient retention

(Bradshaw and Chadwick 1980)

Figure 3: Soil Texture Triangle

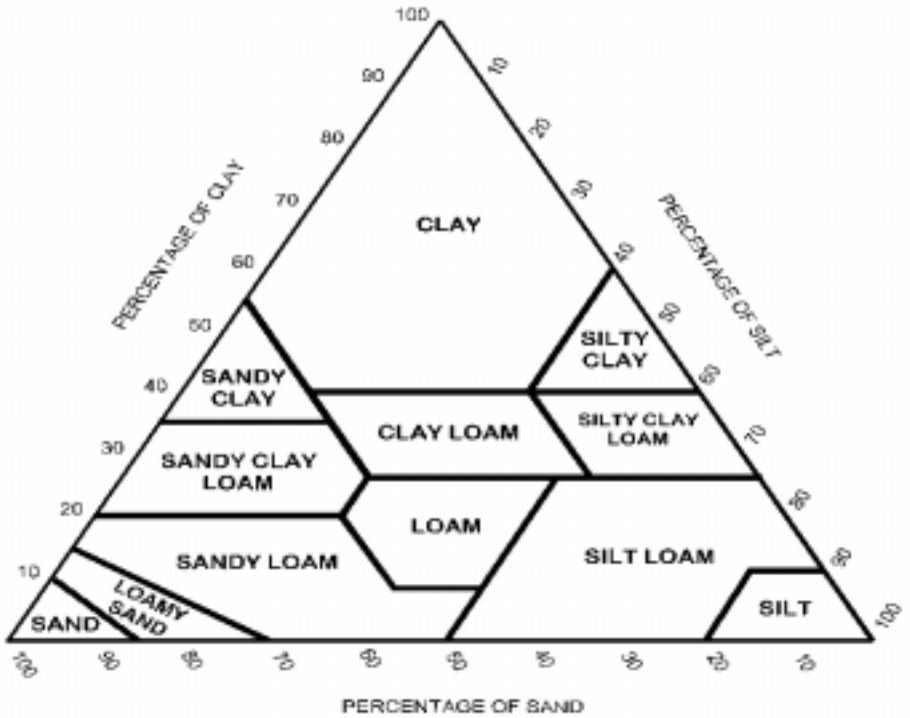
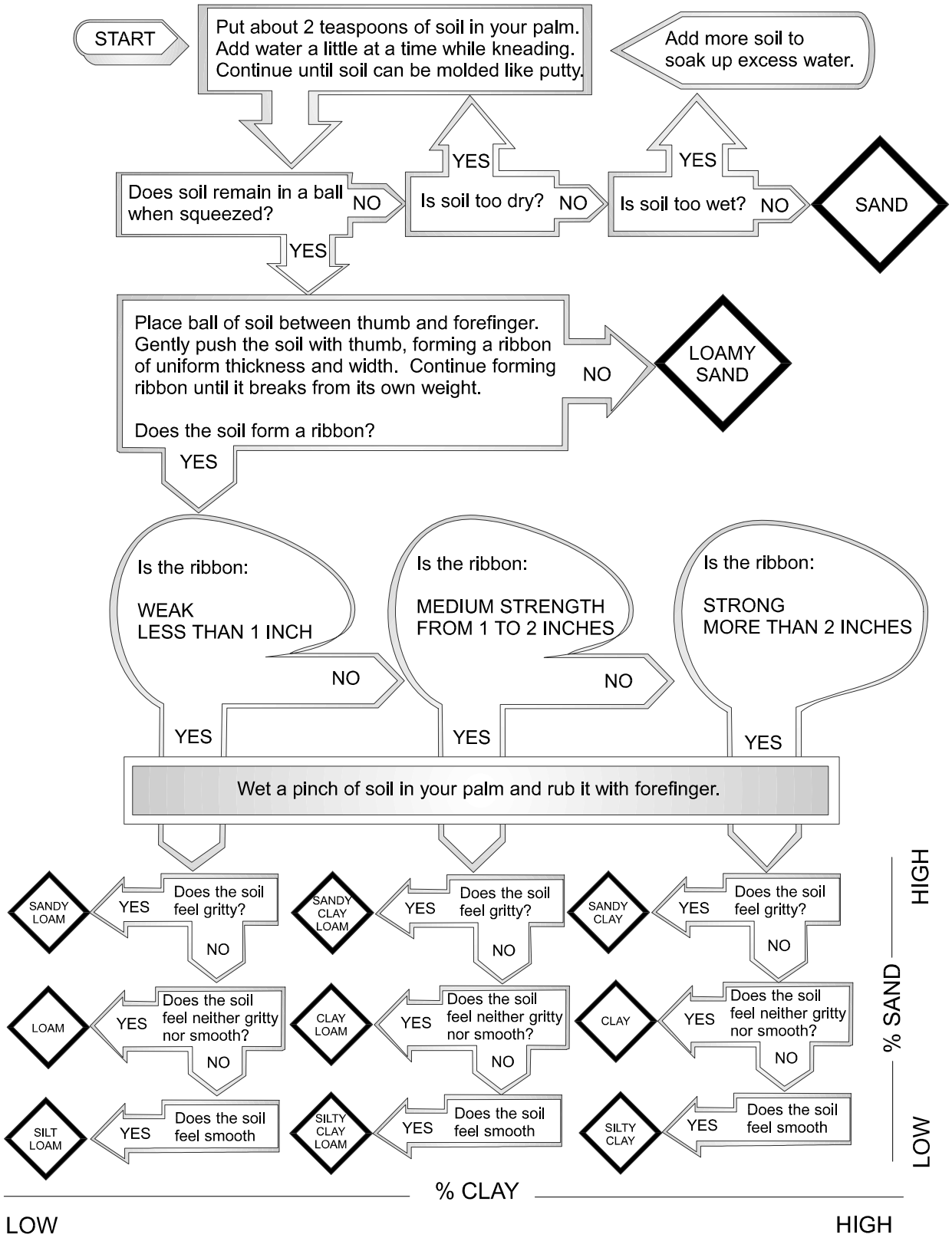


Figure 4: Flow Chart For Determining Soil Texture (after Thein 1979)



SOIL CHEMISTRY

Four chemical properties of soil should be considered before a revegetation project is implemented. These are **pH**, **electrical conductivity**, **sodium adsorption ratio** and **percent organic matter**. These chemical properties are important because they greatly influence the suitability of the soil for plant survival and growth. The easiest way to determine the chemical properties of a soil is to have it tested.

Soil tests are reasonably priced and worth the investment. A soil test will not only aid in the selection of species best suited for your site, but will also identify potential toxicity problems and suggest soil amendments. A basic soil test will provide information on the four soil properties listed above as well as give a more precise soil texture reading compared to what can be done in the field. A test can also give details on the macronutrients (nitrogen, phosphorus, and potassium) and micronutrients (copper, iron, magnesium, and zinc) present in the soil. In some cases, other tests may be necessary for measuring the quantities of salts and heavy metals, as well as other physical properties.

Any soil testing facility can provide specific directions on how to collect a soil sample for analysis at their lab, but we have included a general description of how it is done. Most labs will recommend a composite soil sample.

1. Collect several samples (5 to 20) from an area using a consistent sampling method, and mix them together to form a composite.
2. Take a sample from this composite.
3. Lable the sample with the date and location of collection and keep it on ice in a cooler or frozen until submitted to the laboratory.
4. Send the soil samples to the laboratory as soon as possible after collection to ensure accurate results.

You may make several composite samples representing different soil depths, but at least one composite sample should be taken from the soil surface, at a depth of 0 to 6 inches (0 to 15 cm). For small areas, testing one composite soil sample will be sufficient. For larger areas, several composite soil samples may be necessary. Samples may be removed with a soil corer or a shovel, as long as the sampling method is consistent and the tool is not contaminated with soil from another site. Although perhaps obvious, composited soils should be as similar as possible. If obvious soil differences are ignored, analysis of a composite sample will characterize an average or intermediate soil that does not exist.

Some laboratories offer assistance in interpreting test results. Recommendations given for soil amendments are usually based on agricultural standards, however, and may not always be applicable to native plant growth. The use of fertilizer will be discussed later in the manual, but in general, fertilizer should be used sparingly as native plants, unlike horticultural or agricultural plants, rarely require fertilizer. Table 2 on page 73 offers some guidelines for determining the quality of the topsoil based on the results of your soil test.

Table 2: Criteria To Establish Suitability Of Topsoil

SOIL PROPERTY	SUITABLE		MARGINAL TO POOR	UNSUITABLE†
	GOOD	FAIR*		
pH	6.0-8.4	5.5-6.0 and 8.4-8.8	5.0-5.5 and 8.8-9.0	<5.0 and >9.0
EC (electrical conductivity mmhos/cm soluble salts)	0-4	4-8	8-16 (EC >8 may prove difficult to revegetate)	>16
Texture	sandy loam loam silty loam sandy clay loam	clay loam silty clay loam sandy clay loamy sand	clay silty clay silt sand	
SAR (sodium adsorption ratio)	<6	6-10	10-15	>15
% Organic matter	>2	0.5-2	<0.5	

(Hansen et al. 1991)

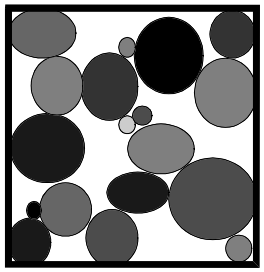
* Native species adapted to highly acidic (pH <6.0) or highly alkaline (pH >8.4) soil conditions should be used when possible instead of attempting to amend the soil. Using additives to change the pH can have complicating side effects and can be expensive. Some ecosystems in Colorado are naturally acidic (very few) or alkaline, and additives should not be used in the restoration of these areas.

† Specific methods to treat or revegetate problem soils that fall under the category of "unsuitable" in Table 2 are beyond the scope of this document, but have been discussed in other references. If a site is particularly challenging, consider consulting an expert.

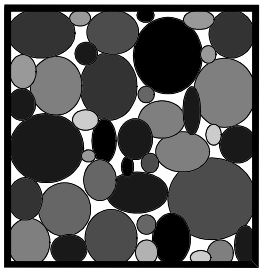
SOIL STRUCTURE

Soils are not usually just collections of loose soil particles; they are composed of clods, clumps and chunks of sand, silt and clay particles mixed with organic material, together with air spaces or pores. Soil structure refers to the relative quantities of air and solid matter in the soil as well as the size, shape and arrangement of these aggregations. Soil scientists use categories of structure to describe these aggregates. Quantitative measure of structure is roughly reflected in **bulk density** data.

Bulk density is the amount of solid material per unit volume (g/cm^3) in the soil. A soil with ideal growing conditions contains about 50 percent solid volume and 50 percent pore volume, with a bulk density of approximately 1.33 g/cm^3. A high bulk density translates to a greater degree of soil compaction and less developed structure.



Low bulk density



High bulk density

Soil compaction is the compression of soil particles. As soil compacts, particles move closer together and the soil volume has fewer air spaces. This is often the result of too many passes of heavy machinery or excessive foot traffic. Neither water nor roots can move readily into and through severely compacted soils. Seeds will sit on top of the soil and be vulnerable to wind, water, the sun's heat and hungry birds or ants.

Soil structure develops over time as the soil itself develops. A loss of soil structure reduces the ability of water to percolate and of air to move in and out of soils between the plant roots and the air spaces within the soil. The greatest danger to soil structure during a restoration project is soil compaction. This usually occurs when heavy equipment is driven over the soil too many times during the course of a project. With each pass, soil particles are compressed and air spaces are reduced. Compaction can also occur in small projects if many people repeatedly walk over the same area. Soil structure may also be damaged by improper seedbed preparation or poor topsoil salvage methods. Use the methods described in the **Site Preparation** section beginning on the next page to avoid destroying soil structure.

STEP 3: SITE PREPARATION

There are two paths one can take to prepare the soil for a restoration project. The path you choose depends on when the planning for the restoration project begins. If you can plan your restoration project before the disturbance and the site is currently occupied by native vegetation, then topsoil salvage is the best option. If land use activities have destroyed native vegetation and topsoils are damaged or absent, then the only option is the development of substitute soils (site conversion).

TOPSOIL SALVAGE

Remember, soil is essentially alive. Topsoil contains microbes, invertebrate animals such as worms and insects, fungi and bits of living plant material. Microbes, worms and insects aid in cycling soil nutrients, aerating the soil and maintaining the soil structure. These creatures are important. Many native plant species are strongly dependent on an association with certain fungi. If these fungi are lacking, the plants may be weakened and less able to compete with weeds. Living plant propagules within the soil, such as roots, tubers, and seeds, are a source of locally adapted native plants that are not available commercially.

> The goal of a topsoil salvage operation is to keep the soil alive, weed-free, and protected from damage until it can be returned to the restoration site for planting or seeding.

DEPTH OF TOPSOIL

For the purposes of salvage, topsoil is generally defined as the upper 6 to 12 inches (15 to 30 cm). Below this depth biological activity is usually limited. In some cases deeper subsoils are salvaged to increase the amount of material available for covering a larger area. **In these cases, separating the topsoil from the subsoil is recommended.** Lower soil materials should be stored separately and marked to distinguish them from the true topsoil. These subsoils should be respread first before the topsoil is placed as the uppermost layer. Subsoils should be treated carefully, but the importance of maintaining structure is not as critical as with topsoil.

WHEN TO SALVAGE

Topsoil should be salvaged when moist, but not wet. Salvage of wet soils, particularly those with fine texture, often severely damages or completely destroys soil structure. The result is a giant “mud pie” that may dry as a massive brick. Salvage of completely dry topsoil may also damage soil structure, though not as severely, and will result in nearly complete loss of living plant material.

STORING AND PROTECTING SALVAGED TOPSOIL

In general, it is best to avoid storing or stockpiling topsoil. If topsoil must be stored, do so as briefly and shallowly as possible. Follow these general guidelines:

- Topsoil should be stored less than one year and in a weed-free location.
- Make storage piles shallow (less than 2 feet is best) to leave more of the soil exposed to air. **Remember, soil is alive!**
- Soil stored for longer than a few weeks should be sown with a protective sterile cover crop.

➲ Deep piles are harmful to salvaged topsoil because the buried soil receives little oxygen and desirable soil organisms die soon after storage.

Examples of **sterile cover crops** are *Regreen* (sterile wheat X wheatgrass cross) or milo.

➲ Barley (*Hordeum vulgare*), wheat (*Triticum aestivum*), or rye (*Secale cereale*) should not be used as temporary cover crops unless they can be mown prior to seed maturity because they can reseed themselves and inhibit the germination of native perennials. Despite claims to the contrary, in some areas *Regreen* has reseeded itself. "Sterile" hybrids usually produce a small number of fertile plants.

RETURNING SOIL TO THE RESTORATION SITE

The manner in which the soil is returned to the site is just as important as the way it is salvaged and stored.

- Topsoil should be replaced with a minimum number of machine passes. "Sloppy work" mimics natural systems which have variable topsoil depths. Project supervisors should accept variability of topsoil depth in lieu of seeking very uniform topsoil thickness through extended machine work.
- Topsoil should be placed only when there is an assurance that the area will be seeded within a few days. Each day that the topsoil remains bare gives weedy species a chance to invade the site and allows erosion from wind and rain. This makes establishment of perennial native species much more difficult.
- If topsoil is imported from another location, the source should be carefully and thoroughly inspected for noxious weeds and undesirable plants and rejected if weeds are found.

DEVELOPMENT OF SUBSTITUTE SOIL

The following guidelines should be used when native vegetation has been absent for the past few years or the soil has been covered by undesirable species. Undesirable species may include exotic invasive weeds or plants purposely introduced, such as forage grasses, nonnative landscaping plants, or agricultural crops.

➲ **Controlling these undesirable plants is the single most important action you can take to increase survival of native species.**

Because weed control is such an important aspect of revegetation, this manual includes a separate section on the topic beginning on page 107. We also recommend that a weed specialist be consulted whenever possible.

There are three general approaches to dealing with a weedy situation:

1. If topsoil is present, eradicate or control undesirable plants, then prepare existing surface soil for seeding or planting.
2. If topsoil is absent, eradicate or control undesirable plants, then import topsoil from another location or commercial source or amend the existing soil material.
3. For sites severely infested with perennial weeds, disposal of the topmost soil could be desirable if elimination of weedy species is not feasible. This alternative could be very expensive and should only be considered if subsoils are of at least moderate quality. Remember, when a weedy plant spreads by rhizomes, the rhizomes often penetrate many feet into the soil and will persist if only a foot or two of soil is removed.

SEEDBED PREPARATION

A well-prepared seedbed is a critical step in a successful restoration project. Seedbed preparation refers to the physical operations necessary to prepare the soil for seeding. There are two extremes to contend with when preparing the seedbed: soil that is too firm (compacted) and soil that is too loose (which can lead to erosion or improper depth of seeding when using a seed drill). An ideal seedbed is midway between these two conditions. Your seedbed should be

- Firm enough so the seed will be in contact with the soil, and the soil will not be easily washed or blown away.
- Loose enough for the seed sprout to penetrate the soil.

All site preparation methods should be done on the contour (across the slope) to prevent soil erosion from surface water runoff.

To alleviate soil compaction the following methods may be used.

SCARIFICATION

Scarification is a form of ripping or chiseling, and consists of breaking up the topsoil aggregates by means of raking the soil surface with a set of sharp teeth. Implements with ripper shanks can be pulled with almost any kind of motorized vehicle, but farm tractors, road graders and tracked bulldozers are recommended because they have sufficient horsepower to accomplish this task. The soil surface can be ripped down to 12 inches (30 cm), but subsoil sweeps should be used with caution as these devices can add to compaction problems in the soil zone immediately below the blade. For large projects in which topsoil has been removed, chiseling or ripping of subsoils to a depth of 6 to 12 inches (15 to 30 cm) prior to replacing the topsoil is recommended

➲ While soil ripping may be beneficial for preparing the seedbed, each episode of such treatment reduces soil moisture (Cotts et al. 1991); however, greater water infiltration from subsequent rains can also be expected.

TILLAGE

At its most basic, tillage is any process which involves cutting through and turning over the soil. Tillage may be used to relieve both soil compaction and to control undesired plants. Plants can be plowed under so that their roots are exposed to the sun to die.

- This method should not be used on undesirable rhizomatous plants because tilling can spread rhizomes. Tillage should also not be used on sites that have high soil erosion potential, such as on slopes or fine textured soils.
- Disc plows are often very harmful to soil structure and should not be used as a means of relieving compaction. However, in cases where the soil surface is dominated by coarse clods (as may occur if it is worked while wet), discing can be effective in reducing clods.

HARROWING OR RAKING

Harrowing or raking is a secondary tillage operation which uses a spiked or toothed cultivating implement to roughen the soil surface uniformly. This method is generally employed to break up crusts or to lightly cover seeds. Harrowing/raking should almost always be used immediately prior to and immediately following broadcast seeding.

SOIL AMENDMENTS

Soil amendments are materials added to the soil to alter or enhance its physical or chemical properties.

NITROGEN FERTILIZERS

Nitrogen fertilizer should be used sparingly or not at all; excess applications can be detrimental to a restoration project. It should only be used where a soil test has revealed a gross deficiency of nitrogen. Test results can be compared with those from a similar intact community as a baseline indicator of natural nutrient levels. One strategy for determining if application of nitrogen fertilizer is appropriate is to wait until the next growing season and look for evidence of severe nitrogen deficiency. Signs of nitrogen deficiency include stunted growth and yellowish color. Fertilizer can then be applied in limited amounts to deficient areas only. Projects lacking topsoil will be the most deficient in soil nutrients and may require some type of fertilizer input.

- Indiscriminate use of nitrogen fertilizer can “burn” young native plant seedlings. Most native plants in Colorado have evolved to thrive in low nutrient soils and will not benefit from high doses of nitrogen nearly as much as will competing nonnative weeds.

- Nitrogen fertilizer can also encourage heavy weed growth. Most introduced weeds and agricultural species are very opportunistic users of nitrogen. Excess amounts of fertilizer can result in a flush of rapidly growing invasive weeds that overwhelm slower growing native species. Some weeds, such as Russian-thistle or kochia, will flourish under the slightest application of nitrogen. In time, as nitrogen is used up or leached out of the soil, these weeds will decrease in abundance; however, in some cases this process may take many years.

Where fertilizer use is appropriate, a low level or **slow release fertilizer** is suggested for the growth of native plants. **Organic fertilizers** are good since they provide macronutrients (nitrogen, phosphorus, and potassium), micronutrients (copper, iron, manganese, zinc) and organic matter to the soil or substrate.

Examples of organic fertilizers include:

- Compost
- Biosolids (sewage sludge)
- Mushroom compost
- Animal waste (i.e. manure)
- Biosol, a byproduct of penicillin production which can be purchased in granular form like chemical fertilizers

Biosol Manufacturer
Bio Resource Management
PO Box 320
Gypsum, Colorado 81637
970-524-9897
FAX: 970-524-1363

Note: This information does not constitute endorsement of this product by the State of Colorado.

PHOSPHORUS

Colorado soils typically have low phosphorus levels and native plant requirements for phosphorus are small. For soils low in this nutrient, amending soils with phosphorus can be beneficial for seed germination and plant growth. Phosphorus applications must be mixed into the soil. A one-time application is sufficient since phosphorus is not easily leached out of the soil like nitrogen. Triple superphosphate (P_2O_5 with an N-P-K of 0-46-0) is the form of phosphorus most commonly used. A soil test can determine if phosphorus is needed in your soil, but be aware that there are currently no accepted guidelines for the phosphorus requirements of native species.

OTHER SOIL AMENDMENTS

Other amendments may include wood chips, sawdust, or microorganisms. Each of these amendments has its advantages and drawbacks.

Wood Chips And Sawdust

Wood chips and sawdust are carbon rich mulches that can aid in erosion control, soil moisture conservation and temperature regulation; however, these mulches can also inhibit seed germination and plant growth. Such growth inhibition is due to the decomposing action of soil microorganisms that use the nitrogen which otherwise would be available to the plants. Over time the soil nitrogen is depleted. Because wood chips and sawdust have this effect on the soil, they are often used as landscape area mulches and are effective in controlling weed growth. Nonnative weedy plant species need available nitrogen in the soil to persist. If the amount of available nitrogen is suppressed, weed growth will be reduced. This method of weed control can be very successful in an area where established native plants are growing under a cover of nonnative species.

Microorganisms

Soil microorganisms are important for nutrient cycling; they process mulch and dead plant material into a form that is available for plant uptake. If these belowground organisms are not re-established, the aboveground plant communities will not become established.

One type of soil microorganism that is especially crucial for the establishment of native plants in our semiarid ecosystems is mycorrhizal fungus. A mycorrhiza is the symbiotic (mutually beneficial) association between a plant root and a specific type of fungus. The fungus aids the plant in the uptake of soil nutrients and water, and receives carbohydrates from the plant in return. Many native Colorado plants that thrive in dry environments and low nutrient soils have mycorrhizae.

The most abundant mycorrhiza, vesicular-arbuscular (VA) mycorrhiza, increases drought tolerance and plant growth where water and nutrients are lacking. Unlike ectomycorrhizal fungi, which are used to inoculate trees for reforestation, there are no wide scale methods for the inoculation of VA mycorrhizal fungi.

There are three ways of adding these beneficial microorganisms into your restoration site.

1. The preferred method is salvaging the topsoil and following the advice given earlier for keeping it alive.
2. If topsoil is not available, adding organic matter can increase soil microorganisms and mycorrhizal development in the restoration site (Fresquez et al. 1982). One way to accomplish this may be to collect the top litter layer (decomposing dead plants) from a nearby, weed-free native plant community and work it into the topsoil of the project site.
3. Another strategy is to plant shrubs or clumps of other large plants that will capture topsoil and mycorrhizal spores transported by the wind.

Certain native plants are known to fix nitrogen in association with a bacterium. These are mostly legumes such as lupine (*Lupinus* spp.) or sweetvetch (*Hedysarum boreale*). They can be planted to enhance soil nitrogen levels.

STEP 4: SEEDING AND PLANTING

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

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

SEEDING

Seeding is one of the most commonly used techniques for establishing native plants because it is usually the most cost-effective. However, the establishment of seeded plant stands can be difficult. Patience and experience are normally required for success. Expect to wait three to five years before seeing significant results of a seeding project. Whenever possible, seeding should be used with planting, described later in this section.

Before planning a seeding operation, answer the following questions:

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

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

The variability of the soil and site conditions means that it is not possible to provide only one set of guidelines. Variation in soil, elevation, site exposure and climate may make establishment difficult. Plant establishment is more likely to be successful if locally adapted species are

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

COLLECTING SEED

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

GENERAL GUIDELINES FOR COLLECTING SEED

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

HARVESTING AND PROCESSING

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

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

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

Dry bags of collected seedheads in the sun for about a week with bags placed about two feet (0.5 m) apart, stirring every few days; or dry in a protected area indoors or outside, by spreading plant material in a thin layer on tarps, screens, wood or cardboard. Dry in a sunny area if the temperature is not over 90° F (32° C). Bring the seed under cover on moist or cool nights and cover with screens if needed to protect from losses by wind or birds.

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

PURCHASING SEED

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

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

- Plan seed orders early, at least 120 days prior to the planting time. This will allow sufficient time to design a seed mix that will perform properly and to check for availability and price.
- Buy seed approximately 90 days prior to planned use. This will allow enough time to examine the seed tags and the seed.
- Check the seed tags and bag labels to verify you are receiving what you ordered. Seed quality can be improved dramatically by requesting certified seed. *How do you know that you are receiving the variety that you ordered?* The only way to tell for certain is to **receive your desired variety in the original bag with the Certified Seed Blue Tag.**

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

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

BUYING PREMIXED VERSUS MIXING YOUR OWN

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

- ➲ If Blue Tagged Certified Seed is specified in the mix, there is no way to assure that certified seed will be used. The buyer should ask for the blue tags removed from the bags of certified seed used in the mix.
- ➲ The expensive component in the mix may actually be reduced while the cheaper component may be increased.
- ➲ Lower quality, weedy lots can be blended into the mix.

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

SEED CERTIFICATION

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

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

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

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

- An accepted practice in the seed industry is to label seed as "Variety Not Stated (VNS)" when the source is not known or where there is an oversupply of a particular variety. Some suppliers, however, have informed their customers that VNS seed is an elite type, but can not be labeled as such because of marketing restrictions. The supplier may sell this seed for a higher price than "Common Class" but less than the actual certified variety. Seed sold in this manner should be purchased as common since there is no proof as to its origin.
- Seed is not certified unless there is a tag attached to the seed bag that clearly states: Certified Seed (Blue Tag) or Source Identified Seed (Yellow Tag). Do not be misled by suppliers who state that the "seed came from a certified field," or "we don't have the tags yet," or "it's just as good as certified." Plain and simple, **bags of certified seed have certified seed tags.**

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

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

SPECIAL CONSIDERATIONS

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

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

"Substandard" Notation

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

ANALYSIS LABELS

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

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

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

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

Association of Official Seed Certification Analysts (AOSCA) approved seed testing laboratory.

c) **Weed Seed**: The analysis should indicate that no noxious weed seeds are present (see Appendix III, page 227). The name and number of seeds per pound of any restricted weeds must be listed on the label. In Colorado the number of restricted weed seeds allowed varies by certification class and species. The general grass seed standards for Colorado are the following:

Table 3: General Grass Seed Standards For Colorado

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

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

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

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

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

Total germination may be given as a percent followed by "TZ", which means that a staining technique with tetrazolium chloride was used to evaluate seed viability. While this technique can be an acceptable substitute for a germination test, it provides no information about the percentage of hard or dormant seed present. In addition, a TZ test

is only as good as the experience of the analyst who administers the test. There are many variables that can give a positive or negative TZ viability indication.

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

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

How To Use PLS

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

TESTING SEED

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

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

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

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

General Procedure For Securing a Sample For Testing

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

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

Size Of Submitted Sample

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

Seed Testing Laboratories

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

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

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

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

SEEDING TECHNIQUES

TIME OF SEEDING

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

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

It is important to seed a site as soon as final grading and topsoil placement have occurred to minimize erosion and weed establishment on the project. During periods of time when seeding cannot be accomplished, soils should not remain unprotected. See the Site Preparation section (beginning on page 75) for suggestions on how to accomplish this.

SEEDING METHODS

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

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

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

Drill Seeding

- Proven high revegetation rates.
- Most successful on slopes 3:1 or flatter.
- Preferred because seed depths and seeding rates can be more closely controlled.
- Seed-soil contact is high, which maximizes germination results.
- ➲ Drill seeding cannot be accomplished where soils are extremely rocky or slopes are steep.
- ➲ Unless specially modified drills are used, all seeds, regardless of size, will be planted at the same depth; the smallest seeds are likely to be planted too deep.
- ➲ Seeds drilled in rows may suffer from high interseedling competition.
- ➲ Drill seeding leaves “rows” which often persist for many years (or even decades on dry sites); this may be a visual or aesthetic liability.

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

- Multiple seed boxes for different types of seed (agitators and picker wheels in at least one box for fluffy seed).

- Double disc furrow openers
- Intact depth bands with functioning scrapers on all disc openers to ensure consistent, uniform seed depth placement
- Seed tubes, which drop between disc openers, large enough to handle fluffy seed
- Packer wheels with adjustable tension, to provide proper soil compaction over and adjacent to the seed
- Coulter wheels to allow penetration of furrow openers where seeding into heavy mulch or cover crop.

Tips For Drill Seeding

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

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

Broadcast Seeding

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

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

Tips For Broadcast Seeding

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

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

Hydroseeding

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

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

Tips For Hydroseeding

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

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

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

POST SEEDING TECHNIQUES

After seeding, most sites will benefit from placement of a protective mulch cover. Such covers protect soil and seeds from erosion by wind and water, and conserve soil moisture from the effects of wind and sun. To be effective, mulches must cover the ground nearly completely and have sufficient durability to survive until the seeds germinate.

MULCH TYPES

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

Hay

- ❖ These materials are often relatively inexpensive to apply.
- ❖ Native grass hay may be available in some areas.
- ➲ May introduce undesirable weeds or nonnatives that will destroy carefully planned and acquired native plantings.
- ➲ Weed content of such material must be very carefully monitored and controlled by inspection and certification as required in project specifications.

- Straw is often used for this purpose, but the almost inevitable inclusion of grain seed in straw materials makes the use of straw highly inadvisable because of the competition that results from germinating grain plants.
- Do not use hay of nonnative species such as smooth brome that may germinate and compete with seeded natives.

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

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

Tips For Using Hay Mulch

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

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

Planted Stubble Mulch Crops

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

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

Tips For Planted Stubble Mulch Crops

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

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

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

Hydromulch

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

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

Tips For Using Hydromulch

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

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

Bonded Fiber Matrix

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

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

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

Tip For Using Bonded Fiber Matrix

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

Erosion Control Mats or Blankets

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

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

Appendix VI (on page 253) lists erosion control products and suppliers.

Tips For using Erosion Control Mats

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

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

PLANTING

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

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

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

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

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

➲ Be aware that nursery stock is costly, and that a successful project will require additional effort and investment to protect planted stock from both wildlife predation and competition from other vegetation (see Protection of Plantings on page 98).

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

PLANT MATERIALS

BAREROOT AND CONTAINERIZED

Bareroot and containerized plants are common types of transplant stock usually purchased from a nursery. If you are purchasing plant materials from a commercial supplier, the decision to use bareroot or containerized stock should be based on the information summarized in Table 4 below.

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

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

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

Ideal ages of containerized stock

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

Table 4: Bareroot vs Containerized Planting Stock

	Bareroot	**Containerized**
Species types	Shallow root systems	Deeper or tap-rooted systems
Processing and planting	Require greater care and planning during shipping, storage, handling, and planting.	Shorter production periods and increased survival after transplanting due to less root disturbance during processing.
	Require irrigated or moist soils.	Perform better on adverse sites, especially in rocky or high-stress areas.
Processing and planting	Lack the advantage of being established with their own soil.	Established with their own soil to which beneficial amendments can be added before planting at the site.
Scheduling	Must be either harvested in late fall, after the onset of dormancy, and held over the winter in cold storage or harvested early in the spring, before the onset of leaf emergence, and directly planted to the field.	Can be established during the spring or fall or any other time of the year when there is adequate moisture and favorable site conditions.
	The time from nursery establishment to lifting varies from approximately 1 to 3 years.	The time from nursery establishment to lifting averages less than 2 years.
Cost	Cost less and, as a consequence of their relatively lighter weight, are less expensive to ship.	More expensive to produce and ship.

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

Ordering And Delivery

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

Upon receipt, all containerized stock should be examined to ensure

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

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

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

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

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

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

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

Protection of Plantings

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

SALVAGE

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

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

Acquiring Salvaged Plants

There are several ways to obtain salvaged plant material.

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

What To Salvage

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

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

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

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

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

When To Salvage

The ideal time to salvage plants is from October to April. Plants can be salvaged at other times of the year if one-third to two-thirds of the plant is cut back and a good rootball is saved and kept moist. A typical salvage day might consist of digging up plants in the morning and transplanting on another site or potting the plants in the afternoon.

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

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

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

CUTTINGS

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

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

SOD

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

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

PLANTING TECHNIQUES

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

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

STORAGE

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

- Heeling-in must be done in such a manner as to ensure good soil coverage and protection from moisture loss. Roots should be adequately covered with soil to the root stem, tamped-in, and immediately watered (Townsend et al. 1993).
- All materials should be stored in a fenced area which minimizes the chances for damage from humans, birds or animals and should be adequately watered and protected from excess sun, wind and cold.
- Transplanting stock should be checked daily for moisture, cold-tolerance, insect or animal damage, and disease.
- With proper timing, most deciduous species can be safely stored for more than 90 days.
- Plants which are stored for extended periods should have adequate root ventilation to minimize heat build-up from respiration (Townsend et al. 1993, Shaw 1984, Ostler and Allred 1987, Landis and Simonich 1984).

- Fall-lifted bareroot transplants can be over-wintered in an appropriate cold storage facility. Proper cold storage involves over-wintering dormant transplants between 34° and 40° Fahrenheit (1°- 4° C) and at approximately 86 percent relative humidity.

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

WATERING

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

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

PLANTING

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

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

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

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

Planting On Steep Slopes

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

A Note About Fertilizer

Test the soil from the planting site before adding any amendments. Once you have determined the actual site nutrient conditions, compare these conditions with those considered optimum, if that information exists for the species involved. The available literature differs on its opinions concerning fertilizer use at the time of transplanting. Ostler and Allred (1987) state that Osmocote tablets, a commercial slow-release fertilizer, should be included at the bottom of the transplanting hole to assist with establishment. Wallace (1987) and Mandel (personal communication) report that many native species, especially those with increased drought tolerance, react adversely to fertilizer use at the time of establishment. With such species, even mild fertilization can cause root-dieback and shoot burning. It is also an excellent idea to consult with a nursery, a plant ecologist, or the Natural Resource Conservation Service (NRCS) in order to determine the specific requirements (Wallace 1987, R. Mandel, personal communication).

STEP 5: MONITORING & STEWARDSHIP

The objective of monitoring is to identify problems that could prevent or interfere with a successful outcome of the project. The goal of stewardship is to ensure that site management alleviates these problems and maintains desired site conditions. The fact that restoration projects are resource intensive in the early stages makes it easy to overlook the potential ongoing costs of monitoring and stewardship. Landowners and managers often commit most of their financial resources to planning a project, procuring the equipment and plant materials, and planting the area. Frequently, little thought is given to the wide variety of problems that can arise after the last seed is sown or shrub is planted, and this oversight can lead to project failure. Monitoring and stewardship are indispensable and cost-effective components of revegetation projects, without which a potentially successful project can deteriorate into a patch of noxious weeds or an eroded gully. For more specific information on evaluating project success, see Chambers and Wade (1990).

MONITORING

If a restored site is never monitored once the initial work has been completed, there is no assurance that the final landscape will match the landowner's vision for the area, and no chance to learn from the results. Successful monitoring should include

- Awareness of potential problems.
- Use of monitoring techniques and frequencies appropriate to the site.
- Detailed summary of information gathered through monitoring, as an aid to the preparation of stewardship plans.
- Means to confirm the effectiveness of management/stewardship actions.

POTENTIAL PROBLEMS

Factors which can interfere with the desired outcome of a revegetation project after initial revegetation work is complete include the following:

- The establishment or re-establishment of nonnative invasive species from remnant roots or from an existing seedbank.
- Preferential foraging by wildlife which may overwhelm the vegetation's ability to recover or selectively alter species composition.
- Erosion caused by sudden or steady influxes of water or wind that can damage plant materials and the soil base.
- Acts of nature such as flooding, windstorm, hail, etc. which severely damage restored areas.
- Failure or lack of vigor in introduced plantings.
- Unexpected successional changes that shift species composition or abundance.
- Unfavorable amounts of moisture (too little, too much, or wrong time of year).
- Damage resulting from human trespass.

Frequent monitoring can detect potential problems in time to rectify or mitigate them.

Preventing Potential Problems

There are a number of steps taken during site preparation and revegetation that can minimize the potential for problems to arise once initial restoration efforts are completed

- Removal of biennial and perennial weeds and the use of certified weed-free plant materials for mulch can limit the extent to which native plantings must later compete with invasive nonnative species.
- Careful landscaping and the use of mulch can reduce the threat of damage caused by water-runoff and erosion.
- Prudent selection and placement of native species as well as protective fencing can mitigate the threat of selective grazing by local wildlife.

Most preventive steps can only mitigate or reduce the threat of such problems arising later. For example, given the root system of perennial invasive species, one shouldn't assume that weeds were eradicated during site preparation; deep rhizomes will resprout. An established seedbank will assure that new plants germinate and find suitable sites to colonize among areas with disturbed soils and favorable conditions.

Techniques and Frequency

Monitoring techniques can range from a quick visual inspection to an in-depth study of species composition, distribution, and density based on quantitative data from random plots, sampling transects, and/or statistical analysis. In any case, monitoring techniques must be designed to gather the information necessary to identify and evaluate problems that could jeopardize the success of the project. The frequency with which a site is monitored will always depend on site conditions. For example, a site prone to low moisture, high erosion, and invasions of weeds should be checked frequently to ensure the health of introduced plantings. Conversely, dormant periods such as the winter necessitate far less frequent visits as do stable and well-advanced successional stages. If problems are detected, monitoring frequency may need to be increased. The ideal monitoring regime will detect both expected and unexpected problems as soon as they arise.

Assessment of Problems and Stewardship Activities

Monitoring will help detect problems that arise as a result of changing site conditions. Once a problem is identified, corrective actions can be taken. A comprehensive stewardship plan for managing the site after restoration is a vital part of every project. Information gathered by monitoring should be incorporated into such plans whenever possible. Monitoring information summaries should include

- A clear description of problems which have been identified at the site.
- Actions required to correct the problems and provisions to monitor the success of these actions.

- Information on any additional considerations affecting the success of the project, including local and/or regional land management laws, particularly when elements such as grazing, controlled burns, herbicide/insecticide application, etc., are being considered.

STEWARDSHIP

Stewardship, as it relates to native plant establishment and restoration projects, can be defined as caring for a site so as to foster natural processes or management activities that emulate natural processes. The simplest form of stewardship occurs on naturally functioning landscapes, where natural processes are in place and negative effects by human presence are absent. Under these conditions, the land steward merely monitors and records observations that relate to trends in climate, wildlife populations, plant succession, etc. Effective site stewardship defines the goals of a project and identifies the steps needed to achieve these goals.

DEVELOPING A STEWARDSHIP PLAN

Begin developing a stewardship plan for your restoration project at the earliest possible moment, preferably even before work has begun on a site. Your plan will be enhanced if you

- Draw upon available expertise.
- Establish clear, site-specific project goals.
- Consider the relationship of the site to the surrounding land and its proposed land use.
- Establish measures for erosion control, buffers, fencing, other protective measures, and prescriptions for management tools, including mowing, grazing, fire, pesticides, etc.
- To the extent possible, design the project to be a self-sustaining and persistent landscape feature.
- Obtain support for the management plan by including current and potential users in the planning process.

In some instances, plans should be reviewed by local law enforcement, transportation and fire protection agencies so that the proper protocols are followed during stewardship activities. Finally, it is always advisable to develop stewardship plans with the involvement of neighboring landowners/managers.

TECHNIQUES

Stewardship techniques are normally designed to correct problems which are in conflict with established goals and/or provide site protection. Some common techniques include

- Fencing for site protection (temporary during construction and permanent afterwards - although fencing may limit many of the natural processes that might otherwise occur).
- Establishment and maintenance of buffer areas around the project site.
- Avoidance of sensitive habitats when possible.
- Control of nonnative plant and animal species.
- Management by burning, mowing, and/or grazing.
- Control of erosion caused by runoff and wind.
- Creation of passive or active recreation activities, if appropriate.
- Creation of educational programs to promote stewardship goals.

- Signage to recognize contributions and to educate visitors and neighbors.
- Recruitment of volunteers to assist with stewardship activities.

Stewardship planning won't prevent damage from catastrophic events such as flooding, extreme hailstorm, tornado, or winter drought and windstorm, but it will help maintain a site in the desired condition under normal conditions. Should the site be damaged by unforseen circumstances, a good stewardship plan will prove to be a valuable resource in the repair process.

WEED MANAGEMENT

Many potentially successful restoration projects have failed due to a lack of proper weed control. A weed management plan for reclamation and restoration projects is as critical as choosing the native species to plant. Appendices III and IV (beginning on page 227) list prohibited and restricted noxious weed seeds, plants to avoid in native plant establishment projects and management techniques for controlling specific noxious weeds commonly found in Colorado.

Weed management must be included in the planning process of every project and should be implemented before the project begins. If a site is seriously infested with weeds, the first year of a project may be dedicated entirely to the control of weeds. Weeds are initially controlled through prevention and eradication; however, because soil disturbances often stimulate dormant weed seeds, monitoring, control, and containment must continue after a site has been planted.

Note: Most revegetation sites will be dominated by "pioneer" or "weedy" species for the first few years following the disturbance. If these plants are not aggressive and tenacious perennial weeds, they will normally be replaced by desirable vegetation over time. Monitoring is especially important in order to insure a timely and appropriate response to the appearance of aggressive noxious weed species.

INTEGRATED WEED MANAGEMENT

Integrated weed management (IWM) is the selection and application of a variety of management techniques that, in combination, shape the composition and structure of the plant community to promote ecosystem health and function. The goal of IWM is not specifically the elimination of undesirable species as much as the development and maintenance of a healthy, desirable community of native species; the eradication and/or reduction of invasive plant populations is merely one beneficial result of effective IWM. The use of a combination of techniques makes it possible to alter site availability for weeds and disturbances, control colonization events, and manipulate species performance in order to transform the existing plant community into a healthy native one.

Most successful weed management efforts include a combination of two or more control methods. To develop an effective IWM plan, each site must be individually evaluated to identify techniques that are feasible and the most appropriate for the site. Every technique has positive and negative aspects that determine its appropriateness for specific situations. Site managers should select and utilize as many appropriate techniques as possible. Reliance on any one particular method frequently results in failure.

- Remember that most control techniques (mowing, herbicides, hand-pulling, etc.) are effective only during certain periods of the target species' life cycle. Every effort should be made to utilize techniques that suppress targeted weed populations throughout the season while promoting desirable species.

Contact your county weed manager or local Colorado State University Cooperative Extension office for more specific information about control methods or for assistance in developing an effective IWM plan for your site.

PREVENTION

Preventing weeds from invading a site is the most effective and least costly method for controlling weeds. It requires constant vigilance from the very beginning of the project and a knowledge of weeds that are found on surrounding lands.

A healthy cover of native vegetation may prevent weed invasions. It is important to understand, however, that most invasive weeds threatening restoration projects in Colorado easily invade established native plant communities, especially in semi-arid environments. The goal is to minimize the amount of time the ground is not covered by a stand of native plants. As discussed in the Planting Techniques section, if the area will not be revegetated immediately, plant a temporary and sterile "cover crop" such as "Regreen" (sterile wheat X wheatgrass cross) or milo.

➲ Barley (*Hordeum vulgare*), wheat (*Triticum aestivum*) or rye (*Secale cereale*) should not be used as temporary cover crops unless they are mown before seed maturity, because they can reseed themselves and inhibit the germination of native seeded perennials.

Removal of weeds from nearby areas will prevent their seeds from invading the revegetation site. Some weeds (see inset) are not of great concern until the soil is disturbed. The seeds of these common weeds germinate once the ground is turned over or if excessive amounts of fertilizer are applied. However, if the site has been properly revegetated, and if the site is not disturbed further and fertilizer is not continuously applied, these weeds will be at a competitive disadvantage and may eventually disappear.

Russian-thistle (*Salsola* species), **Goosefoot** (*Chenopodium* species), **Pigweed** (*Amaranthus* species), and **Kochia** (*Kochia* species), if present, often increase in numbers following disturbance.

Many well-planned projects have been compromised by weeds introduced during the reclamation process via weed-contaminated products or equipment. Use only certified weed-free forage for mulch, noxious weed-free seeds in seed mixes and weed-free compost. A directory of certified weed-free forage (hay and mulch) can be obtained from the Colorado Department of Agriculture. Colorado certified weed-free forage bales are differentiated from other forage bales by one strand of orange and blue baling twine or galvanized wire. Other western states frequently use specific tags to mark certified bales (every bale sold into Colorado from another state should be tagged) but are beginning to adopt Colorado's twine marking system for regionally certified hay.

Inquire about the source and composition of the hay as well. A native big bluestem hay imported from Kansas that is not certified weed-free may be preferable to smooth brome hay from Colorado that is certified weed-free. The use of straw from barley *(Hordeum vulgare),* wheat *(Triticum aestivum),* or rye *(Secale cereale)* should be avoided because seed remaining in the straw will germinate and compete with the native perennial seedlings. Annual straw crops, especially rye, can prevent the germination and establishment of native seedlings. For information on how to buy weed-free or certified seeds, refer to the Seeding section.

All heavy equipment to be used on a project should be cleaned before it is moved to the site. If imported topsoil is required, it is worth the extra effort to inspect the topsoil mining site beforehand to inventory potential weed contaminants. Since all topsoil contains a "seed bank" of normally dormant "weedy" seeds, only extremely poor sites should be candidates for topsoil importation. In most circumstances, it is preferable to amend the soils that are already on site.

ERADICATION

Eradication is the complete removal of weeds from an area. Most weed species are extremely difficult to eradicate due to the hardiness of the targeted species and the longevity of their seed. Eradication is most effective on weed patches smaller than 100 ft^2 (9 m^2) and areas where weeds are newly established. No method (or integration of methods) will achieve eradication for large-scale weed infestations. Eradication requires long-term land management that encourages desirable native vegetation while continuing to remove aggressive weed species from the site. Weed infestations of minimum size should be removed using hand pulling or digging (for biennials and simple perennials) and spot herbicide treatments (for biennials, simple perennials, and especially deep-rooted, creeping perennials).

Management techniques should be directed at disabling the target weeds' biological processes and promoting the vigor of desirable vegetation. Each weed species may react differently to a particular control method, depending on its biological characteristics. For example, tilling an area will not eliminate Canada thistle, but will actually spread the problem since broken root pieces will sprout new growth. Pulling leafy spurge will usually result in stimulated shoot growth from root buds. If eradication efforts create bare ground, revegetation is required to prevent reinfestation of nonnative or weedy species.

CONTROL

Control emphasizes the reduction of a weed population to a manageable level but not the complete elimination or eradication of the problem. With this distinctly different goal, a number of additional weed management tools and techniques instantly become useful. Control methods are used not only to eliminate individual plants but also to suppress the growth and reproduction of (or otherwise stress) targeted weed populations, especially deep-rooted, creeping perennials which cannot easily be reduced or thinned. Such suppression of weed populations helps to relieve desirable natives species of the competitive pressures exerted by the weeds and promote the development of a healthy native plant community resistant to further invasions. There are four main control methods.

BIOLOGICAL CONTROL

Biological control uses predators of a particular weed to reduce or thin populations. In the native habitat of the target alien plants, there are numerous predators, parasites, or pathogens that regulate populations. Some of these agents, frequently insects, are collected and screened for their utility and low risk in North American habitats. Complete biological control requires the full complement of organisms. Not all of these organisms are suitable for North American introduction; thus the few organisms that are cleared for release will not completely control an alien plant species. It is important to note that while some agents have been dramatically

successful (e.g., St. Johnswort *Chrysolina* beetles), effective biocontrol agents may never be available in North America for even the most common noxious weeds such as Canada thistle (*Cirsium arvense*).

Biological control may also include the use of large herbivores such as sheep, goats and cattle. These herbivores can be used at a variety of stocking rates and periods to stress targeted weed species and release desirable species from weed competition.

Biological agents are recommended for large infestations when combined with other methods that contain the existing infestations. After an initial release, it may take three to five years to see the effects of an established biocontrol population at the point of release. Biocontrol agents will not provide noticeable short-term results but they show promise for long-term management. **Biological control agents are not recommended for any weed infestation that is of a potentially eradicable size.**

CHEMICAL CONTROL

Chemical control uses herbicides to disrupt weed growth. As with all management tools, herbicides must be used with caution and should be integrated with other techniques. Herbicides vary in their target plant species, modes of action, toxicity and degradation time. Natural resource managers must familiarize themselves with all these factors in order to choose the most appropriate herbicide. Contact the National Pesticide Telecommunications Network (1-800-858-7378) for the most scientifically proven toxicological and environmental fate data (sponsored by the Environmental Protection Agency and Oregon State University).

- ❖ Always follow all label recommendations, precautions and restrictions when using any herbicide.
- ❖ Herbicides should be applied only by responsible, licensed applicators. Commercial herbicide applicators can be contracted to manage this facet of a weed management program, particularly if restricted use herbicides are advisable.
- ➲ Commercial applicators should demonstrate the ability to distinguish the undesirable species from similar desirable species.

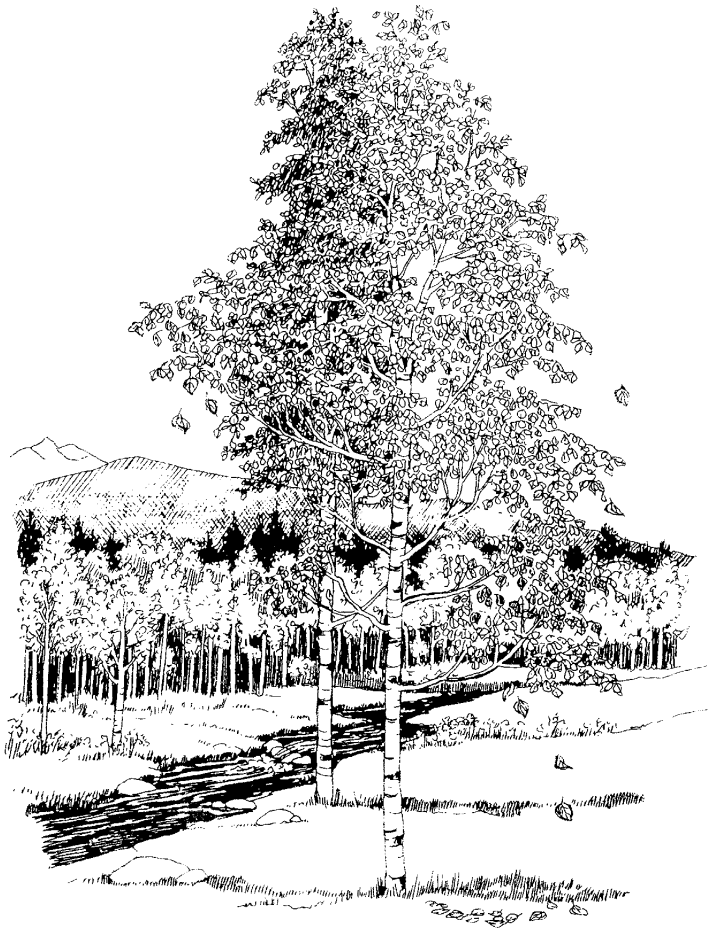
CULTURAL CONTROL

Cultural control promotes the growth of desirable, native plant species by means of planting, appropriate irrigation, nitrogen management, proper grazing management and other techniques. A healthy community of desirable native species provides competition that can help to suppress undesirable alien species and resist future invasions by exotic species.

MECHANICAL CONTROL

Mechanical control disrupts weed growth by physical means. Techniques include tilling, hoeing, hand-pulling, mowing, burning, and mulching. Disking an area can provide temporary (one year) control of annuals and biennials. As described above in the Eradication section, each weed species may react differently to a particular control method, depending on its biological characteristics. Mechanical control techniques should be timed for maximum effect upon the target species based upon the life history characteristics of the weed.

PART II:
WETLAND & RIPARIAN HABITATS



INTRODUCTION

This Wetland and Riparian section is designed to be used in conjunction with the Upland section. Wetlands do not exist in isolation from the surrounding upland communities. Most projects with a wetland focus also have impacts on upland areas as well. Be sure to read the **Introduction**, **Plant Basics** and **Natural Communities** sections at the beginning of this manual. Much of the information in the Upland Habitats section is also applicable to wetland and riparian restoration projects.

Wetland and riparian habitats are different from the upland plant communities described in **Part I.** Effective restoration requires an understanding of hydrology, or how water moves through or is present in the system. Furthermore, there are numerous government regulations concerning activities that affect wetlands. If your site includes wetlands, you may want to consult a wetlands expert before initiating any projects of significant complexity or size. The following sections provide the reader with enough information to carry out simple wetland improvements or to create small wetlands in situations without complex hydrology.

HOW TO USE THIS SECTION

STEP 1: Read the **introductory** sections.

- Wetland and Riparian Defined (page 113)
- Functions of Wetland and Riparian Communities (page 114)
- Important Policies and Regulations (page 115).

These sections contain information important to understanding wetland and riparian habitats and the issues surrounding them. You will also find it helpful to read the **Plant Basics** section beginning on page 7.

STEP 2: Read the **Wetland Delineation** section, beginning on page 116.

This section will help you identify the boundaries of your wetland and to understand some of the reasons the wetland exists where it does.

STEP 3: Proceed to the **Wetland Communities** section, beginning on page 121.

Read the introductory material and determine your site's geographic setting, choosing one of the three sections: Eastern Plains and Foothills, Rocky Mountain Region or Western Plateau and Canyon Region. Decide if your site is a wetland or riparian area. Finally, select the appropriate wetland type. If necessary, refer to the **Communities Descriptions** for upland habitats section beginning on page 15 for additional details in determining your location.

Note: The Plant Finder tables provide a beginning list of species for each type, with some of the the more common species listed in bold type. Not all species found in each community type are listed. Many of the species listed in the Plant Finder tables may not be available commercially. In some cases, it may be necessary to contract with a nursery to have plants grown or to collect native seeds or plants. (See guidelines in text). Appendix II, beginning on page 197 provides details on characteristics for a few species which are most likely to be commercially available.

STEP 4: Refer to the **Wetland Revegetation Techniques** section, beginning on page 153.

This section contains detailed information on planning, implementing and monitoring your wetland project.

WETLAND AND RIPARIAN DEFINED

WETLAND

Wetlands are regulated under a number of laws and ordinances. The most widely accepted definition of wetlands is that used in the federal Clean Water Act. This manual defines wetlands according to the language of that Act.

> "Those areas that are inundated or saturated by surface or ground water 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" (Environmental Laboratory 1987).

RIPARIAN

There are a variety of definitions of "riparian" used by different entities. The word "riparian" is derived the from the Latin *ripare*, meaning "to flow". In this manual the term "riparian" is used primarily as a geographic term, meaning "along the banks of rivers or streams." In many places "riparian areas" and "wetlands" overlap (Cooper and Jones 1993).

THE US BUREAU OF LAND MANAGEMENT identifies riparian areas as a form of wetland transition between permanently saturated wetlands and upland areas. These areas exhibit vegetation or physical characteristics reflective of permanent surface or subsurface water influence. Lands along, adjacent to, or contiguous with perennially or intermittently flowing rivers and streams, glacial potholes, and the shores of lakes and reservoirs with stable water levels are considered riparian areas by the BLM. Excluded are such sites as ephemeral streams or washes that do not exhibit the presence of vegetation dependent upon free water in the soil.

THE COLORADO RIPARIAN ASSOCIATION identifies riparian areas as being characterized by high water tables, distinctive plant communities dependent on water and often distinctive soils and landforms as well. Riparian areas are often associated with streams, lakes, reservoirs and other bodies of water.

THE ENVIRONMENTAL PROTECTION AGENCY defines riparian habitats or zones (that do not fit the wetland definition) simply as areas adjacent to streams, rivers, lakes and freshwater estuaries.

FUNCTIONS OF WETLANDS AND RIPARIAN COMMUNITIES

Wetlands and riparian areas are some of the most biologically productive natural ecosystems in the world. These communities are a valuable part of our environment and perform a variety of important functions.

Improve water quality by

- Removing suspended sediments.
- Removing or using nutrients, such as nitrogen and phosphorus.
- Retaining heavy metals and other pollutants.

Decrease erosion damage by

- Stabilizing shorelines.
- Stabilizing streambanks.

Moderate flood flows by

- Detaining and storing run-off.
- Recharging ground water.
- Providing groundwater discharge areas.

Provide habitat for plants and animals by

- Adding structure to the landscape.
- Enhancing ecosystem productivity through water and nutrient availability.
- Moderating water temperature of aquatic ecosystems.

Increase opportunity for recreation and education such as

- Wildlife photography and observation.
- Fishing and hunting.
- Boating.
- Hiking.
- Bird watching.
- Nature study.
- Educational and research opportunities.

IMPORTANT POLICIES AND REGULATIONS

Within the past decade, federal, state and local policies directed at protection and revegetation efforts for wetlands have expanded. This is due in large part to increased interest in compensating for lost wetlands by creating new wetlands or restoring degraded wetlands (Kusler and Kentula 1990). A large body of information exists concerning wetland and riparian habitat policy and regulation. Below is a brief summary, broken down by federal, state, and local levels.

FEDERAL

Congress has passed legislation that either directly or indirectly provides wetland and riparian habitat protection. The most important items in this body of law include the following:

- Rivers and Harbors Act
- Clean Water Act
- Endangered Species Act
- Migratory Bird Treaty Act
- Migratory Species Act
- North American Wetlands Conservation Act
- Food Security Act
- Wetlands Reserve Program
- National Environmental Policy Act
- Wild and Scenic Rivers Act
- Conservation and Trade Act
- Emergency Wetlands Resources Act
- Fish and Wildlife Coordination Act
- Federal Land Policy and Management Act
- Multiple Use/Sustained Yield Act
- National Historic Preservation Act
- Executive Order 11988 (Floodplain Management)
- Executive Order 11990 (Mitigation of Environmental Impacts to Privately Owned Wetlands: Protection of Wetlands)

Wetland researchers and applicants for construction permits are usually most familiar with **Section 404** of the **Clean Water Act**. This law and the associated regulations include processes for wetland identification, delineation, impact assessment, permitting of impacts, and compensation for impacts to wetlands. Another federal process that is often used is the **National Environmental Policy Act**, or NEPA, which provides guidance for assessing and minimizing adverse environmental effects including impacts to wetlands.

STATE

The Colorado legislature enacted Senate Bill 40 (CRS 33-5-101), which states that, “the fishing waters within the state are to be protected and preserved from the actions of any state agency.” This bill protects wetland and riparian habitats by requiring coordination between state agencies and the Colorado Division of Wildlife (CDOW). For example the CDOW and Colorado Department of Transportation (CDOT) have agreed on a process to coordinate and evaluate road construction and maintenance activities which affect wetland and riparian habitats.

In addition, the CDOW has undertaken a broad scale Colorado Wetlands Program to conserve wetlands through a variety of strategies including public education, restoration and purchase of critical wetlands.

Other state programs involving wetlands include the following:

- The Water Quality Control Division of the Colorado Department of Public Health and Environment reviews federal 404 permit applications to ensure that activities do not violate Colorado water quality standards or effluent limitations.

- CDOT has created an erosion control manual to protect all habitats and water quality during construction projects.

- The Colorado Geological Survey has undertaken several projects to help evaluate the wetlands of Colorado in accordance with a new nationwide system referred to as Hydrogeomorphic Classification System.

- Wetlands and riparian areas may also be recognized under provisions of the Colorado Natural Areas Act. Designated Natural Areas may then be protected and management provisions formalized in a voluntary agreement between the landowner and the Colorado Natural Areas Program (CNAP). As part of the Colorado Division of Parks and Outdoor Recreation, CNAP has prepared a best management practices guide for wetland and riparian habitats in state parks (Peale 1996).

COUNTY & LOCAL

Boulder, Eagle, Larimer and Pitkin counties have introduced processes into land use planning which provide varying degrees of wetland regulation and protection. One element of these efforts is the preparation of accurate maps of existing wetland and riparian habitats.

The cities of Broomfield, Boulder, Denver, Fort Collins, Greenwood Village and Westminster have also conducted advanced wetland inventories and may have incorporated ordinances designed to protect wetlands into their land use codes and regulations.

WETLAND DELINEATION

All wetlands share certain common factors or environmental characteristics which distinguish them from other habitat types. Some areas, like cattail marshes, are obviously wetlands; however, in other circumstances the distinction is less clear cut. Because wetlands are protected and regulated by the federal Clean Water Act (CWA), it is also necessary to define the precise limits (i.e., delineate the boundaries) of a wetland so that citizens have clarity about where the regulations apply.

The current federal wetland delineation methodology used to define wetland habitat under the CWA was produced by the Army Corps of Engineers (COE) and is explained in detail in the 1987 “Corps of Engineers Wetlands Delineation Manual” (Environmental Laboratory 1987). The following diagnostic environmental characteristics and technical approach summarize the guidelines for the identification and delineation of wetlands in the 1987 COE Manual.

DIAGNOSTIC CHARACTERISTICS OF WETLANDS

According to the COE definition, wetlands have the following three general diagnostic characteristics:

1. Hydrophytic vegetation.
2. Sustaining hydrology.
3. Hydric soils.

A wetland habitat is identified and delineated based upon the presence of these three parameters.

Wetland delineation is complicated. The information provided here is intended to introduce the fundamental concepts of delineation—not to train delineators. Contact the Corps of Engineers to determine if you need a wetland delineation for your project. If you do, the Corps can provide a list of qualified wetland consultants.

VEGETATION

Plants usually need air in the soil to allow the roots to breath. However, hydrophytic (wetland adapted) plants have specialized structures which allow them to tolerate soils that are periodically anoxic (lacking oxygen). For example, such structures include internal air spaces that allow air to travel from the aerial portions of the plant into the roots. Some plants are also able to change their metabolic chemistry under anaerobic conditions to prevent the buildup of toxic materials. Wetland plants include the following types:

- **Free-floating plants** float at the surface of ponds and slow-moving streams. These plants, such as duckweed (*Lemna*), have specialized free-floating root systems or leaves that can exchange gases and obtain nutrients from the water.
- **Submerged plants** are rooted in soil and depend on the buoyancy of water to support their stems and leaves. Some examples of submerged plants are watercress (*Nasturtium*) and mare's tail (*Hippuris*).
- **Floating-leaved plants** have well-developed leaves that float on the surface. Gas exchange occurs where the upper surface of the leaves is exposed to the air. Water lilies (*Nuphar* spp.),are an example of rooted floating-leaved plants found in Colorado.
- **Emergent plants** grow above the saturated soils or water. This group include cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), rushes (*Juncus* spp.) and sedges (*Carex* spp.). These plants typically have long, linear leaves which increase the amount of surface available for photosynthesizing in order to compensate for the lack of oxygen in the soil. Many also have hollow tissues that conduct air to the roots.
- **Woody species** can also be hydrophytic. Examples include shrubby willows (*Salix* spp.) and alder (*Alnus* spp.) and trees such as peach-leaf willow (*Salix amygdaloides*) and cottonwood (*Populus* spp.). They are similar to upland species, although they usually possess shallow root systems, adventitious roots and other structures that increase gas exchange between roots and air spaces. Although these woody species can tolerate inundation for short periods, they generally cannot survive continuous saturation of the root zone.

HYDROLOGY

The hydrology of an area is the most critical factor determining the presence of a wetland; without water saturating the soil, no wetlands will occur regardless of what is planted. On

the other hand, wetlands will develop in areas with saturated soils whether or not they are planned as wetlands.

The water level in wetlands can range from constantly inundated shallow ponds to soils which are only saturated during spring runoff. At the wet end of the spectrum, the wetlands seldom occur in water that is greater than 10 feet (3 meters) deep. At the drier end of the spectrum, the soils must be saturated at least long enough for hydric soils to develop and support wetland vegetation. It can be difficult to determine if an area has "wetland hydrology," especially during dry periods.

SOIL

Wetland soils are classified as **hydric**. When the ground is saturated for a long period, air is depleted from the soil. Hydric soils develop specific characteristics due to this lack of air. These soils can be divided generally into two categories.

- **Organic hydric soils (peat soils or histosols)** are formed from accumulations of dead cattails, sedges, and other plants mixed with small amounts of silt and sand. In the absence of oxygen, this material decomposes much more slowly than organic material of upland soils. Organic soils are often foul smelling from bacterial production of hydrogen sulfide and methane.
- **Mineral hydric soils** lack a significant amount of organic material. These soils have a wide range of textures (from sandy to clayey) and have characteristics indicative of an anerobic environment. Some indicators of mineral hydric soils include bluish or greenish gray (gleyed) color, rotten egg odors from sulfur compounds (found only in permanently waterlogged soils), and soils with clumps of brighter colored material from the oxidation of iron and other minerals.

TECHNICAL APPROACH: DELINEATION OF WETLANDS

Except in certain exceptions defined by the Corps of Engineers, you need to have at least one positive indicator from soils, vegetation and hydrology in order to make a positive wetland determination.

➲ The identification and delineation of wetland habitat is a specialized area of expertise typically performed by biologists, botanists, soil scientists or other related environmental scientists. If you believe you may have wetland habitat on your property or in an area of concern, contact the nearest office of the Army Corps of Engineers, the Natural Resource Conservation Service or a professional wetland scientist/consultant.

WETLAND AND RIPARIAN COMMUNITIES IN COLORADO

Wetland and riparian communities occur on a very small percentage of Colorado's total land area, possibly as low as two percent (Cooper and Jones 1993). These habitats are as varied as the landscape. Over the past 150 years, many have been lost, introduced, or changed by human activity. Cooper and Jones (1993) estimated that as much as 50 percent of wetland and riparian habitats have been lost or changed during settlement, and that an unknown amount of wetland and riparian habitats have also been created through irrigated agriculture and water transport and storage systems. The purchase and transfer of water rights to rapidly developing areas of the state may affect the permanence of such recently created wetland habitats.

Wetland communities in Colorado are a direct result of the interaction of water with the topography of the state. Headwater streams arising near the continental divide join other streams as they flow toward the plains thousands of feet below. There are several basic types of wetlands found in Colorado, each associated with a particular combination of water and the landscape.

- **Riverine** Wetlands associated with flowing water
- **Depressional** Wetlands in low spots on the landscape
- **Lacustrine Fringe** Wetlands along the edges of lakes or other deepwater habitats
- **Slope** Wetlands supported by groundwater discharge on a slope
- **Artificial** Wetlands supported by human activities such as irrigation

Within each of these types there may be several classes of wetlands, each with its characteristic suite of vegetation. As with upland communities, species associations vary with changes in elevation. Wetland species, however, tend to be more cosmopolitan than upland species, and therefore, geographic differences are less common with wetland than upland species. For that reason, wetlands on the eastern plains may look very much like the same type of wetland at the same elevation the western slope.

Although wetland and riparian habitats make up a relatively small area of the total land mass, their contribution to biodiversity is tremendous. For example, in the United States wetlands provide habitat for approximately one-third of the plant and animal species federally listed as threatened or endangered, as well as essential nesting, migratory, and wintering areas for more than 50 percent of the nation's migratory bird species (USFWS 1990). Redelf (1983) estimated that 90 percent of the 800 species of fish and wildlife in Colorado depend on riparian communities for various habitat needs. The Colorado Natural Heritage Program (CNHP) lists 29 species of wetland-dependent birds and 11 species of amphibians as “rare and imperiled” in Colorado (CNHP 1996).

IF YOUR SITE IS IN:	GO TO PAGE:
Eastern Plains and Foothills Region	121
Rocky Mountain Region (including Intermountain Parks)	130
Western Plateau and Canyon Region	145

EASTERN PLAINS AND FOOTHILLS REGION

WETLANDS

On the predominantly dry plains of Colorado, wetlands occur along drainages and in shallow depressions with at least periodically wet soils.

Notes on wetland projects

For wetland creation or restoration, hydrology is all important. Some questions to consider are

- What is the source of water for the wetland and how reliable is it?
- How much water is available and for how long during the year?
- Will wetland plants establish naturally or are manipulation of the hydrology and seeding and planting necessary?

Study the arrangement of the plants in wetlands. Different plants grow in different amounts of water or in soils with different saturation levels. As a result, rings of different plant species often form around ponds or playas. For that reason, shallowly graded slopes around ponds will provide more wetland habitat than steep slopes.

There are many references on wetland restoration and creation. A few which are listed in the reference section include Haskisaki 1996, Kusler and Kentula 1990, Mutz et al. 1988, Peale 1996, and Schneller-McDonald 1990.

MARSHES

Marshes are dynamic wetlands that typically receive flows of water in the spring, sometimes resulting in flooding and relatively deep water, followed by dropping water levels later in the season (Cooper and Jones 1993). Marshes are found around ponds, lakes and reservoirs and sometimes in the backwater areas or oxbows of riparian zones. Marsh vegetation consists mainly of large rhizomatous species such as cattails and bulrushes that form monotypic stands around the edges of ponds. Sedges and rushes, such as Nebraska sedge and arctic rush, cover areas that have permanently high water tables and standing water in the spring and early summer. In addition, small ponds and large reservoirs with permanent standing water usually also have floating and submergent vegetation, including yellow pond lily, water smartweed, water millfoil, pondweeds, bladderwort and other plants floating beneath the surface of one to three feet (0.3 to 0.9 m) deep water. Many freshwater plants cannot survive the alkaline conditions that prevail in

areas where periodic saturation causes salts to accumulate in the soil. In these situations, marsh vegetation is dominated by alkaline tolerant plants.

PLAYAS

Ephemeral ponds, or playas, occur in wide, shallow depressions throughout the plains. During spring, water collects in these depressions forming small, shallow ponds. Later in the summer, the ponds usually dry, leaving a grassy swale of sedges, rushes and grasses. Patches of cattails and bulrushes form in wetter areas where the soils are saturated for most of the year. The soils are often very rich in clay. Cottonwoods and willows sometimes surround these temporary ponds.

Wetland / Riparian Plant Finder 1: Wetland - Freshwater Marshes and Playas

(dominant species in bold type)

GRAMINOIDS	
Beckmannia syzigachne	American sloughgrass
Carex aquatilis	**water sedge**
Carex utriculata	**Northwest territory sedge**
Eleocharis palustris	**common spike-rush**
Glyceria striata	fowl mannagrass
Juncus arcticus	**arctic rush**
Juncus longistylis	longstyle rush
Juncus nodosus	jointed rush
Juncus torreyi	Torrey's rush
Persicaria coccinea	scarlet smartweed
Scirpus acutus	**hardstem bulrush**
Scirpus maritimus	saltmarsh bulrush
Scirpus microcarpus	panicled bulrush
Sparganium eurycarpium	Bur-reed
Typha latifolia	**broadleaf cattail**
FORBS	
Alisma triviale	northern water plantain
Lycopus americanus	American water horehound
Lycopus asper	rough bugleweed
Sagittaria cuneata	arumleaf arrowhead
Sagittaria latifolia	broadleaf arrowhead

Wetland / Riparian Plant Finder 2:
Wetland - Alkaline Marshes and Playas

(dominant species in bold type)

GRAMINOIDS	
Carex nebrascensis	**Nebraska sedge**
Eleocharis palustris	**common spike-rush**
Juncus arcticus	**arctic rush**
Juncus compressus	roundfruit rush
Juncus torreyi	Torrey's rush
Puccinellia airoides	**alkali grass**
Scirpus acutus	**hardstem bulrush**
Scirpus nevadensis	**alkali bulrush**
Scirpus maritimus	**saltmarsh bulrush**
Triglochin concinna	low arrow-grass
Triglochin maritima	maritime arrow-grass
Typha angustifolia	**narrow-leaved cattail**
FORBS	
Glaux maritima	sea milkwort
Halerpestes cymbalaria	alkali crowfoot
Persicaria coccinea	scarlet smartweed
Potamogeton pectinatus	sago pondweed
Rumex maritimus	golden dock

MEADOWS

Wet meadows occur on the eastern plains where the water table is high enough to saturate the soil for some portion of the growing season. This can occur along reservoirs and playas where springs emerge, or in irrigated pastures. At the wet end of the scale, communities of Nebraska sedge, baltic rush, and other species grow in areas where the water table is near the surface for most of the year. In slightly drier areas where the water table fluctuates, wet meadows of three-square bulrush, baltic rush, spikerush, switchgrass and other grasses occur. Rings of foxtail barley, western wheatgrass or other grasses can surround the wet meadows. In areas of high surface salinity, species tolerant of saline and alkaline conditions dominate saturated soils.

Wetland / Riparian Plant Finder 3:
Wetland – Marsh Margins and Wet Meadows

(dominant species in bold type)

GRAMINOIDS	
Alopecuris aequalis	shortawn foxtail
Carex emoryi	Emory's sedge
Carex lanuginosa	**woolly sedge**
Carex nebrascensis	**Nebraska sedge**
Eleocharis palustris	**common spike-rush**

Wetland / Riparian Plant Finder 3:
Wetland – Marsh Margins and Wet Meadows

(dominant species in bold type)

GRAMINOIDS (continued)

Hordeum jubatum	**foxtail barley**
Juncus arcticus	**arctic rush**
Juncus confusus	Colorado rush
Panicum virgatum	switchgrass
Pascopyrum smithii	western wheatgrass
Stipa viridula	green needlegrass

FORBS

Asclepias incarnata	swamp milkweed
Apocynum cannabinum	Indian hemp
Asclepias incarnata	marsh milkweed
Asclepias speciosa	showy milkweed
Cicuta douglasii	western water hemlock
Cyclachaena xanthifolia	marsh-elder
Epilobium ciliatum	willow-herb
Euthamia occidentalis	western goldentop
Gaura parviflora	velvetweed
Glycyrrhiza lepidota	wild licorice
Helianthus nuttallii	Nuttall's sunflower
Iris missouriensis	wild iris
Mentha arvensis	wild mint
Mimulus glabratus	monkey-flower
Monolepis nuttalliana	Nuttall's povertyweed
Oenothera elata	Hooker's evening-primrose
Polygonum pensylvanica	smartweed
Rorippa palustris	yellowcress
Rorippa sinuata	spreading yellowcress
Rorippa teres	southern marsh yellowcress
Rumex hymenosepalus	canaigre dock
Scrophularia lanceolata	lanceleaf figwort
Senecio hydrophilus	water groundsel
Stachys palustris	marsh hedge-nettle
Solidago canadensis	**Canada goldenrod**
Urtica gracilis	stinging nettle
Verbena hastata	blue vervain
Veronica americana	American speedwell

TREES AND SHRUBS

Rosa woodsii	Wood's rose
Salix exigua	**sandbar willow**

Wetland / Riparian Plant Finder 4: Wetland – Alkaline Marsh Margins and Salt Meadows

(dominant species in bold type)

GRAMINOIDS	
Alopecurus aequalis	**shortawn foxtail**
Carex nebrascensis	**Nebraska sedge**
Distichlis spicata	**inland saltgrass**
Eleocharis palustris	**common spike-rush**
Hordeum jubatum	**foxtail barley**
Juncus arcticus	**arctic rush**
Juncus nodosus	jointed rush
Juncus saximontanus	Rocky Mountain rush
Juncus torreyi	Torrey's rush
Muhlenbergia asperifolia	**alkali muhly**
Panicum virgatum	switchgrass
Pascopyrum smithii	**western wheatgrass**
Puccinellia airoides	Nuttall's alkali grass
Sporobolus airoides	**alkali sacaton**
Stipa viridula	green needlegrass
Triglochin concinna	arrow-grass
FORBS	
Asclepias speciosa	showy milkweed
Brachyactis ciliata	alkali rayless aster
Brachyactis frondosa	leafy rayless aster
Gaura parviflora	velvetweed
Glaux maritima	sea milkwort
Glycyrrhiza lepidota	wild licorice
Helianthus nuttallii	Nutall's sunflower
Iva axillaris	povertyweed
Oenothera elata	Hooker's evening-primrose
Oenothera villosa	hairy evening-primrose
Solidago canadensis	Canada glodenrod
Suaeda calceoliformis	Pursh seepweed
Suaeda moquini	Mojave seablite
Suaeda nigra	black seablite
TREES AND SHRUBS	
Atriplex argentea	silverscale saltbush
Rosa woodsii	Wood's rose
Sarcobatus vermiculatus	greasewood

RIPARIAN COMMUNITIES

Typically, riparian forests and shrubland communities of the plains occur along streams that meander and braid through wide, flat main channels. Patches of cottonwoods typically form the canopy layer, with sandbar willow along the stream edge and grasses, such as switchgrass and prairie cordgrass, between cottonwood clumps. In the foothills or in canyons on the plains, streams tend to be narrower with swifter flowing water. Water levels in these streams may fluctuate widely during the year, from several feet above the stream bottom during spring and after thunderstorms to a small trickle or even no water in the fall. Foothills riparian areas often have dense shrub layers composed of willows, currants, plums, chokecherries and hawthorn. Riparian areas often include a mosaic of vegetation types, with wetlands at stream edges, in backwater areas, or old oxbows, and upland and transitional vegetation communities interspersed with wetland and riparian vegetation.

Notes on riparian projects

Hydrology and stream dynamics are critical factors for the success of riparian projects. The work needed to restore proper functioning will depend on the current condition of the stream and the riparian vegetation. Questions to consider include

- Would changes in land use (i.e., changes in grazing season or stocking numbers, closing or moving trails, etc.) be sufficient to improve stream functioning and riparian vegetation?
- Is stream hydrology suitable to support the planned changes?

For some of the many available references on riparian projects, see American Fisheries Society 1982, Briggs 1995 and 1996, Clary 1996, Crumpacker 1985, Hughes 1996, and Schultze 1984.

COTTONWOOD/WILLOW SHRUBLANDS AND FORESTS

On the plains, woody vegetation, mostly plains cottonwood and sandbar willow, germinates on the bare sandbars formed by meandering streams. A variety of grasses and forbs grow underneath and in open areas around these trees and shrubs. Along streambanks, switchgrass and prairie cordgrass form wide stands of dense, tall grasses. Nebraska sedge, baltic rush, three-square and other grass-like plants form patches along the edge of permanent streams and at the bottom of intermittent drainages.

Along foothills streams, lanceleaf and narrowleaf cottonwoods replace the plains cottonwoods. Thinleaf alder, river birch and blue spruce (mostly in southern Colorado) mix with the cottonwoods in the valleys along streams. Shrubs such as sandbar and other willows, red-osier dogwood and twinberry grow along the cool, moist creekbanks.

Wetland / Riparian Plant Finder 5: Riparian – Plains

(dominant species in bold type)

GRAMINOIDS

Distichlis spicata	inland saltgrass
Glyceria striata	manna grass
Hordeum jubatum	foxtail barley
Juncus arcticus	arctic rush
Panicum virgatum	switchgrass
Pascopyron smithii	western wheatgrass
Spartina pectinata	prairie cordgrass
Sporobolus airoides	alkali sacaton

FORBS

Apocynum cannabinum	Indian hemp
Asclepias incarnata	swamp milkweed
Clematis ligusticifolia	western white clematis
Cyclachaena xanthifolia	marsh-elder
Glycyrrhiza lepidota	wild licorice
Hydrophyllum fendleri	Fendler's waterleaf
Iris missouriensis	Rocky Mountain iris
Maianthemum stellatum	starry false Solomon's seal
Mentha arvensis	wild mint
Monarda fistulosa	wildbergamot beebalm
Parthenocissus inserta	Virginia creeper
Potentilla rivalis	brook cinquefoil
Solidago canadensis	Canada goldenrod

TREES AND SHRUBS

Acer negundo	**box-elder**
Amorpha fruiticosa	desert indigobush
Artemisia tridentata ssp. *tridentata*	big sagebrush
Baccharis salicina	Great Plains false-willow
Celtis reticulata	netleaf hackberry
Chrysothamnus nauseosus	rubber rabbitbrush
Chrysothamnus viscidiflorus	green rabbitbrush
Forestiera pubescens	stretchberry
Juniperus monosperma	oneseed juniper
Juniperus scopulorum	Rocky Mountain juniper
Prunus virginiana	**black chokecherry**
Populus angustifolia	**narrowleaf cottonwood**
Populus deltoides	**plains cottonwood**
Populus tremuloides	quaking aspen
Rhus trilobata	skunkbush sumac
Ribes aureum	golden currant
Rosa woodsii	Woods' rose
Salix amygdaloides	**peachleaf willow**
Salix bebbiana	**Bebb willow**
Salix exigua	**sandbar willow**
Salix *lucida*	shining willow

Wetland / Riparian Plant Finder 6: Riparian – Foothills and Canyons

(dominant species in bold type)

GRAMINOIDS

Glyceria grandis	American mannagrass
Glyceria striata	fowl mannagrass
Hordeum jubatum	foxtail barley
Juncus arcticus	arctic rush
Juncus confusus	Colorado rush
Pascopyron smithii	western wheatgrass
Poa palustris	fowl bluegrass
Stipa viridula	green needlegrass

FORBS

Apocynum cannabinum	Indian hemp
Clematis ligusticifolia	western white clematis
Cyclachaena xanthifolia	marsh-elder
Epilobium angustifolium	fireweed
Equisetum arvense	field horsetail
Glycyrrhiza lepidota	wild licorice
Heracleum sphondylium	cow-parsnip
Hydrophyllum fendleri	Fendler's waterleaf
Hypericum formosum	St. Johnswort
Iris missouriensis	Rocky Mountain iris
Juncus arcticus	arctic rush
Maianthemum stellatum	starry false Solomon's seal
Mentha arvensis	wild mint
Mertensia ciliata	mountain bluebells
Monarda fistulosa	wildbergamot beebalm
Potentilla rivalis	brook cinquefoil
Solidago canadensis	Canada goldenrod
Vicia americana	American vetch

TREES AND SHRUBS

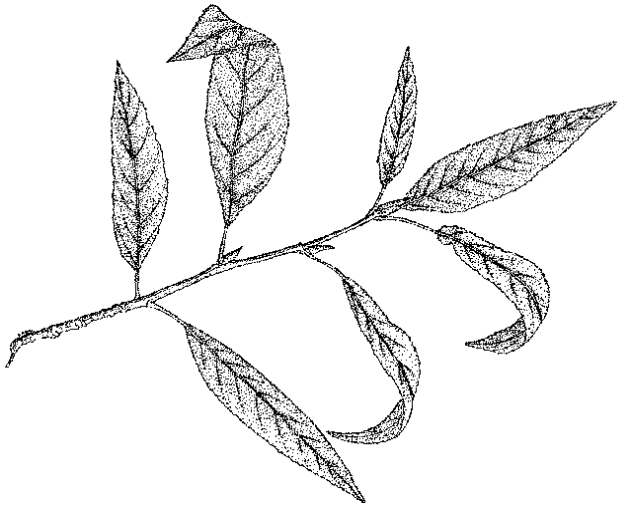
Acer glabrum	**Rocky Mountain maple**
Acer negundo	box-elder
Alnus incana	**thinleaf alder**
Betula occidentalis	water birch
Crataegus rivularis	**river hawthorn**
Picea pungens	Colorado blue spruce
Populus angustifolia	**narrowleaf cottonwood**
Populus deltoides	plains cottonwood
Populus tremuloides	quaking aspen
Prunus americana	**American plum**
Prunus virginiana	**black chokecherry**
Pseudotsuga menziesii	Douglas-fir
Ribes aureum	golden currant
Ribes cereum	**wax currant**
Rosa woodsii	**Woods' rose**

Wetland / Riparian Plant Finder 6: Riparian – Foothills and Canyons

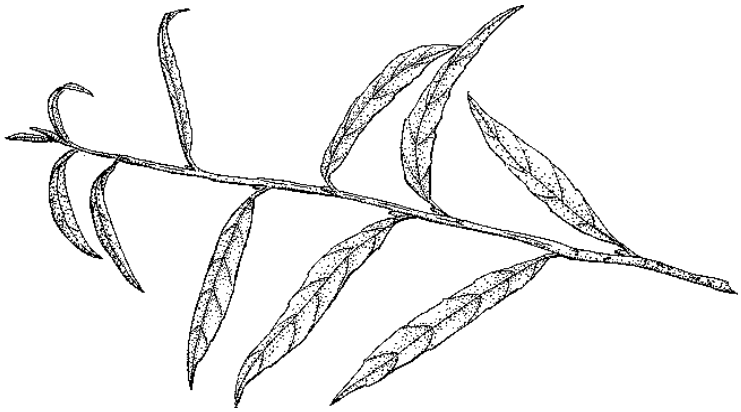
(dominant species in bold type)

TREES AND SHRUBS (continued)

Rubacer parviflorum	thimbleberry
Salix amygdaloides	peachleaf willow
Salix bebbiana	Bebb willow
Salix drummondiana	Drummond's willow
Salix geyeriana	Geyer's willow
Salix irrorata	bluestem willow
Salix lucida	shining willow
Salix monticola	mountain willow
Swida sericea	red-osier dogwood



Populus angustifolia



Salix exigua

ROCKY MOUNTAIN REGION

Most of the naturally-occurring wetlands in Colorado are found in the montane and subalpine zones. There are a number of reasons for this. First, it rains and snows more at higher elevations. Second, air temperatures are cooler at higher elevations, so there is less evaporation than on the plains. Third, most of the montane and subalpine zone was glaciated during the last ice age, and glaciers tend to turn narrow, V-shaped mountain valleys into broad, flat, U-shaped valleys more suitable for wetland development. Glaciers also create a large number of specialized landforms where wetlands can develop, including cirque basins and kettle lakes.

Wetland and riparian habitats within the montane and subalpine zones are similar in location, structure and the functions attributable to them. Moisture from snow melting from high peaks supports a wide variety of wetlands in ponds, shallow depressions and along streams. They range from aquatic systems to herbaceous wet meadows and fens, to willow carrs and forested habitats. At lower elevations they intergrade into wetland and riparian communities of the foothills and piñon pine-juniper woodlands, and at higher elevations they intergrade into the alpine wetland communities. Depending on site hydrology and topography, a mosaic of wetland types may occur at a single location.

WETLANDS

Notes on wetland projects

For wetland creation or restoration, hydrology is all important. Some questions to consider are

- What is the source of water for the wetland and how reliable is it?
- How much water is available and for how long during the year?
- Will wetland plants establish naturally or are manipulation of the hydrology and seeding and planting necessary?

Study the arrangement of the plants in wetlands. Different plants grow in different amounts of water or in soils with different saturation levels. As a result, rings of different plant species often form around ponds or playas. For that reason, shallowly graded slopes around ponds will provide more wetland habitat than steep slopes.

There are many references on wetland restoration and creation. A few which are listed in the reference section include Haskisaki 1996, Kusler and Kentula 1990, Mutz et al. 1988, Peale 1996, and Schneller-McDonald 1990.

MARSHES

Marshes occur in a variety of situations in the Rocky Mountain region of the state. Natural lakes dot the higher portions of the mountains where snowmelt from the high peaks collects in basins. In the San Luis Valley, the perenially high water table creates numerous shallow ponds with ideal conditions for marsh development. In lower elevation areas, dams by humans and beavers create small and large bodies of water.

On the shallow shores of the lakes and ponds, plants rooted in the muddy bottom emerge from the surface of the water. Large patches of cattails, sedges, spikerush and other emergent vegetation may form rings around the lake shores. As the water gets deeper, rooted plants with floating leaves such as water lilies and burreed spread across the water. Submergent plants, such as pondweeds and water crowfoot, occur in deeper water. Where periodic saturation causes salts to accumulate in the soil, marsh vegetation is dominated by alkaline tolerant plants.

PLAYAS

Shallow playas, also called internal drainage basins or ephemeral ponds, are most extensive in the San Luis Valley. During spring, water collects in these depressions forming small, shallow ponds. Later in the summer, the ponds usually dry, leaving a grassy swale of sedges, rushes, and grasses. Patches of cattails and bulrushes form in wetter areas where the soils are saturated for most of the year. The soils are often very rich in clay. Cottonwoods and willows sometimes surround playas. Often greasewood shrubs are present within the playas where they grow on low sand dunes on the playa bottom or in a band along the upper playa margin.

Wetland / Riparian Plant Finder 7: Wetland - Freshwater Marshes and Playas

(dominant species in bold type)

GRAMINOIDS	
Beckmannia syzigachne	American sloughgrass
Carex aquatilis	**water sedge**
Carex utriculata	**Northwest territory sedge**
Eleocharis palustris	**common spike-rush**
Glyceria grandis	American mannagrass
Glyceria striata	fowl mannagrass
Juncus arcticus	**arctic rush**
Juncus longistylis	longstyle rush
Juncus nodosus	jointed rush
Juncus torreyi	Torrey's rush
Scirpus acutus	**hardstem bulrush**
Scirpus maritimus	**saltmarsh bulrush**
Scirpus microcarpus	**panicled bulrush**
Scirpus pungens	**three-square bulrush**
Typha latifolia	**broadleaf cattail**

Wetland / Riparian Plant Finder 7: Wetland - Freshwater Marshes and Playas

(dominant species in bold type)

FORBS

Alisma triviale	northern water plantain
Lycopus americanus	American water horehound
Lycopus asper	rough bugleweed
Persicaria coccinea	scarlet smartweed
Sagittaria cuneata	arumleaf arrowhead
Sagittaria latifolia	broadleaf arrowhead

Wetland / Riparian Plant Finder 8: Wetland - Alkaline Marshes and Playas

(dominant species in bold type)

GRAMINOIDS

Carex nebrascensis	Nebraska sedge
Eleocharis palustris	**common spike-rush**
Juncus arcticus	**arctic rush**
Juncus torreyi	Torrey's rush
Juncus compressus	roundfruit rush
Puccinellia airoides	Nuttall's alkali grass
Scirpus acutus	**hardstem bulrush**
Scirpus nevadensis	alkali bulrush
Scirpus maritimus	**saltmarsh bulrush**
Triglochin concinna	low arrow-grass
Triglochin maritima	maritime arrow-grass
Typha angustifolia	**narrowleaf cattail**

FORBS

Glaux maritima	sea milkwort
Halerpestes cymbalaria	alkali crowfoot
Persicaria coccinea	scarlet smartweed
Potamogeton pectinatus	sago pondweed
Rumex maritimus	golden dock

MEADOWS

A wide variety of wetlands occur in stream valleys, in small depressions, and in other areas where the ground is saturated for a substantial portion of the growing season but pools of water rarely form. The type of wetland depends on the soil characteristics, the duration of soil saturation, and the vegetation.

WET MEADOWS

Wet meadows of sedge, arctic rush, tufted hairgrass and other grasses occur along streams and around ponds in the broad mountain valleys. Wild iris may dot the meadows especially in heavily grazed areas. These meadows form where the soils are saturated in the spring and early summer, but usually dry out later in the summer.

Wetland / Riparian Plant Finder 9: Wetland – Montane and Subalpine Wet Meadows

(dominant species in bold type)

GRAMINOIDS	
Alopecuris aequalis	shortawn foxtail
Carex emoryi	Emory's sedge
Carex lanuginosa	woolly sedge
Carex nebrascensis	Nebraska sedge
Carex praegracilis	clustered field sedge
Deschampsia cespitosa	**tufted hairgrass**
Eleocharis palustris	**common spike-rush**
Hordeum jubatum	foxtail barley
Juncus arcticus	**arctic rush**
Juncus bufonius	toad rush
Juncus compressus	roundfruit rush
Juncus nodosus	jointed rush
Juncus saximontanus	Rocky Mountain rush
Juncus torreyi	Torrey's rush
Stipa viridula	green needlegrass
FORBS	
Antennaria corymbosa	flattop pussytoes
Antennaria rosea	rosy pussytoes
Apocynum cannabinum	Indian hemp
Asclepias speciosa	showy milkweed
Cicuta douglasii	western water hemlock
Conioselinum scopulorum	Rocky Mountain hemlock-parsley
Cyclachaena xanthifolia	marsh-elder
Epilobium ciliatum	willow-herb
Iris missouriensis	Rocky Mountain iris
Limosella aquatica	water mudwort
Mentha arvensis	wild mint
Mimulus glabratus	monkey-flower
Monolepis nuttalliana	Nuttall's povertyweed
Oenothera elata	Hooker's evening-primrose

Wetland / Riparian Plant Finder 9:
Wetland – Montane and Subalpine Wet Meadows

(dominant species in bold type)

FORBS (continued)	
Oenothera villosa	hairy evening primrose
Ranunculus gmelinii	Pursh's buttercup
Rorippa palustris	Fernald's yellowcress
Rorippa sinuata	spreading yellowcress
Rorippa teres	southern marsh yellowcress
Rumex hymenosepalus	canaigre dock
Scrophularia lanceolata	lanceleaf figwort
Senecio hydrophilus	water groundsel
Sidalcea neomexicana	New Mexico checkermallow
Stachys palustris	marsh hedge-nettle
Solidago canadensis	Canada goldenrod
Urtica gracilis	stinging nettle
Veronica americana	American speedwell
TREES AND SHRUBS	
Pentaphylloides floribunda	shrubby cinquefoil

SALT MEADOWS

Salt meadows occur in areas of high surface salinity where the water table is close to the surface and where evaporation exceeds precipitation. Salt meadows are common in lower and middle elevations in Colorado and are most extensive in South Park and in the playas of the San Luis Valley. Greasewood shrubs are present within the playas where they grow on low sand dunes on the playa bottom or in a band along the upper playa margins.

Wetland / Riparian Plant Finder 10:
Wetland- Montane and Subalpine Salt Meadows

(dominant species in bold type)

GRAMINOIDS	
Alopecurus aequalis	**shortawn foxtail**
Carex nebrascensis	**Nebraska sedge**
Carex douglasii	Douglas' sedge
Distichlis spicata	**inland saltgrass**
Eleocharis palustris	**common spike-rush**
Hordeum jubatum	**foxtail barley**
Juncus arcticus	**arctic rush**
Juncus nodosus	jointed rush
Juncus saximontanus	Rocky Mountain rush
Juncus torreyi	Torrey's rush
Muhlenbergia asperifolia	**alkali muhly**
Pascopyrum smithii	**western wheatgrass**
Puccinellia airoides	Nuttall's alkali grass

Wetland / Riparian Plant Finder 10:
Wetland- Montane and Subalpine Salt Meadows
(dominant species in bold type)

GRAMINOIDS (continued)	
Stipa viridula	green needlegrass
Sporobolus airoides	**alkali sacaton**
Triglochin concinna	low arrow-grass
Triglochin maritima	maritime arrow-grass
FORBS	
Asclepias speciosa	showy milkweed
Brachyactis ciliata	alkali rayless aster
Brachyactis frondosa	leafy rayless aster
Iva axillaris	povertyweed
Oenothera elata	Hooker's evening-primrose
Oenothera villosa	hairy evening-primrose
Solidago canadensis	Canada goldenrod
Suaeda calceoliformis	Pursh seepweed
Suaeda moquini	Mojave seablite
Suaeda nigra	black seablite
TREES AND SHRUBS	
Atriplex argentea	silverscale saltbush
Chrysothamnus nauseosus	rubber rabbitbrush
Sarcobatus vermiculatus	greasewood

FENS

Fens occur on organic soils nourished by both surface runoff and groundwater sources. They can be found in relatively flat, constantly wet mountain valleys. Peat accumulation in fens occurs slowly, at a rate of about eight inches every 1,000 years (Cooper and Jones 1993). Rich fens, fens on soils rich in calcium carbonate and other salts, are extremely rare in Colorado, but are most common in South Park. Sedges, spike rush, tufted hairgrass and Canadian reedgrass dominate these wetlands. Colorful patches of marsh marigold, elephantella, queen's crown, king's crown and other wildflowers occur in many fens. In some of the wetter areas, only one or two species of sedge may dominate the entire site.

➲ The U. S. Fish and Wildlife Service is in the process of listing fens as Resource Categories 1 or 2 of the FWS Mitigation Policy (Federal Register, Volume 46, Number 15, 1981). Since these wetlands are essentially irreplaceable (they take hundreds or thousands of years to develop), the FWS mitigation goal is no net loss of existing habitat value or no net loss of in-kind habitat value, depending on the richness of the wetland being evaluated (USFWS 1997).

ALPINE WETLANDS

Alpine habitats are those that occur above treeline, where vegetation patterns are controlled by snow retention, wind desiccation and permafrost (Galatowitsch 1988). Alpine wetlands occur where permanent snow fields provide a steady source of water through the growing season. They are highly variable, ranging from late-lying snowbed communities to communities surrounding permanent pools. Alpine wetland and riparian communities occur at the highest elevations in the Rocky Mountains, near or above treeline and are similar on both the east and west slopes.

Tips for alpine projects

Due to the high elevation, harsh environmental conditions, and difficult access, planting in the alpine zone presents special complications.

- Short growing seasons and cold temperatures limit plant growth rates, slowing establishment and visible progress of revegetation.
- Few high altitude native plant materials are available from commercial suppliers.
- Very little information regarding the germination requirements of native high-altitude species is available. High altitude species are even less likely than lower altitude native species to conform to the desired "garden model" of rapid germination and vigorous establishment.

The severe environmental conditions of high elevations can devastate carefully acquired/propagated plant materials. Among the most harmful factors are wildlife browsing (including pocket gophers), summer freezes, snowmold and frost-heaving especially during spring when young seedlings trapped in a frozen surface soil layer are often ripped out of the ground by ice crystals growing from below.

- Below treeline and in the moister, less windy alpine communities, plants listed in the Plant Finders can perform well if seeded in the fall and provided with a durable mulch cover such as bonded fiber matrix or well-anchored excelsior or other organic mats.

- In moderately windy sites, establishment must be done via planting rather than seeding. Appropriate species for such sites are not ordinarily available (e.g., Bellardi kobresia *(Kobresia myosuroides)*, or blackroot sedge *(Carex elynoide*s)) and must be propagated by special order. Mulches in these sites must be more carefully applied than those in sheltered sites.

- In the most exposed alpine sites (fellfields), prospects of successful revegetation within a decade are small. Success is likely to result from custom propagation of fellfield native species, careful positioning relative to microtopography, and subtle use of microtopographic objects such as rocks to produce a moderate, but not overly protected microsite for the plantings.

For more information, see Proceedings of the High Altitude Revegetation Workshops, Willard 1972.

ALPINE SNOW GLADES

Alpine snow glades occur in areas with late-season snow retention, where snow cover protects plants from winter frost, shortens the growing season and provides moisture during the growing season (Galatowitsch 1988). Characteristic species of snow glades include tufted hairgrass, phippsia, black sedge, avens, alpine sagewort and daisy fleabane.

Wetland / Riparian Plant Finder 11: Wetland- Alpine Snow Glades

(dominant species in bold type)

GRAMINOIDS	
Carex crandallii	**Pyrenean sedge**
Carex nigracans	**black sedge**
Deschampsia cespitosa	**tufted hairgrass**
Juncus drummondii	Drummond's sedge
Phippsia algida	phippsia
Phleum communtatum	alpine timothy
FORBS	
Artemisia scopulorum	alpine sagewort
Erigeon melanocephalus	black-headed daisy
Erigeron simplex	onestem fleabane
Geum rossii var. *turbinatum*	alpine avens
Ranunculus adoneus	snow buttercup
Sibbaldia procumbens	sibbaldia
SHRUBS	
Salix arctica	arctic willow

ALPINE WET MEADOWS

Alpine wet meadows occur below persistent snow drifts, behind solifluction terraces, over permafrost and around cirque or tarn lakes and ponds (Galatowitsch 1988, Peale 1996). Solifluction depressions (nivation depressions) and pools also accumulate water from summer thunderstorms, greatly augmenting available soil moisture (Willard 1979). Characteristic alpine wet meadow species include tufted hairgrass, Nelson's sedge, mountain sedge , Drummond rush , marsh marigold, alpine bistort, elephantella, and Parry's primrose.

Wetland / Riparian Plant Finder 12: Wetland- Alpine Wet Meadows

(dominant species in bold type)

GRAMINOIDS	
Carex crandallii	**Pyrenean sedge**
Carex nelsoni	**Nelson's sedge**
Carex scopulorum	**mountain sedge**
Deschampsia cespitosa	**tufted hairgrass**

Wetland / Riparian Plant Finder 12: Wetland- Alpine Wet Meadows

(dominant species in bold type)

GRAMINOIDS (continued)

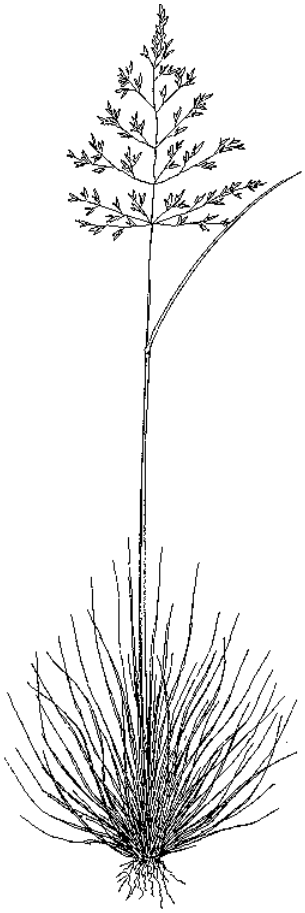
Juncus castaneus	chestnut rush
Juncus drummondii	**Drummond's rush**

FORBS

Polygonum bistortoides	American bistort
Polygonum viviparum	**alpine bistort**
Caltha leptosepala	**marsh marigold**
Clementsia rhodantha	queen's crown
Epilobium anagadallidifolium	alpine willowherb
Pedicularis groenlandica	elephantella
Primula parryi	Parry's primrose

SHRUBS

Salix planifolia	planeleaf willow



Deschampsia cespitosa

RIPARIAN COMMUNITIES

Along mountain streams, discontinuous patches of forest intermix with shrub communities and herbaceous wetlands. Forests of narrowleaf cottonwood, river birch, mountain alder, and clumps of aspen occur along the banks of the Colorado streams. Along permanent streams in cooler canyons, blue spruce, Douglas-fir, and white fir (southern Colorado) anchor the banks. At higher elevations, Englemann spruce becomes the dominant tree. Dense thickets of shrub willows, red-osier dogwood and gooseberries occur under the forest canopy. Wildflowers such as cow parsnip, chimingbells, monkshood and bittercress form a dense, showy understory along many mountain streams.

In open, unforested areas, dense patches of willow shrubs, bog birch and shrubby cinquefoil may form. Sedges, rushes, and grasses such as tufted hairgrass grow in grassy strips on the banks of many streams, especially where grazing occurs. In the subalpine, communities of chimingbells, monkeyflower, bittercress and other wildflowers cover the banks of small streams.

Notes on riparian projects

Hydrology and stream dynamics are critical factors for the success of riparian projects. The work needed to restore proper functioning will depend on the current condition of the stream and the riparian vegetation. Questions to consider include

- Would changes in land use (i.e., changes in grazing season or stocking numbers, closing or moving trails, etc.) be sufficient to improve stream functioning and riparian vegetation?
- Is stream hydrology suitable to support the planned changes?

For some of the many available references on riparian projects, see American Fisheries Society 1982, Briggs 1995 and 1996, Clary 1996, Crumpacker 1985, Hughes 1996, and Schultze 1984.

WILLOW CARRS

Willow carrs occur on organic soils along montane and subalpine streams, on broad floodplains inundated by beaver dams, around the edges of sedge-dominated fens, and around glacial lakes and on solifluction terraces in the alpine zone.

MONTANE CARRS

In the montane zone, willow carrs occur adjacent to meandering streams on broad floodplains often inundated by beaver dams. Tall willows, in various combinations, often dominate these communities. Typical tall willow species include Drummond's willow, Geyer's willow, planeleaf willow, shining willow and mountain willow. Barrenground willow, Wolf's willow and bog birch may be present, but more commonly occur at higher elevations. Water sedge, beaked sedge and bluejoint reedgrass are common in the understory along with a variety of forbs.

SUBALPINE CARRS

In the subalpine, planeleaf willow is usually the dominate species of willow carrs; bog birch, Wolf's willow and barrenground willow may also be important. These species may form short, but nearly impenetrable thickets around small glacial lakes or on poorly-drained soils along streams. Shrubby cinquefoil may form a ring around the edge of the willow carrs, especially in heavily grazed areas. Understory vegetation may be sparse where willows are dense or may be extremely dense and diverse. Elephantella, marsh marigold, globe flower, water and beaked sedges are common understory species. Many other species, not listed here, may be found in native willow communities.

Wetland / Riparian Plant Finder 13:
Riparian – Willow Carrs
(dominant species in bold type)

GRAMINOIDS	
Alopecuris alpinus	shortawn foxtail
Calamagrostis canadensis	bluejoint reedgrass
Carex aquatilis	**water sedge**
Carex lanuginosa	woolly sedge
Carex nebrascencis	Nebraska sedge
Carex scopulorum	mountain sedge
Carex utriculata	**beaked sedge**
Deschampsia cespitosa	**tufted hairgrass**
Eleocharis palustris	common spike-rush
Eleocharis quinqueflora	fewflower spike-rush
Juncus arcticus	**arctic rush**
Juncus castaneus	chestnut rush
Juncus confusus	Colorado rush
Juncus longistylis	longstyle rush
Juncus mertensianus	Merten's rush
Juncus parryi	Parry's rush
Juncus saximontanus	Rocky Mountain rush
Luzula parviflora	smallflowered woodrush
Muhlenbergia filiformis	pullup muhly

Wetland / Riparian Plant Finder 13: Riparian – Willow Carrs

(dominant species in bold type)

GRAMINOIDS (continued)	
Phleum commutatum	**alpine timothy**
Poa leptocoma	bog bluegrass
Poa palustris	fowl bluegrass
Poa reflexa	nodding bluegrass
FORBS	
Allium geyeri	Geyer's onion
Allium schoenoprasum	wild chives
Androsace filiformis	filiform rock-jasmine
Antennaria corymbosa	flattop pussytoes
Antennaria rosea	rosy pussytoes
Anticlea elegans	mountain death camas
Astragalus alpinus	alpine milkvetch
Polygonum bistortoides	**American bistort**
Polygonum vivipara	alpine bistort
Caltha leptosepala	**marsh marigold**
Cardamine cordifolia	heartleaf bittercress
Clementsia rhodantha	**queen's crown**
Delphinium barbeyi	tall larkspur
Epilobium saximontanum	Rocky Mountain willow-herb
Erigeron peregrinus	subalpine fleabane
Geum macrophyllum	largeleaf avens
Heracleum sphondylium	cow-parsnip
Iris missouriensis	Rocky Mountain iris
Pedicularis groenlandica	**elephantella**
Polemonium foliosissimum	towering Jacob's ladder
Potentilla pensylvanica	Pennsylvania cinquefoil
Rhodiola integrifolia	king's crown
Senecio integerrimus	lambstongue groundsel
Swertia perennis	star gentian
Thermopsis montana	mountain thermopsis
Trollius laxas	**American globe-flower**
Valeriana edulis	edible valerian
Valeriana occidentalis	western valerian
Veronicastrum serpyllifolium	thyme-leaved speedwell
TREES AND SHRUBS	
Betula glandulosa	**bog birch**
Kalmia microphylla	alpine laurel
Pentaphylloides floribunda	**shrubby cinquefoil**
Ribes lacustre	prickly currant
Salix brachycarpa	**barrenground willow**
Salix drummondiana	**Drummond's willow**
Salix geyeriana	**Geyer's willow**
Salix monticola	**mountain willow**
Salix planifolia	**planeleaf willow**
Salix wolfii	**Wolf's willow**
Vaccinium cespitosum	dwarf blueberry

RIPARIAN FORESTS

Riparian plant communities consist largely of deciduous forests on lower montane streams and rivers and evergreen forests of higher elevations. Characteristic tree species of the montane zone include narrowleaf cottonwood, Douglas-fir or aspen. Commonly associated understory species include river birch, alder, red-osier dogwood, bush honeysuckle, and sandbar, mountain, Drummond's, Geyer's, and shining willow. Higher elevations are characterized by quaking aspen, Engelmann spruce and subalpine fir; Colorado blue spruce and white fir are common in both zones in southern Colorado. The shrub and herbaceous layers in subalpine riparian forests tend to be extremely lush and diverse. Since they vary considerably from one site to another, only a few of the herbaceous species in the Plant Finder are listed in bold. Many of the understories species from the montane are also found in subalpine riparian forests.

Wetland / Riparian Plant Finder 14: Riparian – Montane and Subalpine Forests

(dominant species in bold type)

GRAMINOIDS	
Alopecuris alpinus	shortawn foxtail
Calamagrostis canadensis	**bluejoint reedgrass**
Calamagrostis stricta	slimstem reedgrass
Carex aquatilis	water sedge
Carex utriculata	beaked sedge
Deschampsia cespitosa	tufted hairgrass
Eleocharis palustris	common spike-rush
Juncus arcticus	arctic rush
Juncus confusus	Colorado rush
Juncus longistylis	longstyle rush
Juncus mertensianus	Merten's rush
Juncus saximontanus	Rocky Mountain rush
Luzula parviflora	smallflowered wood-rush
Phleum commutatum	alpine timothy
Poa leptocoma	bog bluegrass
Poa palustris	fowl bluegrass
Poa reflexa	nodding bluegrass
FORBS	
Allium geyeri	Geyer's onion
Allium schoenoprasum	wild chives
Cardamine cordifolia	heartleaf bittercress
Clementsia rhodantha	queen's crown
Delphinium barbeyi	tall larkspur
Erigeron peregrinus	subalpine fleabane
Frasera speciosa	monument-plant
Galium septentrionale	northern bedstraw
Galium trifidum	threepetal bedstraw
Geranium viscosissimum	sticky purple geranium
Heracleum sphondylium	**cow-parsnip**

Wetland / Riparian Plant Finder 14: Riparian – Montane and Subalpine Forests

(dominant species in bold type)

FORBS (continued)	
Iris missouriensis	Rocky Mountain iris
Ligusticum porteri	**Porter's licoriceroot**
Micranthes odontoloma	brook saxifrage
Pedicularis groenlandica	elephantella
Pedicularis procera	giant lousewort
Potentilla pensylvanica	Pennsylvania cinquefoil
Rudbeckia hirta	**black-eyed susan**
Senecio serra	**tall ragwort**
Senecio triangularis	**arrowleaf groudsel**
Thermopsis montana	mountain thermopsis
Valeriana edulis	edible valerian
Valeriana occidentalis	western valerian
Veronicastrum serpyllifolium	thyme-leaved speedwell
Vicia americana	American vetch
TREES AND SHRUBS	
Abies concolor	**white fir**
Abies lasiocarpa	**subalpine fir**
Acer glabrum	**Rocky Mountain maple**
Acer negundo	box elder
Alnus incana	**thinleaf alder**
Betula occidentalis	**water birch**
Crataegus rivularis	river hawthorn
Lonicera involucrata	**twinberry honeysuckle**
Pentaphylloides floribunda	**shrubby cinquefoil**
Picea engelmannii	**Engelmann spruce**
Picea pungens	**blue spruce**
Populus angustifolia	**narrowleaf cottonwood**
Populus tremuloides	**quaking aspen**
Prunus virginiana	black chokecherry
Ribes lacustre	**prickly currant**
Ribes montigenum	**gooseberry currant**
Salix brachycarpa	barrenground willow
Salix drummondiana	**Drummond's willow**
Salix geyeriana	**Geyer's willow**
Salix lucida	shining willow
Salix monticola	**mountain willow**
Salix planifolia	planeleaf willow
Salix wolfii	Wolf's willow
Seriphidium canum	silver sagebrush

ALPINE RIPARIAN COMMUNITIES

Herbaceous riparian communities occur in the tundra along the headwaters of streams. These narrow bands of lush vegetation are composed primarily of forb species with occasional graminoids.

Wetland / Riparian Plant Finder 15: Riparian- Alpine Riparian Communities

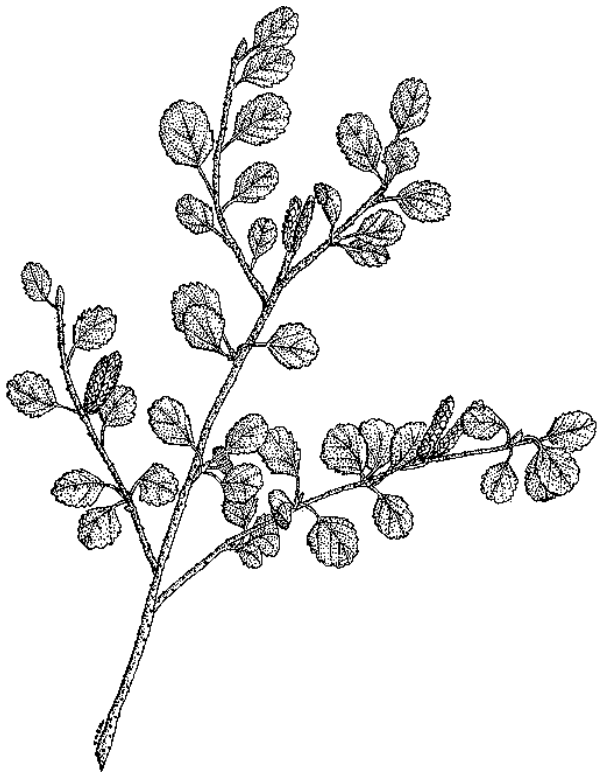
(dominant species in bold type)

GRAMINOIDS

Deschampsia cespitosa	tufted hairgrass

FORBS

Cardamine cordifolia	**heartleaf bittercress**
Delphinium barbeyi	**tall larkspur**
Epilobium anagallidifolium	alpine willowherb
Erigeron peregrinus	subalpine fleabane
Mertensia ciliata	**mountain bluebells**
Primula parryi	Parry's primrose
Senecio triangularis	**arrowleaf groundsel**



Betula glandulosa

WESTERN PLATEAU AND CANYON REGION

The landforms of western Colorado are an interesting mosaic of mountains (Uinta, Park, Gore, Elk, Sawatch and San Juan Ranges), mesas (Battlement and Grand), plateaus (White River, Roan and Uncompahgre), and basins (Wyoming, Piceance and San Juan). Major river systems draining the region and sometimes forming large canyons and valleys, include the Yampa, White, Colorado, Gunnison, Dolores and Animas. Wetland and riparian communities are as varied as the terrain; many are extremely saline or alkaline and are described more fully below.

WETLANDS

Notes on wetland projects

For wetland creation or restoration, hydrology is all important. Some questions to consider are

- What is the source of water for the wetland and how reliable is it?
- How much water is available and for how long during the year?
- Will wetland plants establish naturally or are manipulation of the hydrology and seeding and planting necessary?

Study the arrangement of the plants in wetlands. Different plants grow in different amounts of water or in soils with different saturation levels. As a result, rings of different plant species often form around ponds or playas. For that reason, shallowly graded slopes around ponds will provide more wetland habitat than steep slopes.

There are many references on wetland restoration and creation. A few which are listed in the reference section include Haskisaki 1996, Kusler and Kentula 1990, Mutz et al. 1988, Peale 1996, and Schneller-McDonald 1990.

MARSHES

Freshwater marshes occur in water less than 1.5 feet (0.5 m) deep and on adjacent saturated soils. Typical associated plant species include softstem bulrush, broad-leaved cattail, spike-rush, Arctic rush and arrowhead. Alkaline and saline marshes are characterized by hardstem and three-square bulrush, narrow-leaved cattail and arctic rush, growing on periodically saturated soils. Submergent and floating aquatic plants occur where water is deeper than 1.5 feet (0.5 m), and are characterized by pondweeds, bladderwort, water milfoil and water crowfoot.

Wetland / Riparian Plant Finder 16: Wetland - Freshwater Marshes

(dominant species in bold type)

GRAMINOIDS

Beckmannia syzigachne	American sloughgrass
Carex aquatilis	**water sedge**
Carex utriculata	**Northwest territory sedge**
Eleocharis palustris	**common spike-rush**
Glyceria grandis	American mannagrass
Juncus arcticus	**mountain rush**
Juncus longistylis	longstyle rush
Juncus nodosus	jointed rush
Juncus torreyi	Torrey's rush
Persicaria coccinea	scarlet smartweed
Scirpus acutus	**hardstem bulrush**
Scirpus pungens	**three-square bulrush**
Scirpus maritimus	saltmarsh bulrush
Scirpus microcarpus	panicled bulrush
Typha latifolia	**broadleaf cattail**

FORBS

Alisma triviale	northern water plantain
Lycopus americanus	American water horehound
Lycopus asper	rough bugleweed
Sagittaria cuneata	arumleaf arrowhead
Sagittaria latifolia	broadleaf arrowhead

Wetland / Riparian Plant Finder 17: Wetland - Alkaline Marshes

(dominant species in bold type)

GRAMINOIDS

Carex nebrascensis	**Nebraska sedge**
Eleocharis palustris	**common spike-rush**
Juncus arcticus	**arctic rush**
Juncus compressus	roundfruit rush
Juncus torreyi	Torrey's rush
Puccinellia airoides	**alkali grass**
Scirpus acutus	**hardstem bulrush**
Scirpus nevadensis	**alkali bulrush**
Scirpus maritimus	**saltmarsh bulrush**
Triglochin concinna	low arrow-grass
Triglochin maritima	maritime arrow-grass
Typha angustifolia	**narrow-leaved cattail**

FORBS

Glaux maritima	sea milkwort
Halerpestes cymbalaria	alkali crowfoot
Persicaria coccinea	scarlet smartweed
Potamogeton pectinatus	sago pondweed
Rumex maritimus	golden dock

MEADOWS

WET MEADOWS

Wet meadows often surround marshes, occupying saturated to moist soils. Plant species present reflect the degree of alkalinity or salinity; when the pH is near-neutral to slightly alkaline, Nebraska sedge, arctic rush, common spike-rush and Torrey's rush are common species.

Wetland / Riparian Plant Finder 18: Wetland – Marsh Margins and Wet Meadows

(dominant species in bold type)

GRAMINOIDS	
Alopecuris aequalis	shortawn foxtail
Carex emoryi	Emory's sedge
Carex lanuginosa	**woolly sedge**
Carex nebrascensis	**Nebraska sedge**
Eleocharis palustris	**common spike-rush**
Hordeum jubatum	**foxtail barley**
Juncus arcticus	**arctic rush**
Juncus confusus	Colorado rush
Juncus longistylis	longstyle rush
Juncus nodosus	jointed rush
Juncus saximontanus	Rocky Mountain rush
Juncus torreyi	Torrey's rush
Panicum virgatum	switchgrass
Pascopyrum smithii	western wheatgrass
Stipa viridula	green needlegrass
FORBS	
Apocynum cannabinum	Indian hemp
Asclepias speciosa	showy milkweed
Cicuta douglasii	western water hemlock
Cyclachaena xanthifolia	marsh-elder
Epilobium ciliatum	willow-herb
Gaura parviflora	velvetweed
Glycyrrhiza lepidota	wild licorice
Helianthus nuttallii	Nuttall's sunflower
Mentha arvensis	wild mint
Mimulus glabratus	monkey-flower
Monolepis nuttalliana	Nuttall's povertyweed
Oenothera elata	Hooker's evening-primrose
Rorippa palustris	yellowcress
Rorippa sinuata	spreading yellowcress
Rorippa teres	southern marsh yellowcress
Rumex hymenosepalus	canaigre dock
Scrophularia lanceolata	lanceleaf figwort

Wetland / Riparian Plant Finder 18:
Wetland – Marsh Margins and Wet Meadows

(dominant species in bold type)

FORBS (continued)	
Senecio hydrophilus	water groundsel
Solidago canadensis	**Canada goldenrod**
Stachys palustris	marsh hedge-nettle
Veronica americana	American speedwell
TREES AND SHRUBS	
Pentaphylloides floribunda	shrubby cinquefoil
Rosa woodsii	Wood's rose
Salix exigua	**sandbar willow**

SALT MEADOWS

Where the sites are moderately to highly alkaline or saline, saltgrass, alkali sacaton, alkali-grass, alkali cordgrass, meadow foxtail, foxtail barley, three-square bulrush, sea-blite and arrowgrass are typically present. Moist to wet swales and seeps also support the characteristic plant species identified in the above discussion.

Wetland / Riparian Plant Finder 19:
Wetland – Alkaline Marsh Margins and Salt Meadows

(dominant species in bold type)

GRAMINOIDS	
Alopecurus aequalis	**shortawn foxtail**
Carex nebrascensis	**Nebraska sedge**
Distichlis spicata	**inland saltgrass**
Eleocharis palustris	**common spike-rush**
Hordeum jubatum	**foxtail barley**
Juncus arcticus	**arctic rush**
Juncus nodosus	jointed rush
Juncus saximontanus	Rocky Mountain rush
Juncus torreyi	Torrey's rush
Muhlenbergia asperifolia	**alkali muhly**
Panicum virgatum	switchgrass
Pascopyrum smithii	**western wheatgrass**
Puccinellia airoides	Nuttall's alkali grass
Sporobolus airoides	**alkali sacaton**
Stipa viridula	green needlegrass
Triglochin concinna	low arrow-grass
FORBS	
Asclepias speciosa	showy milkweed
Brachyactis ciliata	alkali rayless aster
Brachyactis frondosa	leafy rayless aster
Gaura parviflora	velvetweed
Glaux maritima	sea milkwort

Wetland / Riparian Plant Finder 19: Wetland – Alkaline Marsh Margins and Salt Meadows

(dominant species in bold type)

FORBS (continued)

Glycyrrhiza lepidota	wild licorice
Helianthus nuttallii	Nutall's sunflower
Iva axillaris	povertyweed
Oenothera elata	Hooker's evening-primrose
Oenothera villosa	hairy evening-primrose
Solidago canadensis	Canada glodenrod
Suaeda calceoliformis	Pursh seepweed
Suaeda moquini	Mojave seablite
Suaeda nigra	black seablite

TREES AND SHRUBS

Atriplex argentea	silverscale saltbush
Rosa woodsii	Wood's rose
Sarcobatus vermiculatus	greasewood

Distichlis spicata

RIPARIAN COMMUNITIES

Typically, riparian forests and shrubland communities of lower elevations of the Western Plateau and Canyon region occur on low terraces and floodplains. In the foothills, streams tend to be narrower with swifter flowing water. Water levels on these streams may fluctuate widely during the year, from several feet above the stream bottom during spring and after thunderstorms to dry or a small trickle in the fall. Riparian areas often include a mosaic of vegetation types, with wetlands at stream edges, in backwater areas, or old oxbows, and upland vegetation interspersed with riparian species.

Notes on riparian projects

Hydrology and stream dynamics are critical factors for the success of riparian projects. The work needed to restore proper functioning will depend on the current condition of the stream and the riparian vegetation. Questions to consider include

- Would changes in land use (i.e., changes in grazing season or stocking numbers, closing or moving trails, etc.) be sufficient to improve stream functioning and riparian vegetation?
- Is stream hydrology suitable to support the planned changes?

For some of the many available references on riparian projects, see American Fisheries Society 1982, Briggs 1995 and 1996, Clary 1996, Crumpacker 1985, Hughes 1996, and Schultze 1984.

COTTONWOOD/WILLOW FORESTS

Riparian plant communities consist largely of deciduous forests on lower river terraces and floodplains, dominated by Fremont cottonwood in the lower elevations and narrowleaf cottonwood along moderate-gradient streams above about 6,000 feet (1829 meters) elevation. Commonly associated shrubs at lower elevations include skunkbush sumac, rabbitbrush, sandbar willow, and groundsel-tree; at higher elevations, box-elder and Douglas-fir trees, and sandbar willow, Woods' rose, river birch, alder, and red-osier dogwood are typical species in riparian communities. Many of these communities have been invaded by nonnative salt-cedar, Russian-olive and Siberian elm.

Wetland / Riparian Plant Finder 20:
Riparian – Floodplains and Terraces
(dominant species in bold type)

GRAMINOIDS	
Distichlis spicata	inland saltgrass
Hordeum jubatum	foxtail barley
Juncus arcticus	arctic rush
Panicum virgatum	switchgrass
Pascopyron smithii	western wheatgrass
Spartina pectinata	prairie cordgrass

Wetland / Riparian Plant Finder 20: Riparian – Floodplains and Terraces

(dominant species in bold type)

FORBS

Apocynum cannabinum	Indian hemp
Clematis ligusticifolia	western white clematis
Cyclachaena xanthifolia	marsh-elder
Glycyrrhiza lepidota	wild licorice
Hydrophyllum fendleri	Fendler's waterleaf
Iris missouriensis	Rocky Mountain iris
Maianthemum stellatum	starry false Solomon's seal
Mentha arvensis	wild mint
Monarda fistulosa	wildbergamot beebalm
Potentilla rivalis	brook cinquefoil
Solidago canadensis	Canada goldenrod

TREES AND SHRUBS

Acer negundo	**box-elder**
Amorpha fruiticosa	desert indigobush
Artemisia tridentata ssp. *tridentata*	big sagebrush
Baccharis salicina	Great Plains false-willow
Celtis reticulata	netleaf hackberry
Chrysothamnus nauseosus	rubber rabbitbrush
Chrysothamnus viscidiflorus	green rabbitbrush
Forestiera pubescens	stretchberry
Juniperus scopulorum	Rocky Mountain juniper
Prunus virginiana	**black chokecherry**
Populus angustifolia	**narrowleaf cottonwood**
Populus deltoides ssp.*wizlizenii*	**Fremont cottonwood**
Populus tremuloides	quaking aspen
Rhus trilobata	skunkbush sumac
Ribes aureum	golden currant
Rosa woodsii	Woods' rose
Salix amygdaloides	**peachleaf willow**
Salix bebbiana	**Bebb willow**
Salix exigua	**sandbar willow**
Salix *lucida*	shining willow

Wetland / Riparian Plant Finder 21: Riparian – Foothills and Canyons

(dominant species in bold type)

GRAMINOIDS

Glyceria grandis	American mannagrass
Glyceria striata	fowl mannagrass
Hordeum jubatum	foxtail barley
Juncus arcticus	**arctic rush**
Pascopyron smithii	western wheatgrass

Wetland / Riparian Plant Finder 21: Riparian – Foothills and Canyons

(dominant species in bold type)

GRAMINOIDS (continued)

Poa palustris	fowl bluegrass
Stipa viridula	green needlegrass

FORBS

Apocynum cannabinum	Indian hemp
Clematis ligusticifolia	western white clematis
Cyclachaena xanthifolia	marsh-elder
Epilobium angustifolium	fireweed
Equisetum arvense	field horsetail
Glycyrrhiza lepidota	wild licorice
Heracleum sphondylium	cow-parsnip
Hydrophyllum fendleri	Fendler's waterleaf
Iris missouriensis	Rocky Mountain iris
Maianthemum stellatum	starry false Solomon's seal
Mentha arvensis	wild mint
Mertensia ciliata	mountain bluebells
Monarda fistulosa	wildbergamot beebalm
Potentilla rivalis	brook cinquefoil
Solidago canadensis	Canada goldenrod
Veratrum tenuipetalum	Colorado false hellebore
Vicia americana	American vetch

TREES AND SHRUBS

Acer glabrum	**Rocky Mountain maple**
Acer negundo	box-elder
Alnus incana	**thinleaf alder**
Betula occidentalis	water birch
Crataegus rivularis	river hawthorn
Lonicera involucrata	twinberry honeysuckle
Picea pungens	Colorado blue spruce
Populus angustifolia	**narrowleaf cottonwood**
Populus deltoides	plains cottonwood
Populus tremuloides	quaking aspen
Prunus virginiana	**black chokecherry**
Pseudotsuga menziesii	Douglas-fir
Ribes aureum	golden currant
Ribes cereum	**wax currant**
Rosa woodsii	**Woods' rose**
Rubacer parviflorum	thimbleberry
Salix amygdaloides	**peachleaf willow**
Salix bebbiana	Bebb willow
Salix exigua	**sandbar willow**
Salix lucida	shining willow
Salix monticola	mountain willow

WETLAND REVEGETATION TECHNIQUES

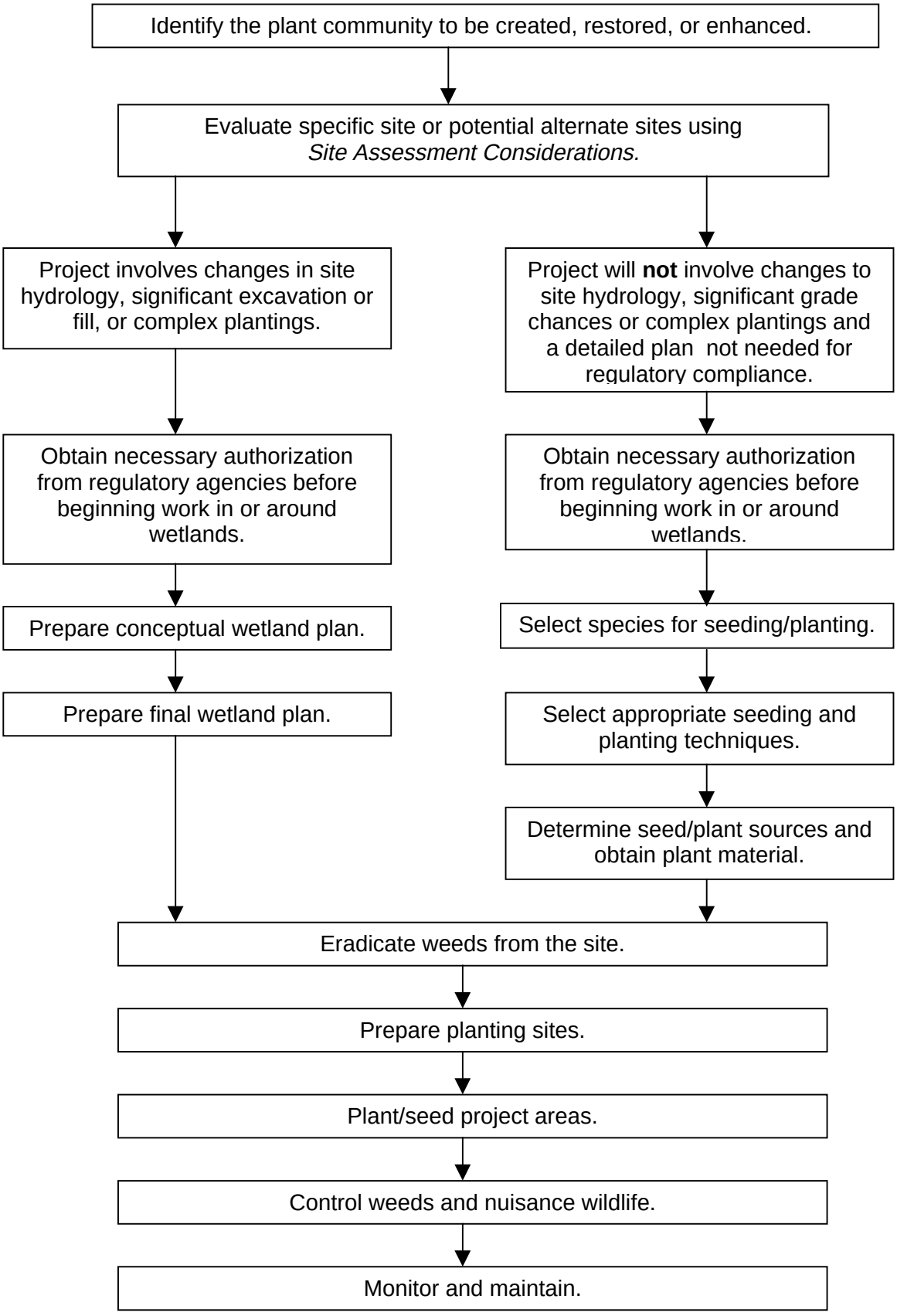
This section is divided into five steps:

WETLAND PROJECTS:
REGULATORY COMPLIANCE & COMPENSATORY MITIGATION

Regulatory agencies such as the Corps of Engineers and the Environmental Protection Agency may require an applicant for a wetlands permit to construct, restore, or enhance wetlands to compensate for impacts to other wetlands. This guide provides information that can help you carry out such a project. However it is not meant as specific guidance for regulatory compliance. Always make sure that you have contacted the appropriate regulatory agency to understand their requirements for planning, implementing and monitoring the construction of a compensatory wetland project. A list of agency contacts is included in Appendix VII on page 255.

The following flow-chart presents the steps which are required for successful completion of a wetlands creation/restoration/enhancement project. The path you take will depend upon your goals for the project. The sequence of procedures will depend on the current condition of the project site. The following sections provide more detailed information on each step.

STEP 1: PLANNING YOUR PROJECT



STEP 2: SITE SELECTION

The success of a project depends on selecting a suitable site which will meet the goals and objectives of your wetland plan. In many cases, especially for simple revegetation projects, you may only be considering a single potential site for your project. For compensatory wetland projects, on-site mitigation of wetlands with similar functions (in-kind) is preferred. On-site replacement is not always possible, however, and you must find a suitable site for your project.

You should collect sufficient information for each project to

- identify possible sites
- compare the features of these sites
- estimate construction costs

The extent of site evaluation will depend on the type and size of the proposed project. Coordinate with other resource or regulatory agencies involved in the project.

Resource agencies may at times prefer off-site, out-of-kind mitigation if it creates a wetland type with higher value. If on-site, in-kind areas cannot be found, the preference is for replacement sites in the same watershed to avoid red-tape. For instance, consumptive water loss due to evapo-transpiration from created wetlands in another watershed may mandate the acquisition of adjudicated water rights.

SITE ASSESSMENT CONSIDERATIONS

Site selection and evaluation involves collecting and analyzing information on such items as hydrology, soils, topography, biology, land ownership and use, and construction feasibility.

HYDROLOGY

Evaluating the hydrology of the site involves understanding surface and groundwater locations, quantity and quality of water, surface and subsurface flow patterns and seasonal fluctuations (Hammer 1992).

Surface water

The amount and type of surface water available will influence the type and size of the wetland project. Items to consider when looking at a surface water wetland site include

- Maintaining water levels will be difficult or impossible if surface run-off is inadequate and alternative water sources are not available.
- The amount of sediment entering the project area.
- The likelihood of flooding and the severity of subsequent erosion (Hammer 1992).

If there are lakes or streams near the project site, monitor water elevation, flow rate and seasonal fluctuations in order to quantify water levels. Flow volumes in streams and lakes are often monitored by the US Geological Survey, state governments, irrigation districts and

other agencies. Where previously recorded data are unavailable, collecting information yourself will be necessary (Cooper 1993).

The water surface elevation in relation to a site is important and can be determined by installing and monitoring staff gauges. These gauges are essentially sturdy rulers anchored in a non-turbulent portion of the stream. At a minimum, data should be collected bi-weekly during the growing season and monthly in late summer and fall. Winter monitoring is normally not necessary. Data should be collected for at least one year (Cooper 1993).

Ground Water

On wetland sites which will be supported by ground water, the review process must include on-site monitoring wells to measure ground water levels. Wells should be installed by someone who is experienced and qualified, and should be placed in a grid pattern across the potential site(s). The number of wells will depend on the size and complexity of the site.

During analysis and interpretation of data collected from wells, look for

- Seasonal fluctuations of water. A site which has a large fluctuation in water elevations may not be a suitable project location.
- Depth to ground water. The deeper the hole, the less feasible a site will be due to costs associated with excavation and the potential that the site is not large enough to contain the excavation.
- Precipitation records for the watershed to determine if data were collected during a wet or dry year (Cooper 1993).
- How the water table is distributed across the site, whether water is isolated or perched and how it flows.
- Whether ground water adjacent to a stream is flowing into ("gaining") or out of ("losing") the stream. In a "losing" stream situation, ground water decreases rapidly away from the stream and constructing a site will become a source of frustration. Wetland projects next to a "gaining" stream will typically be successful.

While reviewing the site, determine whether permanent structures or water diversions during construction will be needed to make the wetland successful. Project sites that require little or no future maintenance are preferred over those that use high-maintenance and man-made structures.

SOILS

Soils should be evaluated for permeability, erodability, texture, nutrients, pH and possible contaminants. Water holding capacity is influenced by soil texture, which will determine how long a soil will remain inundated. Coarse textured soils are more permeable than fine textured soils. Where soils are too porous, a clay liner, soil amendments or addition of topsoil may be needed to retain water. Such amendments will increase the cost of the project. Local soil surveys and soil testing labs (see page 72) can provide detailed analysis of soil samples. In many cases comparing the soils on your project site with the soil underlying an adjacent wetland can provide a good indication of the soil's ability to support a wetland.

TOPOGRAPHY

The site must be surveyed prior to designing the wetland. The survey should be completed using one foot contour intervals, and include elevations of any groundwater wells, stream staff gauges, locations of existing vegetation, fences, and utilities. Relief should be low compared to the water table or surface water in order to minimize the cost of grading and excavation.

BIOLOGY

The current ecological function and social value of a site (see page 114) must be considered during site evaluation. The project should not destroy any existing wetlands or detrimentally affect any threatened or endangered species, or aesthetic values. Construction should be timed to avoid disrupting nesting birds or wildlife. The plants and animals which currently occupy the site are a good indicator of site quality because they reflect the present conditions of soil, water, climate and land use.

If surveys for threatened and endangered species are required, this may delay the project until a time when planting is undesirable, migratory birds are present, wildlife is breeding or rearing young, fish are spawning, etc.

If a selected site is adjacent to an existing wetland, construction should not alter the water conditions of the wetland or cause sediment to run into the wetland. An existing, high quality wetland could provide a plant and seed source for the proposed site, but it may also serve as a seed source of invasive plants. Avoid building adjacent to weedy wetlands.

LAND OWNERSHIP AND USE

Information on land ownership, use (historical and present) and availability, costs, zoning, local ordinances and water rights is crucial to the site selection process. Adjacent land use is important; it could negatively affect the project's goals or the project may create conflicts for surrounding land uses. For example, selecting a site next to a highway where run-off is heavily laden with roadway salts and sediments could shorten the life of the wetland. Wildlife attracted to a roadside wetland could become a hazard to travelers on the road.

CONSTRUCTION AND MAINTENANCE

Construction feasibility is an important component of site selection. Is the site accessible? Will temporary roads or stream crossings have to be built? Will a temporary or permanent right-of-way agreement be required? Will material being excavated from the site have to be hauled away or can it be used on-site?

If maintenance will be required on the proposed wetland, consider the cost of maintaining the wetlands, availability of personnel and equipment to maintain the site and site access for maintenance (gates, roads, fencing, etc.).

OTHER CONSIDERATIONS

Additional factors which should be considered in the site selection process include

- Proximity to potential disturbances or impacts.
- Utility conflicts and relocation requirements.

- Need to fence and protect the site from wildlife, livestock, or people.
- Regulatory considerations, agency concerns and permit requirements.
- Presence of archeological or historical sites.
- Anticipated costs.
- Existence of benchmarks.
- Educational components for land managers.
- The public.

STEP 3: DEVELOPING A SITE SPECIFIC PLAN

SETTING YOUR GOALS: CREATION, RESTORATION OR ENHANCEMENT

CREATION OF A WETLAND

Creation is defined as human modification of the environment in areas which would not otherwise support wetland or riparian habitats. Wetland creation can be very complicated, and successful projects require the following practices.

> In the creation, restoration, and/or enhancement of wetland and riparian habitats, the most basic and important need is to understand the hydrology (Zedler and Weller 1989).

- Collect baseline data on ground and surface water throughout the growing season for at least one year.
- Compare the data collection year with long-term records to determine if it was average, wet, or dry.
- Design for a self sustaining wetland.
- Understand the water and shade tolerance of the species that you wish to introduce.
- Grade the site for average water levels.
- Create topographic relief to account for hydrologic variability.
- Create a spectrum of habitats from shallow water (up to 3 feet (0.9 m) deep), to moist soils, to soils with subsurface hydrology up to 2 to 5 feet (0.6 to 1.5 m) below the surface.
- Seal the bottoms of dammed ponds or lakes if you wish to avoid an increase in water levels below the dam over time.

More detail is provided later in this section.

RESTORATION OF A WETLAND

Restoration is generally defined as the process of returning a site from a disturbed or totally altered condition to a previously existing or natural condition. As for creation projects, there are practices that help assure success in restoration.

- Collect baseline data on ground and surface water throughout the growing season for at least one year.
- Remember that fertilizers are rarely necessary or helpful.
- Be aware that some species may be adapted to particular soil types.
- Use only plants well adpated for the elevation of the project.
- Consider the site in the context of the current watershed condition (degraded versus healthy).
- For restoration in and along stream channels, consider these areas in the context of watershed, upstream impacts, flow volume, flow fluctuation, seasonality of flow, total sediment load, sediment particle size, channel bank vegetation and valley gradient.

- Consider the dynamic nature of streams and rivers prior to restoration/rehabilitation activities.

ENHANCEMENT OF A WETLAND

Enhancement is defined as the increase in ecological function or societal values of an existing wetland as a result of human activity. Enhancement project needs are similar to those described above for the habitat restoration projects.

You will notice in the sections which follow that there is an emphasis on the development of detailed plans. This guidance is provided because of the legal and ecological complexities associated with creating and restoring wetlands. But what if your project is not complex? You may want to skip this section, and go directly to the Seeding and Planting section beginning on page 173. There you will find a variety of techniques and general guidance that can be used for smaller scale projects where the hydrology is understood, no major grade changes are proposed, and planting is proposed for a single moisture regime.

THE CONCEPTUAL WETLAND PLAN

Once you have selected whether you plan to create, restore or enhance a wetland, you must begin to make sense out of the ecological and legal complexities of your project. Wetland specialists often use a Conceptual Wetland Replacement Plan to prepare for projects. This plan is generally developed for the benefit of project sponsors and/or regulatory agencies, and is meant to confirm that the project design meets the desired goals and objectives. The conceptual plan describes the wetland replacement plan through diagrams and notes or text.

The conceptual plan may be developed for one or more of the following reasons:

- To verify that a wetland can be developed/restored/enhanced at the selected replacement site and that it meets the desired goals and objectives.
- To confirm for internal review the feasibility, desirability and cost factors prior to committing to the wetland replacement design or collecting additional information and data needed to develop final plans and specifications.
- To allow affected parties (including regulatory agencies) to review and comment early in the process.
- To allow the project sponsor or regulatory agencies to announce the plan in Public Notices requesting comments on the proposed action.
- To verify and/or identify the types of additional information required.

FORMAT AND CONTENTS

There is no specific format for a Conceptual Wetland Replacement Plan. The text may contain sections covering summary information, hydrology, general construction and grading, and vegetation. Diagrams should be at a scale of 1 inch = 100 feet (2.5 cm= 30 m) or greater (e.g., 1 inch = 50 feet), depending on the size of the site and the amount of detail that is necessary. Important sections or details may be drawn to scale; however, conceptual diagrams do not need to be drawn to scale.

Summary Information

- A statement of the goals and objectives of the plan, how they were determined, and how the proposed design (as shown on the plan sheets) will achieve these goals and objectives. A report of the functions and values of the wetland to be lost and the replacement wetland would also be discussed here.
- The acreage and type of the project wetland and that of the wetland to be lost (if any), including any transition zone, buffer area, and upland island(s).
- A discussion and summary of estimated costs (construction, maintenance, monitoring) associated with the project.
- Other possible considerations relating to the proposed wetland, including provisions for ownership and maintenance once the wetland project has been completed, and a summary indicating that permit stipulations (if any) have been satisfied for regulatory review.
- The proposed monitoring protocol and schedule. (Note: This may also be required for regulatory review.)

Hydrology

- A demonstration, with appropriate calculations, that the necessary hydrology will be available to sustain the project. If not yet documented, then the diagrams or notes should detail what studies and/or monitoring *will* be done to ensure that the final design incorporates the necessary hydrology and hydraulic design.
- Water depths (seasonal, temporary, or permanent) for the specified vegetation species and communities should be shown on the diagrams. Although additional hydrologic information may be necessary in order to produce the final plans, the conceptual plan should show intended water levels.

REGULATORY COMPLIANCE NOTE

The level of information provided at this stage of project development varies with regulatory requirements and the type of project. Some regulatory agencies or permit programs have established procedures for a Section 404 Permit application to be coordinated with the preparation of environmental assessments or environmental impact statements.

General Construction and Grading

- A discussion of information, other than hydrological, that must be acquired before developing the final plan.
- Existing and final grades, if known, should be included on the plans. If these are unknown, a note should indicate that this information will be acquired. Any other physical features of the project area should be described (e.g., stream location, unusual substrates, etc.).
- Construction techniques, to the extent known, should be described in the text or on the diagrams where necessary.
- Typical and clarifying cross-sections of the wetland should appear on the diagrams.
- Any existing site constraints for construction and subsequent maintenance should be identified in the plan (e.g., site access).

Vegetation

- Plant communities and their extent (in acres) should be listed in the notes or text and identified on the diagrams. Open water, mudflats, channels, upland, transition and buffer zone, etc. should also be identified and mapped.

FINAL WETLAND CONSTRUCTION PLANS

The most important documents produced for a wetland project are the Final Wetland Construction Plans. They should be developed in consultation with wetland professionals with an established record of successful projects. Furthermore, to ensure project success, the project designer must anticipate the timetable for acquiring all the information necessary for the final plans and specifications. Most of the necessary design information should be collected during the site selection process. Final Wetland Construction Plans contain more detailed data than the Conceptual Plan and will be used on site by construction crews.

ACCURACY AND CLARITY

Because Final Wetland Construction Plans are the most important documents produced for a wetlands project, they must contain clearly presented and accurate information. The success of the project is critically dependent on the accuracy and clarity of the Final Wetland Construction Plans. If it has not been verified during the conceptual planning phase, these plans should document that the goals and objectives of the project will be realized.

The monitoring protocol formulated for the wetland replacement project will be based on the premise of correct plans and specifications. Consequently, every effort should be taken to ensure that these plans contain

- Accurate site hydrology information.
- Planting plans appropriate for the various hydrologic regimes.
- Correct construction specifications.

The construction plans and specifications must be sufficiently detailed and complete so that they can be used for

- Bidding purposes.
- Engineering, hydrologic, and ecological/biological review.
- Project implementation.
- Verification of the “as built” conditions.

If the plans contain any engineered items such as water control, diversion, conveyance, detention structures or other items that require engineering, they must be signed and sealed by a licensed professional engineer.

The Final Wetland Construction Plans should demonstrate a complete understanding of the technicalities of wetland replacement. The two most important factors that relate to the success of replacement projects, and which have been stressed throughout the design process, must be reflected in the plans.

1. The **hydrology** that will be associated with the wetland replacement project must be clearly understood and known to be reliable so that vegetation communities can be assigned with confidence to the correct site elevations.

2. The **construction plans and specifications** must be site specific, sufficiently detailed, and accurate so that the wetland replacement project, if constructed according to the plans and specifications, will succeed.

The single most severe flaw with existing wetland replacement plans and specifications is that the designed hydrology and/or the relationship between this hydrology and the associated vegetation is not understood.

To ensure that the document is clear, understandable and contains all the necessary information, it should be reviewed by wetland professionals prior to construction. This review may reveal whether design modifications or additional studies are required to minimize or eliminate costly mistakes and time-consuming corrective actions once construction begins.

The construction plans and specifications will be the permanent record of the project and will serve as the project's baseline for post-construction monitoring and follow-up evaluations. Therefore, any discrepancies between the "as-built" project and the plans and specifications must be clearly noted on the plans with explanations.

The project wetland should require minimal maintenance; therefore, self-sustaining parameters (such as the source of sustaining hydrology) are preferred to engineered parameters. Reality dictates that after several years, or as determined by the wetland permit conditions (if any), the planned maintenance will stop and the wetland must persist.

FORMAT AND CONTENTS

For most public agencies, a project will need to be described in the format appropriate for bidding packages. Typically, the information listed in the following categories is required.

- Summary information.
- Hydrology report.
- Biology report.
- General construction and grading.
- Vegetation (Planting Plans).
- Sediment stabilization and erosion control.

This information, much of which is also recommended for the conceptual plan, is summarized on the next page as a checklist. The individual items are discussed in detail in the following sections.

SECTION	INFORMATION TO INCLUDE (All of the information listed does not necessarily apply to all projects)
Summary Information	❑ Results of functional evaluations ❑ Goals and objectives ❑ Wetland types and acreage involved ❑ Costs ❑ Earthwork calculations and topsoil requirements ❑ Provisions for ownership ❑ Monitoring protocol and schedule
Hydrology Report	❑ Hydrology summary (illustrated on plans and described in writing) ❑ Assumptions or modeling data ❑ Hydrologic verification
Biology Report	❑ Biological benchmarks ❑ Soil seed bank studies
General Construction And Grading	❑ Notes ❑ Plans ❑ Materials ❑ Construction timetable ❑ Benchmark locations ❑ Important site features ❑ Limits of disturbance ❑ Areas to be graded and back-filled ❑ Typical and atypical condition sections ❑ Stream/channel dimensions and configurations ❑ Details for construction of all structures ❑ Slope stabilization techniques ❑ Special considerations ❑ Specifications for de-consolidation of substrate ❑ Maintenance procedures
Vegetation	❑ Lists of species for planting/seeding ❑ Lists of acceptable substitutes ❑ Commercial sources of plant materials ❑ Field collection instructions ❑ Special conditioning requirements ❑ Planting timetable ❑ Areas to be vegetated, identified by method ❑ Details for slope stabilization with vegetation ❑ Identification of party responsible for marking planting zones ❑ Criteria for acceptable plant material ❑ Plant handling instructions ❑ Special planting techniques ❑ Wetland topsoiling instructions ❑ Planting and fertilizing techniques ❑ Seeding instructions ❑ Soil amendment details ❑ Wildlife control structures ❑ Guarantee requirements ❑ Vegetation maintenance requirements
Sediment Stabilization And Erosion Control	❑ Plans for the entire area must be prepared according to state and/or local requirements

Summary Information

If a conceptual plan was developed and summary information included, it may be redundant to provide this information in the Final Wetland Construction Plan. Such information is important for internal consideration, for regulatory agency consideration, for the public record, and to track the history of the wetland replacement project. Suggested summary information includes:

Results of Functional Evaluations

The results of any functional evaluations of the affected wetland and of the replacement wetland (if required).

Goals and Objectives

The goals and objectives of the wetland project should be stated and, if such goals and objectives arose from an evaluation of the affected wetland, then an evaluation of the new wetland should be provided—showing how the project objectives were met.

Wetland Types and Acreage Involved

This can include a summary statement explaining the following (as applicable):

- The acreage and type of wetland to be lost due to the project and what will be replaced. The wetland areas that are proposed for restoration or enhancement.
- Any buffer, transition, and upland habitat areas and/or which areas are being given replacement (mitigation) credit.

Costs

These include estimated pre-construction, construction, maintenance, monitoring and reporting costs for wetland replacement.

Earth Work Calculations and Topsoil Requirements

A summary of the volumes of cut, fill, and topsoiling with conventional soils and/or wetland soils required for wetland replacement.

Provisions for Ownership

Provisions for ownership that have been made after construction has been completed and all permit conditions (if any) have been satisfied.

Monitoring Protocol and Schedule

State the success criteria (i.e., goals), the monitoring parameters (i.e., methods), the monitoring schedule and date(s) (e.g., annually at the end of the growing season), and reporting schedule (e.g., report to be submitted to the Corps of Engineers by November 1 of each year).

Hydrology Report

If the hydrologic studies and analyses produce voluminous data and results, it may be helpful to develop a hydrology report as part of the Final Wetland Construction Plan. However, summary statements regarding the designed hydrology must also be provided in the notes. Where applicable, the following elements should be included, at least in summary in the notes and in detail in the hydrology report:

Hydrology Summary

The conclusions from all hydrologic evaluations must be summarized in the notes on the diagrams so that any person reviewing them will clearly understand the source of sustaining hydrology associated with the wetland project site.

Assumptions or Modeling Data

All assumptions made in the analysis must be clearly stated. If such assumptions relate to the transfer of data from one watershed to another where the wetland project is located, then data must be presented that validates, at least in part, the assumptions made. Similarly, if hydrological modeling was employed, information in the form of field data (collected at the wetland replacement site) should be presented that validates the model and assumption.

Hydrologic Verification

Any time a wetland project site is connected to an existing wetland, a hydrologic analysis should be conducted to verify that the hydrology is sufficient to sustain both the existing wetland and the project. Such an analysis should be conducted during the site selection process and possibly during information gathering.

Biology Report

The biology report should provide detailed information which will facilitate replication of the desired type of natural ecosystem. The following elements are recommended:

Biological Benchmarks

A reference wetland provides valuable information during the wetland design process in the form of "biological benchmarks." **Biological benchmarks are the physical parameters of an existing, natural habitat** which can be measured, quantified and documented. Examples include plant densities, plant composition and zones, and ground surface distance from the sustaining hydrology. These documented parameters may then be utilized as a model for the restoration of a similar natural habitat.

> Using biological benchmarks as the basis for a wetland replacement plan minimizes the potential for human error in interpreting and replicating a natural ecosystem and maximizes the probability of success of the project.

Generally, the **reference wetland** will be located close to the wetland project site. A reference wetland is not usually necessary if the purpose of the wetland project is to replace the affected wetland "in-kind" (i.e., same wetland type with same species composition) and the design team was able to assess the affected wetland prior to project initiation. In this instance the species composition and habitat type(s) are known. A reference wetland may still provide valuable data regarding proper grades in relation to the source of sustaining hydrology. A reference wetland is always useful when the project goal is "in-kind," and the affected wetland could not be assessed; and when the project goal is "out-of-kind" (i.e., different wetland type and/or different species composition from the affected wetland).

After the desired wetland type has been established, the design team should identify a local wetland (preferably adjacent to the replacement site) which is similar in characteristics to the planned wetland. This wetland should then be assessed for its applicable biological benchmarks.

Soil Seed Bank Studies
If a donor seed bank (i.e., from the topsoil of the affected wetland) is proposed for use in the wetland, then a soil seed bank study may be desirable. This study may yield valuable information on the species composition of the seed bank, and the abundance and distribution of the species (Welling et al. 1988). With this information, predictions can be made about the vegetation which may become established from the donor seed bank. The process can be time consuming and expensive. It is typically used in areas where the presence of any weedy species would compromise the project or the overall management principles of the agency. Plan seed bank studies at least one year in advance of finalizing your wetland project. For further information on seed banks, see Baskin and Baskin 1998, Leck et al. 1989, Gross 1990, Iverson and Wali 1982, and Roberts 1972 and 1981.

General Construction and Grading

The general construction and grading plans and specifications must be sufficiently complete and specific so that the general contractor does not need to make decisions that may affect the success of the project. It is recommended that the general construction and grading sections of the plans and specifications include, but not necessarily be limited to, the following items:

Notes

Notes on the plans should contain

- A summary statement regarding the designed hydrology at the site.
- A statement directing the reviewer to the plan sheets to see the elevation(s) of the designed water level(s).
- The project elevation and all water elevations tied to it.
- Acceptable tolerance(s) in the final grades.
- A restatement of any element in the construction timetable that is critical for success.
- A restatement of any element in the special considerations and conditions for construction that is critical for success.
- A restatement of any item in the special conditions of the wetland permit that relates to construction.

Plans

All plans should be scaled at 1 inch = 100 feet (2.5 cm = 30 m) or larger (e.g., 1inch = 50 feet) and show one-foot contours or better (e.g., 0.5-foot contours) throughout the final grades of all wetland areas. Spot elevations at all critical locations should be given.

Materials

Details, requirements, quantities, and specifications for all listed materials (e.g., stone, added topsoil, wetland topsoil, geo-textiles, etc.) must be placed in the specifications. Summary tables should also be included on the plans.

Construction Timetable

The construction timetable should be clearly placed on the plans. Poor construction timing may often be linked to problems with, or failures of, wetland replacement projects. It is important to develop a thoughtful construction timetable that does not lead to inflated construction costs and yet ensures that a minimum of problems will arise due to construction delays.

Benchmark Locations

The location(s) of all physical benchmark(s) must be shown on the plans with corresponding elevations clearly identified.

Important Site Features

Features such as access points, power lines, rights of way, and property lines should be shown on the plans.

Limits of Disturbance

The limits of all disturbance due to construction of the wetland replacement should be shown on the plans. Acceptable construction staging areas should also be identified on the plans.

Areas to be Graded and Backfilled

Areas to be graded below the final grade and then backfilled with conventional topsoil or wetland soils to the final grade must be clearly shown on the plans and sections, as well as discussed in the specifications. When a specific soil type is required for the establishment of vegetation, this should be clearly stated. Backfilling with acceptable soils may be necessary after sealing a site with a clay liner or when existing soils are not suitable for the establishment of specified vegetation.

Typical and Atypical Condition Sections

Sections (such as a cross section for a typical segment of the wetland) in the plans must be shown for all typical and atypical conditions.

Stream/Channel Dimensions and Configurations

If stream/channel dimensions and configurations have been modeled to ensure configuration (erosional/depositional) stability, this should be stated in the plans and specifications so that extreme care will be taken to construct the stream/channel according to plan.

Details for Construction of All Structures

Final Wetland Construction Plans must include detailed information regarding the construction of any water control/conveyance/diversion structures, as well as details for other structures such as stone aprons, concrete headwalls, etc. As indicated previously, the plans and specifications containing the design of such structures may have to be signed and sealed by a licensed engineer.

Slope Stabilization Techniques

The final diagrams should indicate slopes that may be unstable even when vegetated. The plans should detail stabilization techniques, including stone armoring, combining appropriate geo-textile materials plus seeding/planting, or combining appropriate geo-textile materials plus stone armoring. Slope stabilization on vegetated slopes will vary depending on site conditions. For example, soil types and conditions, water flow rates in constructed streams and ditches, currents and waves generated by winds, etc.

Special Considerations

Special considerations and conditions for construction should be placed in the specifications and restated in the notes when the item is critical to project success.

Specifications for De-consolidation of Substrate

The substrate (soil) associated with all areas that are to be vegetated need to be de-consolidated (loosened) following construction. Specifications for substrate de-consolidation in these areas by disking, ripping, plowing or roto-tilling need to be provided.

Maintenance Procedures

Maintenance procedures as they relate to structures and other non-vegetation related items should be detailed in the notes. Maintenance of vegetation should be placed in the vegetation section. If the necessary maintenance is to be performed under a separate contract, then it should not be a part of these plans.

Vegetation

Vegetation (i.e., landscaping tables, lists, notes and specifications) and the relationship of vegetation to the site hydrology are an important part of the Final Wetland Construction Plans. Items that need to be addressed (at a minimum) in the plans and specifications are provided below.

Lists of Species for Planting or Seeding

Lists should provide

- Scientific and common names of plant species.
- Types of plant materials (e.g., dormant bare root, growing bare root, unrooted cutting, balled & burlapped, container, fiber pot, etc.)
- Container size, caliper and heights of trees and shrubs.
- On-center spacings of plant materials and whether within areas or within clusters.
- Quantities of plant materials.
- Fertilizer formulations, rates, and quantities (if necessary, but they are not usually recommended for wetlands).
- Soil amendments required (e.g., compost, sand, etc.).
- Seed(s) and seeding rate(s).

Lists of Acceptable Substitutes

Lists and tables identifying “Acceptable Substitutes” should be included because of the potential that some plant species and types of plant materials may be unavailable.

Commercial Sources of Plant Materials

The names, addresses, phone and FAX numbers of all acceptable sources of plant material should be identified.

Field Collection Instructions

Reuse of salvaged on-site materials is preferred over purchasing commercial materials. If plant materials are to be obtained through field collection, the following information should be included in the plan:

- Identify the permitting agency or agencies (if any).
- Detail which species may be collected.
- Recommend method(s) of collections.
- Identify optimum time for collection.
- Establish maintenance requirements following collection.
- Identify specific locations of acceptable donor sites that meet the approval of any necessary agency or agencies.

Special Conditioning Requirements

Any special conditioning and time requirements for preparing plants to site conditions should be explained in the specifications.

Planting Timetable

Recommended times for planting should be stated. If planting can be done during different seasons of the year, identify the acceptable types of plant materials by date. In certain instances the site's hydrology may not be expected to stabilize (or to achieve the designed pool level) rapidly. In such cases, planting of the wetland species may have to be delayed for up to one year or more following the construction of the wetland. Such instances must be clearly stated in the plans and specifications so the landscape contractors bidding the job understand the uncertainties associated with obtaining the necessary plant materials and with scheduling the work.

Areas to be Vegetated, Identified by Method

All planting and seeding zones for specified species should be labeled clearly on the plans. Open zones specified for natural colonization, areas requiring topsoiling with wetland soils, and experimental work zones should also be labeled. Associated elevations for all of these areas should be clear on the plans.

Details for Slope Stabilization with Vegetation

If slope stabilization will be achieved with vegetation, details for seeding or planting in these areas should be included. There should be an explanation of how geo-textile materials will be combined with vegetation where this method is necessary.

Identification of Party Responsible for Marking Planting Zones

The individual responsible for staking or flagging the zones prior to planting/seeding should be listed (e.g., the project designer, landscape architect, the landscape contractor, or the general contractor).

Criteria for Acceptable Plant Material

Criteria for ensuring the quality of plant materials at time of delivery or pick up at the nursery should be stated in the planting specifications. It should be clear what is considered acceptable and not acceptable for the types of plant materials specified.

Plant Handling Instructions

Instructions for the handling, storage, and maintenance of plant materials once they are delivered to the job site should be given.

Special Planting Techniques

If planting "in the dry," directions for removal of water from the site prior to planting and returning water to the site following planting must be given. If planting "in the wet" (i.e., under water), directions and techniques must be described for proper installation of plant materials so that these items do not float out of the planting holes following planting.

Wetland Topsoiling Instructions

If wetland soils are used for topsoiling ("mucking"), then provide specifications for obtaining, storing and stockpiling, maintaining and spreading the soils.

Seeding, Planting and Fertilizing Instructions

Specifications should describe seeding, planting and fertilizing (note that fertilizers are usually not used or recommended in wetlands), including details regarding the size of the planting hole, the underground depth of planting, what to do with excess soils after planting, where to place the fertilizer, etc.

➲ Beware of specifying the use of commercially available "wetland seed mixes". They often contain undesirable invasive species and noxious weeds that have little wildlife value.

Soil Amendment Details

If soil amendments are to be used, details about the proportions to use, how to mix them, and what equipment, if any, might be used should be stated.

Wildlife Control Structures

If wildlife grazing or browsing is expected to be a problem, specifications should include the construction of and timing for installing wildlife enclosures and/or other management controls. If trapping and relocation of wildlife is proposed, requirements of this activity, together with information about any necessary permits should be stated. Statements relating to the continuance of wildlife management should also be placed in the specifications for maintenance, since this will most likely be an ongoing activity.

Guarantee Requirements

Details about guarantee requirements of the landscape contractor should be specified, and should include

- Guarantee period.
- Survival percentages required for both herbaceous and woody plant materials

- Guarantee required of seeding (if any).
- Under what conditions the guarantee requirements will be relaxed and the landscape contractor not held responsible (e.g. if plants are in the ground and dead the contractor must replace them; if plants are pulled out or missing – the contractor is not responsible).

Vegetation Requirements Maintenance

If maintenance is considered part of the contract, then describe any maintenance items required for vegetation. Otherwise, maintenance specifications should be included in a separate maintenance contract.

Soil Stabilization and Erosion Control

Separate soil stabilization and erosion control plans for the entire area throughout the limits of disturbance need to be prepared. Standard requirements and specifications for the preparation of these plans are generally available from the USDA, CDOT, UDFCD, state natural resources agencies or other equivalent departments.

STEP 4: SEEDING AND PLANTING

The wetland and riparian plant materials and planting techniques listed below are not a comprehensive list of all possible options. Rather, they list the materials and techniques which have been found to be most effective in Colorado's wetland and riparian areas. Some of the materials and techniques presented are specifically applicable to wetlands only and are indicated as such. Because riparian habitats are composed of a mosaic of wetland, upland and transitional vegetation communities, it is important to apply the proper planting materials and techniques to each specific micro-habitat or vegetation community within a riparian area. The information in this chapter should be used in combination with the information presented in the **Revegetaion Techniques** section of the **Upland Habitats** portion of this manual, beginning on page 67, to formulate planting plans for riparian areas. There are also many other references on wetland and riparian revegetation techniques. For more information, see the reference section.

WETLAND AND RIPARIAN SEEDING

Seeding is normally the least expensive approach to establishing vegetation. Consequently, there is great interest in its application in wetland and riparian replacement projects. Unfortunately, there is little information available in the literature, from wetland scientists or from wetland restoration practitioners about which wetland plant species can be successfully seeded. Many wetland plants reproduce exclusively or primarily by vegetative means (shoots, suckers, rhizomes and stolons). For those species which can be successfully seeded, information about the technique(s), limitations and special requirements for successful seeding must be understood and incorporated into the plans and specifications. For these reasons, it is strongly suggested that wetland plant seed be used only in combination with other planting techniques and never used as the sole planting technique.

PREFERRED SEEDING METHODS

- Hydroseeding is an inappropriate technique for wetland and riparian replacement. Should water levels at the replacement site rise above the seeded area prior to seed germination and seedling establishment, the mulch, binder and seed/seedlings will float and wash away.

The preferred method for dry seeding wetland and riparian areas is **drill seeding** (see page 89). More often than not, however, wetland and riparian replacement sites are inaccessible to large equipment; in these cases **broadcast seeding** (see page 90) is preferable.

WETLAND SEED MIXES

- A few nurseries and seed suppliers provide wetland seed mixes. However, the seeds in such mixes often include undesirable species or species having limited habitat value and limited tolerance to varied hydrologic regimes. **We strongly recommended that these "boxed" seed mixes never be considered for use in wetland and riparian replacement projects**.

GENERAL CONSIDERATIONS FOR PLANTING

Planting wetland and riparian plants (herbaceous and woody) is not significantly different from planting other types of plants. Although some sample planting specifications are provided here, planting specifications in general reflect those standards of the landscaping industry.

Using wetland/riparian replacement projects to experiment with new techniques that might improve the process and make it less costly should be encouraged, but not at the expense of overall success of the project. Consequently, experimental work should be confined to a small percentage (e.g., ≤ 5 percent of the overall project) so that this work, if unsuccessful, does not jeopardize the success of the entire project.

WET VS DRY PLANTING

Planting with most of the water drained from the site ("dry" planting) is desirable. This method should only be used if supplemental water will be available to prevent the plants from drying out. If dry planting is used, the planting will most likely be accomplished properly, and planting costs will be reduced by as much as a factor of ten. Even in six inches of water, planting costs may be double that for planting in the dry. The greatest difficulty in planting under water is to get the planting crew to take their time and ensure that the plants are firmly installed within the sediments so they do not float out. If planting under water is required, include in the specifications of the plan that the landscape contractor will be required to re-install any plants that float or are washed away.

PLANTING DENSITIES

Planting densities will greatly influence planting costs and should not be casually specified or arbitrarily copied from the specifications of another wetland/riparian replacement project. As discussed below, planting densities should be arrived at objectively. There should be good reasons, other than cost, for low density plantings.

Substrate compaction will greatly affect herbaceous and woody plant survival as well as development and the rate of spreading of herbaceous and sometimes woody (spread by suckers) plants. It is important that substrate compaction not be a determining factor of planting density. The de-consolidation by physical means of substrates to be planted should be specified as part of the wetland/riparian replacement site construction plans and specifications. Substrates to be planted with herbaceous plants need to be de-consolidated to depths of four to six inches; substrates to be planted with trees and shrubs that are taller than one year old seedlings may require de-consolidation to depths of twelve to eighteen inches.

PLANT MATERIALS AND TECHNIQUES

Although an increasing number of nurseries are offering wetland and riparian plant species, the number of such nurseries is low. Even fewer nurseries carry a significant inventory of native plant species. Consequently, the required plant material for wetland and riparian projects are often not available from commercial sources.

When plant materials are unavailable commercially, the only sources are the natural habitats. Extracting large quantities (thousands to tens of thousands) of plugs or other planting units from

natural wetlands and riparian areas can have significant negative effects even when undertaken by knowledgeable persons. From a practical standpoint the wetland/riparian replacement process is unproductive if it leads to significant adverse impacts to natural donor habitats.

On occasion, there is sufficient time available (i.e., more than one calendar year) to obtain the required plant materials. We strongly recommend that plant material needs for wetland and riparian replacement projects be identified well in advance, especially when the required quantities are in the hundreds of stems for woody materials and in the thousands for herbaceous materials. Such planning should involve contract growing arrangements with native plant nurseries. These arrangements ensure the production of the required plant materials and allow the nursery ample time to produce high quality materials. This manual provides a current list of native nursery and seed suppliers (see Appendix V on page 253).

Plant materials and their corresponding planting techniques below are divided into two categories: herbaceous and woody:

Herbaceous Plant Material	**Woody Plant Material**
Containerized	Containerized trees and shrubs
Plugs	Transplanted trees and shrubs
Bareroot	Poles (Trees)
Wetland seed	Live stakes (Shrubs)
Salvaged wetland topsoil	Wattles (Shrubs)

HERBACEOUS PLANT MATERIALS AND TECHNIQUES

The following text provides a brief description of the collecting and planting techniques, intended application and design considerations for herbaceous plant material.

Containerized

Containerized herbaceous material is typically grown from seed (either commercially supplied or collected on site) at a native plant nursery until it reaches a specified container size (e.g., 2.5 inch container, 10 cubic inch cone, 5 gallon pot, etc.). Bareroot material, rhizomes, tubers or bulbs of specific wetland and riparian species may also be selectively collected and contract grown within containers to a specified size at a native plant nursery. Containerized material is often the preferred form for herbaceous species because it provides a well developed soil/root mass which is hardy and has a relatively high survival rate.

- Containerized plant material may be planted in spring, summer or fall. Spring planting is preferred because it allows the plant a full growing season to become established.
- Containerized material allows flexibility in a project because it can be stored (under proper conditions) for a moderate period prior to installation.

Plugs

Wetland plugs contain stems, roots, underground perennial parts and associated substrate of wetland plant material. Plugs are best transplanted into wetland sites where significant competition from other plants will not be a factor.

- Collect plugs from adjacent or nearby wetlands with similar hydraulic regimes.
- Take only a few plugs from each area of the wetland to disperse the impact of the harvest.

- Remove plugs including rootmats with a pipe, post hole digger, tile spade or similar tool. The plug should be a minimum of 4 inches (10 centimeters) in diameter and 6 to 8 inches (15 to 20 cm) thick.
- Transplant directly into the project site, in areas which meet the hydraulic requirements for each plant species.
- Place in prepared hole, making sure that the soil surface of plug and new site are at the same grade. Do not compress the existing root mass.
- For plugs of herbaceous fibrous root or rhizomatous material, soil may be removed and the plugs planted bareroot with good success. These plugs may also be divided into many more plants.

➲ Make sure that plugs do not contain rhizomes of noxious species such as Canada thistle, quackgrass, smooth brome, etc.

Bareroot

Bareroot herbaceous material may be supplied as whole plants (i.e., upper plant parts and root systems) or as underground plant parts (i.e., propagules) such as rhizome cuttings, tubers and bulbs. This material is typically field collected or propagated at a native plant nursery and supplied without a container or soil.

- Bareroot material is often purchased, potted, and grown into a larger size prior to planting.
- Bareroot material has a somewhat lower survival rate than other herbaceous plant forms, and it must be planted (or potted) immediately upon delivery from the nursery.
- Spring is the preferred season for planting bareroot material so that it is allowed a full growing season to mature. Fall planting is feasible; however, the survival rate decreases.
- Bareroot material is typically planted by hand or with the use of an automated planter (e.g., Holland tree planter).

➲ Bareroot plant material is not as hardy as containerized material, but it is less expensive.

Seeding

Seeds, whether collected from existing wetlands or purchased, may be used to re-establish portions of a wetland site. Seeding can aid in erosion control, improve wildlife habitat and improve aesthetics.

- Seed in saturated or moist soils. Seeding underwater is difficult to control and once the seeds have germinated, the seedlings may float to the surface.
- Seed in fall or early spring.
- Prepare soil by tilling to a depth of 4 to 6 inches (10 to 15 cm). Do not add fertilizer to the site.
- Drill seed if the site is not too moist. For saturated areas or sites too small for a drill, broadcast seed by hand and rake to cover the seed. Mulch with certified weed-free hay, crimped into the topsoil.

➲ Seed left on the surface is good for birds and rodents but not for growing plants!

Salvaged Wetland Topsoil

When impacts to existing wetlands cannot be avoided, the use of the existing wetland topsoil should be considered. Wetland topsoil contains valuable seeds and root stock, which will re-establish quickly in the proposed project site.

- Wetland topsoil can be stockpiled or placed directly into the new site. The less time the topsoil is stockpiled the better, as seeds will begin to lose their viability.

- Topsoil may be stripped to a depth of up to 18 inches (46 cm). Place topsoil at a minimum of 4 to 6 inches (10 to 15 cm) deep.
- Seeding, placing plugs, perennial pots and rhizomes may not be necessary when wetland topsoil is available. Woody plant material may be used if it meets the goals and objective of the wetland plan.
- ➲ Avoid topsoil which contains any weeds or nuisance plants. The presence of these species may destroy your planting project.

GENERAL TIPS FOR PLANTING HERBACEOUS MATERIAL

Density

The density at which herbaceous species are planted will affect the rate at which the plants cover the area. Rapid vegetation coverage may be critical in the following instances:

- The replacement site is surrounded by an abundance of one or more invasive plant species. The longer open ground is available, the greater the likelihood that these species will invade the replacement site and become a significant management problem.
- There may be an abundance of wildlife in the area that will be particularly damaging to vegetation that remains clumped and isolated, as opposed to uniformly covering the site.
- Site grades or surface flow conditions may be such that rapid sediment stabilization for erosion control is important.
- A design function of the replacement site may be such that rapid vegetation coverage is necessary (e.g., water quality improvement or cover for wildlife).

In other instances, rapid vegetation coverage may not be as important. Open areas throughout the replacement site may be desirable for certain lengths of time to recruit other desirable species known to be in adjacent habitats.

Table 5 provides recommended planting densities for achieving uniform aerial coverage for slow spreading herbaceous plants and uniform ground coverage for moderately and rapidly spreading herbaceous plants in one, two and three growing seasons. Use this table to estimate the planting density required for the time period (either desired or mandated) in which the site must achieve uniform vegetation coverage.

Table 5: Recommended Planting Densities for Achieving Uniform Coverage

Rate of Spread	Uniform Aerial Coverage			Uniform Ground Coverage		
	1 Year	2 Year	3 Year	1 Year	2 Year	3 Year
Rapid (>1.0 ft./year)	-	-	-	2 ft OC	4 ft OC	6 ft OC
Moderate (0.5-1.0 ft./year)	-	-	-	1 ft OC	2 ft OC	3 ft OC
Slow (< 0.2 ft./year)	0.5 ft OC	1 ft OC	1.5 ft OC	-	-	-

OC = On Center Plant Spacing

Use Table 6 or the equation below to calculate the required number of plants for the project based upon the planting density.

$$\text{Number of Plants} = \frac{\text{(area in sq. ft.)}}{\text{(on center distance in ft.)}^2}$$

Table 6: Calculation of the Required Number of Plants to Achieve Desired Density

If on center distance =	*Then* number of plants =
0.5 ft	(area in sq. ft) (4)
1 ft	(area in sq. ft)
1.5 ft	(area in sq. ft) (0.444)
2 ft	(area in sq. ft) (0.25)
3 ft	(area in sq. ft) (0.11)
4 ft	(area in sq. ft) (0.625)
5 ft	(area in sq. ft) (0.04)
6 ft	(area in sq. ft) (0.028)

Careful consideration should be given to proper planting densities. If in doubt, consult a nursery or density data from a reference wetland.

Planting in Freezing Climates

If emergent herbaceous plants are to be planted at the end of the growing season in frigid sites where the water may rise above the ground surface during freezing temperatures, specify that the tops of the plant materials be cut within two inches of the ground surface so that rising ice will not pull the plants out of the ground. If planting is completed at the beginning of or during the growing season, cutting the plants back at the end of the growing season generally will not be necessary; the plants should be well rooted by then.

WOODY PLANT MATERIALS AND TECHNIQUES

Trees and shrubs provide wildlife habitat, aesthetics and erosion control to a site. The following provides a brief description of collecting and planting techniques, intended application and design considerations for woody plant material.

Containerized Trees and Shrubs

- Use native plant material that is adapted to the local hydrologic conditions.
- Plant after all grading is completed and once the water levels at the site have stabilized.
- Areas for tree and shrub planting should be staked by a wetland botanist and/or landscape architect so that the plants are placed in areas which meet their moisture and aspect requirements.
- Dig hole two times wider than the ball or container.
- Place each plant 1 to 2 inches (2.5 to 5 cm) higher than surrounding ground and backfill with soil from the hole. Aspen humus may be used to amend the soil.
- When planting in riparian areas or drier sites, water the plants for a minimum of one growing season.

Transplanted Trees

- Transplant trees that would otherwise be removed or damaged during construction.
- Transplant healthy trees.
- Plant to areas which will not be disturbed by construction activity.
- When transplanting to a constructed wetland site, wait until grading and water levels have been established.

- A wetland botanist and/or landscape architect should stake plant locations based on each species' water requirements.
- For optimal survival, transplant in early spring while the plant is dormant.
- ➲ Avoid transplanting in summer.
- Use a tree spade for transplanting. The following table gives the minimum size of spade machine equipment for transplanting, based on caliper (trunk diameter) size. It also represents the minimum diameter of rootballs for machine transplanted plants.

Table 7: Minimum Sizes of Spade Machine

Caliper(in.)	Min. Spade Machine Size (in.) (Based on root ball width)
1 to 3	44
3 to 6	65
6 to 9	80
9 to 12	90+

- Transport the tree directly to new site using the same spade with which it was dug.
- ➲ Do not remove the tree from the spade.
- Planting pits for machine-dug trees should have the same dimension as the machine ball being placed.
- Fill the planting pit hole half full of water and allow to drain prior to planting.
- Once the tree is placed, fill the voids with soil and tamp.
- Build a basin around the tree to hold a minimum 30 gallons (115 liters) of water. Water tree thoroughly.
- Water trees twice a month with approximately 70 gallons (265 liters) of water each, watering throughout the summer.
- Stake and guy trees.
- ➲ Fence transplants where deer and beaver are active.

Transplanted Shrubs

Transplanted trees and shrubs (e.g., willow "clumps") are native species which are removed from a wetland or riparian impact area (prior to its destruction) and transplanted directly to the replacement site. Transplants may also be obtained from donor sites; however, be sure to obtain prior approval and authorization. Transplants allow the use of native wetland and riparian vegetation and are relatively hardy due to the retention of the entire root mass, surrounding soil and indigenous soil microorganisms.

- These plants may be removed by hand (shovel and bucket) or by construction equipment (e.g., backhoe, excavator or tree spade).
- Although direct transplanting to the replacement site is the preferred method, shrub transplants may be stored on a short term basis provided they are heeled-in (see page 100), watered, stored in the shade and protected from freezing.
- Wetland and riparian shrubs may be transplanted in the spring or fall, with higher relative survival rates if transplanted while dormant.

Pole Planting

Pole planting consists of planting tree cuttings from young, rapidly growing cottonwoods or native willow. Pole plantings can be used where the water table is more than two feet (0.6 m) below the soil surface and fluctuates less than 6 feet (1.8 m). Water salinity should be

less than 3,000 parts per million. Plantings are used for bank stabilization, shading and wildlife habitat.

- ❖ Obtain poles from stands of open grown, young, rapidly growing trees, using wood that is four years old or less.
- ❖ Collect while the plant is dormant, preferably as early in spring as the ground can be augured, usually from February to April.
- ❖ Cut poles up to 20 feet (6 m) in length, three inches (7.6 cm) or greater in diameter.
- ❖ Store cutting with butt end in water at all times.
- ❖ Plant in a 15 inch (38 cm) diameter hole augured to the water table, making sure that four to six feet (1.2 to 1.8 m) remain above the soil surface. Backfill completely with soil, tamp firmly.
- ❖ Stake the pole to prevent wind damage.
- ➲ Fence to protect against deer and beaver where necessary.

Live Stakes

Live stakes are cuttings which are harvested from wetland and riparian shrub species. The species which are suitable for harvesting live stakes are those which have adventitious buds along their stems from which new leaves, stems or roots can grow (e.g., willows, red-osier dogwood). **Live stakes must be collected while the donor shrub is dormant (i.e., before leaf-out).** No more than one-third of the donor shrub should be harvested. The minimum diameter of the cuttings should be 0.5 inch (1.2 cm); larger live stakes contain a greater amount of the stored energy required to form leaves, stems and roots. After they are harvested, the live stakes should be submerged (at least the lower one-third) in water and stored in a cool, dark place for a period of 24 to 48 hours. Immediately after soaking and storage, the live stakes should be planted.

The term “live stake” refers to a single cutting which is planted vertically in the ground; however, live stakes may also be planted vertically in a group of two or more (a bundle) or horizontally below the ground surface (see “wattles” below). Live stakes are commonly used for erosion control (e.g., stream bank stabilization); however, they have a wide variety of applications in wetland and riparian replacement projects. If an adjacent donor site is not available, cuttings should be harvested from a site that is within 100 miles (160 kilometers) and approximately 2,000 feet (600 meters) elevation of the project site. The allowable elevation difference will vary depending upon the particular species; therefore, it is best to collect similar species from similar elevations.

- ❖ Insert the cutting vertically (i.e., oriented in the same direction which it grew on the shrub) into the substrate so that approximately two-thirds of the total length is below the surface.
- ❖ The length of the cutting should be a minimum of 24 inches (61 cm).
- ❖ In many saturated wetland substrates the cutting can be pushed into the ground, however, a planting bar may be required to form the planting hole (a piece of re-bar can be used).
- ❖ The cutting must be inserted deep enough to ensure that it reaches the water table throughout the entire growing season. Therefore, the appropriate length of the live stakes will vary, based upon the relationship of the ground surface to the sustained water table.
- ❖ After the live stake is inserted, the planting hole must be backfilled with native soil and lightly tamped to prevent air pockets.

- The use of rooting hormones generally does not increase survival for these plant species, however, soaking the cuttings in water for a period of 24 to 36 hours does increase survival rates (Windell 1992).

Wattles

Wattles are bundles of live, dormant willow cuttings, placed into the ground for revegetation. Wattles are best used in areas where sheet erosion is occurring and on stream banks or fill areas for stabilization.

- Select live, dormant willows
- A mix of older and younger wood (including wood less than one year old) should be used; most of the material should be one to four years old.
- Select cuttings 3/8 inches to 1 ½ inches (0.95 to 3.8 cm) in diameter and a minimum of six feet (1.8 m) long, with the bottom end cut off at an angle.
- Tie bundles 8 to 12 inches (20 to 30 cm) in diameter, and a minimum of six feet (1.8 meters) in length, tapering at each end.
- The growing tips and ends of cuttings should orient in alternating directions, with tips being staggered and evenly distributed throughout the length of the bundle.
- Compress the bundles and tie tightly with biodegradable rope, spaced 12 to 15 inches (30 to 40 cm) apart.
- Excavate a trench parallel with the contour of the ground, approximately half the diameter of the wattle.
- Place the wattle in the trench. Using stakes 1 x 1 x 18 inch or larger, secure wattles firmly in place with one row of stakes on the downhill side of the bundle, not more than three feet (1 m) apart. Place a second row of stakes through the wattle, near the ties, using a minimum of two stakes per bundle.
- Overlap the tapered ends of adjacent wattles so that the overall thickness is uniform. Use two stakes at each bundle overlap, driving a stake between the last two ties of each wattle.
- Backfill the wattle with soil, work into spaces and compact the soil behind and below the bundle by foot tamping.
- Puddle with water and allow soil to settle, then add more soil as needed. The top of the bundle should be slightly visible when the installation is complete.
- Water daily for 30 days.
- If necessary, wattles can be stored totally submersed for up to two weeks.

General Tips For Planting Woody Material

Density

In planting forest or shrub wetland/riparian replacement sites, density considerations are different from those for planting herbaceous sites. The density of tree and shrub planting will not affect the rate of recruitment of invasive plant species, the incursion by problem animals, soil stabilization, or the short-term functioning of the project site as directly as will herbaceous plant density.

Target tree and shrub densities should not come from a single “reference” wetland or riparian area. Rather, relative densities of these species should be obtained from a number of regional “reference” wetlands or riparian areas of the same type as is being targeted by the project.

When determining planting densities, consider potential losses due to wildlife browse, drought and natural thinning, as well as gains arising from possible natural regeneration.

"Saucers"

Wetland and/or riparian replacement plans sometimes specify that saucers must be developed around the planting holes of trees and shrubs with the leftover soils from the plant pit. Mulching throughout the saucers also is frequently specified. In some instances these saucers facilitate manual watering by creating a basin which can be filled with water.

➲ Be aware that in many cases such soil mounding will actually withhold water from the plant. This is particularly true in riparian and wetland areas which derive some (or all) of their sustaining hydrology from water which flows over the soil surface. Also, in more permanently flooded wetlands and riparian areas, sustaining hydrology is derived from an elevated ground water table and saucers will serve no function. Therefore, we recommend that surplus soils from planting woody species be raked or spread about the plants so as not to restrict water flow or to significantly alter ground surface elevations. In situations where manual watering/irrigation is to be used, saucers may still not provide the proposed benefit. If plants have to be watered by hand during periods of drought, the absence of saucers would require watering at slower flow rates than with saucers, and this slower flow rate may help ensure that each plant actually receives an adequate amount of water.

Stabilizing Woody Vegetation

Staking trees and shrubs more than four feet in height (using standard landscape specifications) is strongly recommended under the following conditions:

- The wetland or riparian replacement site will have saturated soils year-round.
- In frigid areas where the depths of ponded water during periods of freezing will be less than several inches.

Staking does provide a factor of safety for all replacement projects since most wetland (and some riparian) trees and shrubs root at shallow depths. Until the surface roots become well developed, such plants are subject to being blown over.

Planting in Freezing Climates

If trees and/or shrubs are to be planted in frigid sites that are expected to have more than several inches of standing water during freezing weather, they should be wired to metal anchors, regardless of size. Standard landscape specifications should be used, except that anchors should be specified to be sufficiently deep so as not to be pulled out if the plants are lifted by ice. Also, under these types of conditions, planting should take place in the beginning of the growing season in order to provide maximum time for rooting and stabilization before freezing. Fertilizer, if used at all, should be a zero or low nitrogen-based slow release fertilizer to promote root development.

Hole Shape

Plant roots do not develop through pockets of air; roots stop developing when they reach the air and become "air pruned." Make sure that plants from flat bottomed containers are not

planted in V-shaped (spade dug) holes. The air pockets at the bottom of the holes may cause plant mortality.

Trees should be planted erect and that any trees showing a lean of greater than ten degrees from perpendicular must be straightened or replanted. Leaning trees often die or sprout a new leader from close to ground level.

Pruning

Pruning trees and shrubs prior to or following planting is not recommended, unless site-specific conditions and/or timing require the plant to devote more energy to root development. Native wetland and riparian replacement projects are not ornamental gardens and dead branches do not threaten the success of the project.

ACCEPTABILITY OF PLANT MATERIALS

Acceptable parameters for plant materials should be specified in sufficient detail that an inexperienced inspector can make a rapid determination of acceptability. At a minimum, include general appearance and health (i.e. no sign of disease), as well as plant size and form.

PARAMETERS

The height of plant materials is often specified as a criteria for acceptability; however, height alone is not an acceptable parameter. The standard parameters which are applicable to all plant material types include

- Container size (e.g., 2.5 inch container, 10 cubic inch cone, 5 gallon pot, etc.)
- Plant form (e.g., bareroot, seed, containerized, ball and burlap, etc.).
- Diameter (or caliper), height and age are secondary parameters utilized in specifying woody plant material; however, none of these parameters should be used as the sole specification.

For herbaceous species, specify plant height sufficient to ensure that the plants are tall enough to emerge above the intended water level (pool level) of the wetland and/or riparian zone. Specifying diameter (caliper) or age for herbaceous plant materials is inappropriate.

COMPARISON OF PLANT MATERIALS

The table below summarizes the preferred planting times and relative success of each of the plant material types. This table provides a qualitative comparison of the various planting techniques and is intended to guide the user in selecting the most appropriate technique for the time of year in which the project is being implemented.

Table 8: Plant Materials: When to Plant and Relative Survival Rates

TYPE	WHEN TO PLANT	RELATIVE SURVIVAL RATE
Herbaceous Material		
Containerized	Spring*/Summer/Fall	High/Intermediate
Plugs	Spring	Intermediate to High
Bareroot (rhizomes, tubers, etc.)	Spring*	Intermediate
Wetland seeding	Spring/Summer/Fall	Intermediate (All Seasons)
Salvaged wetland topsoil	Spring*/Summer/Fall	Intermediate (All Seasons)
Woody Material		
Containerized trees & shrubs	Spring/Summer/Fall	High/Intermediate/High
Transplanting trees & shrubs	Spring/Fall	Intermediate/Intermediate
Poles (trees)	Dormant season	Low to Intermediate
Live stakes (shrubs)	Dormant season	Intermediate to High
Wattles (shrubs)	Dormant season	Intermediate to High

* Preferred planting season

FIELD COLLECTION OF PLANT MATERIALS

WHERE TO COLLECT

Collect native plant material from areas which will be destroyed by construction, as this plant material will otherwise be wasted. If collection from the affected area is inappropriate (e.g., other plant species are being specified in the plan) or not feasible (e.g., seasonal or construction related timing problems), then arrangements must be made to collect from other "donor" wetlands or riparian areas. These arrangements include identifying locations for collections, obtaining any necessary authorizations, permits, or permissions for collections, and scheduling the collections.

If seeds are being collected, seed production and quality may vary yearly due to meteorological factors, disease and insect infestations. The only reliable way to identify suitable locations for collection is through on-site verifications.

From ecological and economical perspectives, wetland and riparian areas that are dominated by the desired plant species are preferred for collection over wetlands with a high species diversity. Commonly, collecting the desired plant materials from such monotypic habitats will be most economical because it can be accomplished quickly and efficiently. Never collect in such a way that your actions change the composition of the donor community.

If field collection of plant materials is necessary, the Final Wetland Construction Plans (see page 162) must provide the information on where, when and how to collect. These plans also must indicate what authorizations, permits, or permissions are necessary for collection, or indicate that the necessary approvals will be provided to the landscape contractor by the project sponsor.

WHEN TO COLLECT

Timing depends on the types of plant materials that are specified and when they must be planted to the wetland replacement site.

Seed

Timing for seed collection is critical because if the seed collection "window" is missed, an entire year is lost. There are three types of plants from which it is difficult to collect seed.

- Plants that produce seeds that fall to the ground soon after ripening. Many species in the grass and aster families fall into this category. For this plant type, one storm or windy day soon after seed ripening can cause the loss of seed.
- Plants that flower and produce seeds during much of the growing season so that there is no optimum time for seed collection.
- Plants that produce seeds of high value to wildlife so that one must compete with local fauna to collect the seed.

The optimum time for seed collection of any species will vary depending on location within the state or region, therefore, this information is best obtained through consultation with local wetland scientists and botanists.

Herbaceous Plant Material

Examples of herbaceous plant material include bareroot plants and plugs. The optimum time to collect the specified plant materials is just before they are to be transplanted to the replacement site; this practice eliminates any storage and maintenance requirements. Consequently, collection and planting processes should be coordinated. Although bareroot material may be collected in advance, stored and prepared at a native plant nursery, plugs should only be used when direct transplanting is possible.

Woody Plant Material

Although some tree and shrub species transplant well, transplanted trees and shrubs may have slower growth rates and lower overall survival than containerized material. This difference is due to the potential reduction in root biomass which results from being dug up, and because of the loss of optimum growing conditions provided in the original site. Trees and shrubs should be collected while dormant.

HOW TO COLLECT

Seed

Mechanical devices have been developed for the field collection of prairie plant seeds and these may be applicable for seed collection under certain wetland and riparian conditions. Seed collection by hand using hedge cutters, shears, sickle or other cutting tools will probably work best under most wetland conditions. Seed collection is also an excellent opportunity to encourage volunteer participation.

Herbaceous Plant Material

Collection of herbaceous plant materials (e.g., bareroot and plugs) from the wetland or riparian area(s) that will be affected might be assisted (depending upon ground conditions) by the use of a backhoe, excavator or other mechanical means. However, collection by hand or shovel (sharpshooter) is preferable; the use of excavators and other mechanical devices for collecting in natural habitats is generally too destructive. The use of a pressurized water sprayer might assist in cleaning some of the sediments off growing bareroot plants, making them easier to ship and plant. Plugs do not need to be washed; in fact, it is better to transplant the native soil and microbes that are bound to the root/rhizome mass.

When collecting material from a donor wetland, under no circumstances should a gap be created that will not be filled in by surrounding vegetation in a year. The preferred method is to collect plant materials in a "checkerboard" pattern (i.e., a "checkerboard" grid of about five ft^2). These requirements should be included in the Final Wetland Construction Plans.

When collections are made from peat wetlands, the holes created by taking plugs or the removal of other plant materials will often fill in with water rather than with sediments. Plants will not return to these "collection holes" unless they are filled with sediment. If the donor wetland conditions result in "collection holes" it is important to specify in the Final Wetland Construction Plans that holes be filled with mineral sediments following the collection process. If this is not done, these "collection holes" will persist and negatively affect the wetland, particularly for projects where large amounts of plant materials are collected.

If "collection holes" are filled by sediment, either naturally or artificially, vegetation will usually fill in these bare areas within several years. For this process to succeed, the "checkerboard" grid size for collection must not too great, and the surrounding vegetation must be of the type that propagates by rhizomes, stolons or tubers. If the perennial parts of the surrounding vegetation are bulbs or corms, the surrounding vegetation will only fill in through seeding or other species will colonize the bare areas. The spreading rates of plant species that are given in Appendix II beginning on page 197 will provide some indication of the time it will take for surrounding vegetation to fill in the bare areas depending on the size of the collection grid.

Woody Plant Material

Depending on ground conditions, the use of a backhoe, excavator, or tree spade will greatly facilitate the lifting of the larger plants for transplanting. Plugs of small (12 to 24 inch) seedlings, with soil intact, can often be extracted using a shovel.

WHAT TO DO WITH THE COLLECTED MATERIALS

Seed

Unlike other collected plant materials, collected seed should not be used for seeding a wetland replacement area immediately after collection. Before seeding, the seed purity and germination percentage must be determined, and seeding specifications should indicate seeding rates using pure live seed (PLS). The collected seed must be cleaned, processed, analyzed for purity, stored, and germination tested before being used (see seeding section

beginning on page 81 for details). Consult a local wetland scientist about when to collect seed in order to compile the proper specifications for processing and storing seed.

Herbaceous and Woody Plant Material

Herbaceous and woody plant material should generally be collected just before planting. It is important that these plant materials be delivered in accordance with the Final Wetland Construction Plans.

FERTILIZER AND OTHER SOIL AMENDMENTS

Fertilization requirements vary greatly depending upon the specific nutrients available in the soil of the project site and the particular species being planted.

> ➲ In general, fertilizers are not needed or recommended for wetland revegetation projects.

In order to determine specific fertilization requirements, soil tests must be performed on the planting site. Once the on site nutrient conditions have been determined, they may be compared with those that are considered optimum for the species involved. You should also consult the supplying nursery to determine the specific requirements for the varieties and/or ecotypes to be planted at the site (R. Mandel, personal communication). Keep in mind that the release of nitrates and other fertilizers into water can be extremely toxic to fish and may also cause large algal blooms.

Opinions vary regarding the use of polymers and other moisture-retaining soil additives. The soil moisture in most wetland planting sites (during the growing season) should be adequate to maintain native wetland species; however, it is still advisable to water wetland plants immediately after planting to reduce shock and assist in soil compaction in the planting pit. Available soil moisture in riparian areas will vary greatly depending upon the relation (topographic elevation) of the planting site to the river or creek, the moisture retention properties of the soil, and the species being planted. Directions for upland plant watering requirements are generally applicable to most riparian plantings and are provided in the Upland Revegetation Techniques section of this manual. Available soil moisture should be determined prior to the time of planting to calculate site-specific soil additive and watering requirements. These data are typically gathered during the site design process, particularly data regarding the sustaining hydrology of the system.

STEP 5: MONITORING AND STEWARDSHIP

The step of monitoring and stewardship is no less important than that of the planting techniques or species selection. The processes and techniques used for the monitoring and stewardship of wetland or riparian communities are essentially the same as for upland plant communities (see Monitoring and Stewardship, beginning on page 103).

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APPENDIX I: UPLAND PLANT CHARACTERISTICS

Species described in this appendix include those marked as dominant in the upland habitats plant finders. Some additional species are included; however, not all species in the plant finders are shown here. Many of these species are not yet commerically available and little is known about their use in revegetation projects. The Forbs (Table A2) begin on page 205, and the Shrubs and Trees (Table A3) begins on page 213.

GRAMINOIDS

Table A1: Upland Plant Characteristics - Graminoids

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	SEASONALITY	GROWTH FORM	HEIGHT	WILDLIFE AND LIVESTOCK VALUE	COMMENTS
Agropyron spicatum	*Psuedoroegneria spicata*	BLUEBUNCH WHEATGRASS	Cool	Bunch	3-10"	Good	Begins growth early and stays green well into summer; reproduces primarily by seeds
Agropyron spicatum var. *inerme*	*Psuedoroegneria spicata* var. *inermis*	BEARDLESS BLUEBUNCH WHEATGRASS	Cool	Bunch	3-10"	Good	As above
Alopecurus alpinus	*Alopecurus alpinus*	ALPINE FOXTAIL	Cool	Rhizomes	10-30"	Fair	Good soil binder; subalpine meadows and gravelly streamsides
Andropogon gerardii	*Andropogon gerardii*	BIG BLUESTEM	Warm	Rhizomes	40-80"	Excellent	Very attractive grass; attractive summer and late season color
Andropogon hallii	*Andropogon hallii*	SAND BLUESTEM	Warm	Rhizomes	40-80"	Excellent	Attractive late season color; sand dunes on the Eastern Plains
Blepharoneuron tricholepis	*Blepharoneuron tricholepis*	PINE DROPSEED	Cool	Bunch	10-26"	Good	Attractive summer grass; good soil binder; rocky meadows, gravelly soils in open spruce or pine forests
Bouteloua curtipendula	*Bouteloua curtipendula*	SIDEOATS GRAMA	Warm	Rhizomes	20-30"	Good	Sod former; gravelly soils; plains and foothills on the East Slope; sagebrush and piñon-juniper on the West Slope

Table A1: Upland Plant Characteristics - Graminoids

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	SEASONALITY	GROWTH FORM	HEIGHT	WILDLIFE AND LIVESTOCK VALUE	COMMENTS
Bouteloua gracilis	*Chondrosum gracile*	BLUE GRAMA	Warm	tillers; appears as a bunch	4-6"	Good	Forms bunches or sod depending on available moisture; nice to mix with buffalograss for lawn seeding; excellent soil binder; good for roadsides and lawns; attractive for landscaping
Bouteloua hirsuta	*Chondrosum hirsutum*	HAIRY GRAMA	Warm	Short rhizomes; appears as a bunch	6-12"	Fair	Gravelly soils
Bromopsis pumpelliana	*Bromopsis pumpelliana*	PERENNIAL BROME	Cool	Rhizomes	15-40"	Excellent; remains palatable even after flower developmen t	Montane to subalpine
Bromus anomalus	*Bromopsis porteri*	NODDING BROME or PORTER BROME	Cool	Bunch	15-25"	Excellent	Woodlands and forest openings above 5,500 ft
Buchloe dactyloides	*Buchloe dactyloides*	BUFFALOGRASS	Warm	Stolons	4-6"	Fair	Sod former; separate male and female plants
Calamagrostis canadensis	*Calamagrostis canadensis*	BLUEJOINT or CANADA REEDGRASS	Cool	Rhizomes	25-50"	Bird habitat	Excellent soil binder; will grow from moist gravel and peat
Calamovilfa longifolia	*Calamovilfa longifolia*	PRAIRIE SANDREED	Warm	Rhizomes	20-70"	Moderate; prairie chicken shelter	Good binder of sandy soils; erosion control; common in sand dune blowouts; plains and piedmont valleys on the East Slope; very beautiful tall grass
Carex filifolia	*Carex filifolia*	THREADLEAF SEDGE or BLACKROOT SEDGE	Cool	Bunch	3-12"	Excellent; valuable early spring forage	Dry grasslands from plains to montane

Table A1: Upland Plant Characteristics - Graminoids

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	SEASONALITY	GROWTH FORM	HEIGHT	WILDLIFE AND LIVESTOCK VALUE	COMMENTS
Carex geyeri	*Carex geyeri*	ELK SEDGE or GEYER SEDGE or PINE SEDGE	Cool	Stolons	4-15"	Good for elk and cattle; fair for sheep and deer; valuable early spring forage	Open spruce-fir, Douglas-fir and oak-serviceberry shrubland understory
Carex inops ssp. *heliophila*	*Carex pensylvanica* ssp. *heliophila*	SUN SEDGE	Cool	Short rhizomes	3-12"	Good early spring forage	Dry forested areas; the earliest flowering sedge in the foothills; also found in prairie sites
Carex spp.	*Carex* spp.	SEDGE	Various	Various	Variousu sually under 20"	Usually good to excellent	
Danthonia intermedia	*Danthonia intermedia*	TIMBER OATGRASS or TIMBER DANTHONIA	Cool	Bunch	4-22"	Excellent; valuable spring forage	Attractive with purple hued inflorescences; subalpine and alpine grasslands, meadows, and forest floors
Danthonia parryi	*Danthonia parryi*	PARRY'S DANTHONIA or PARRY OATGRASS	Cool	Bunch	12-24"	Fair; seldom abundant enough	Attractive summer grass; dry gravelly hillsides in upper montane
Deschampsia cespitosa	*Deschampsia cespitosa*	TUFTED HAIRGRASS or SALT-AND-PEPPER GRASS	Cool	Bunch	8-30"	Fair wildlife forage; good to excellent for livestock	Tenacious, attractive plant; will grow from moist gravel and peat
Distichlis spicata	*Distichlis stricta*	INLAND SALTGRASS	Warm	Rhizomes	5-15"	Poor	Good sod former; robust; stays green through fall; alkaline and saline soils

Table A1: Upland Plant Characteristics - Graminoids

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	SEASONALITY	GROWTH FORM	HEIGHT	WILDLIFE AND LIVESTOCK VALUE	COMMENTS
Elymus lanceolatus	*Elymus lanceolatus*	STREAMBANK WHEATGRASS or THICKSPIKE WHEATGRASS	Cool	Rhizomes	15-30"	Good forage for most livestock and big game, fair for sheep	Grows among rocks on slopes and in moist burrow pits
Elymus trachycaulus	*Elymus trachycaulus* ssp. *andinus*	SLENDER WHEATGRASS	Cool	Bunch	12-40"	Good to excellent	Subalpine to alpine meadows and roadsides; shortlived in most revegetation contexts
Festuca arizonica	*Festuca arizonica*	ARIZONA FESCUE or PINEGRASS or MOUNTAIN BUNCH GRASS	Cool	Bunch	15-30"	Not very palatable but important due to its abundance	Dry pine forests (especially ponderosa pine) in southern counties; remains green well into fall
Festuca brachyphylla	*Festuca brachyphylla*	COLORADO FESCUE	Cool	Bunch	usually over 4"	Unknown	Characteristic of dry tundra
Festuca idahoensis	*Festuca idahoensis*	IDAHO FESCUE or BLUE BUNCHGRASS	Cool	Bunch	12-40"	Excellent; important in late season	Grows on a broad range of soils on rocky slopes and open forests
Festuca kingii	*Leucopoa kingii*	SPIKE FESCUE	Cool	Rhizomes	12-39"	Fair	Dry, gravelly soils on slopes
Festuca rubra	*Festuca rubra*	RED FESCUE	Cool	Short rhizomes	8-10"	Good forage and cover	Often included in lawn mixtures; needs water 3 times a week
Festuca saximontana	*Festuca saximontana*	ROCKY MOUNTAIN FESCUE or SHEEP FESCUE	Cool	Bunch	Rarely up to 48"	Valuable; palatable very early in spring	Dry mountain meadows and forest openings; does comparatively well in poor, sandy, gravelly soils
Festuca thurberi	*Festuca thurberi*	THURBER'S FESCUE	Cool	Bunch	15-40"	Poor	Good soil binder; attractive summer grass; especially abundant in the San Juan Mountains
Hilaria jamesii	*Hilaria jamesii*	GALLETA	Warm	Rhizomes	15-25"	Good early forage	Drought resistant; excellent for difficult areas that receive erosion pressure or heavy traffic; common in sagebrush stands
Hordeum jubatum	*Critesion jubatum*	FOXTAIL BARLEY or BOBTAIL BARLEY	Cool	Bunch	8-30"	Poor	Tolerates flooding; attractive for landscaping; CAREFUL! Can be aggressive and invasive in wetlands

Table A1: Upland Plant Characteristics - Graminoids

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	SEASONALITY	GROWTH FORM	HEIGHT	WILDLIFE AND LIVESTOCK VALUE	COMMENTS
Kobresia myosuroides	*Kobresia myosuroides*	BELLARDI KOBRESIA	Cool	forming hummocks		Unknown	Alpine tundra
Koeleria macrantha	*Koeleria macrantha*	PRAIRIE JUNEGRASS	Warm	Bunch	15-25"	Good	Attractive spring grass; good soil binder; be careful if buying seed commercially as it may be of European origin - verify its source!
Lycurus phleoides	*Lycurus setosus*	COMMON WOLFSTAIL	Warm	Rhizomes	10-25"	Good forage	Gravelly soils
Leymus cinereus	*Leymus cinereus*	BASIN WILD RYE	Cool	Bunch	3-10’	Fair to good	Very tall
Leymus salinus	*Leymus salina*	SALINE WILD RYE	Cool	Bunch	15-55"	Fair	
Melica spectabilis	*Bromelica spectabilis*	PURPLE ONIONGRASS or SHOWY ONIONGRASS	Cool	Rhizomes	10-30"	Good to excellent	Aspen woodlands in northern counties; attractive grass
Muhlenbergia asperifolia	*Muhlenbergia asperifolia*	ALKALI MUHLY	Warm	Rhizomes	5-20"	Poor	Good ground cover; very fine foliage; saline tolerant
Muhlenbergia montana	*Muhlenbergia montana*	MOUNTAIN MUHLY	Warm	Bunch	10-25"	Fair	Good soil binder; dry montane hillsides
Muhlenbergia pungens	*Muhlenbergia pungens*	SANDHILL MUHLY; RING MUHLY	Warm	Rhizomes	10-24"	Poor	Sand dune blowouts and plains in San Luis Valley and Moffat County
Muhlenbergia racemosa	*Muhlenbergia racemosa*	MARSH MUHLY or GREEN MUHLY	Warm	Rhizomes	12-40"	Poor for wildlife; fair for cattle	Rocky places; often associated with sagebrush or aspen
Muhlenbergia torreyi	*Muhlenbergia torreyi*	RING MUHLY	Warm	Short rhizomes	4-16"	Fair	Soil binder; soils on sandy East Slope
Oryzopsis hymenoides	*Achnatherum hymenoides*	INDIAN RICEGRASS	Cool	Bunch	15-25"	Good	Beautiful plant when in fruit; extremely drought tolerant; good for erosion control; seeds are especially sensitive to ecotypic variation, thus it is best to plant seeds that have been grown in similar environmental conditions
Oryzopsis micrantha	*Piptatherum micranthum*	LITTLESEED RICEGRASS	Cool	Bunch	12-28"	Poor	Attractive slender, delicate grass; sandy plains and hills
Panicum virgatum	*Panicum virgatum*	SWITCHGRASS	Warm	Bunch	40-80"	Fair forage; bird habitat	Excellent soil binder; adapted to moist conditions but surprisingly drought tolerant once established
Pascopyrum smithii	*Pascopyrum smithii*	WESTERN WHEATGRASS	Cool	Rhizomes	15-30"	Good winter forage	Sod former; good for erosion control along waterways, terraces, and stream banks; drought tolerant; aggressive

Table A1: Upland Plant Characteristics - Graminoids

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	SEASONALITY	GROWTH FORM	HEIGHT	WILDLIFE AND LIVESTOCK VALUE	COMMENTS
Phleum alpinum	*Phleum commutatum*	ALPINE TIMOTHY	Cool	Short rhizomes	8-16"	Good	Good soil binder; subalpine meadows
Poa alpina	*Poa alpina*	ALPINE BLUEGRASS	Cool	Bunch	4-8"	Poor to fair	Attractive summer plant; good ground cover; tundra and gravelly upper subalpine
Poa fendleriana	*Poa fendleriana* ssp. *longiligula*	MUTTONGRASS	Cool	Bunch	10-22"	Good	Gravelly soils; good soil binder; piñon-juniper to timberline
Poa nervosa	*Poa nervosa*	WHEELER BLUEGRASS	Cool	Rhizomes		Fair	Common in forests and meadows; montane and subalpine
Poa secunda	*Poa secunda (includes P. sandbergii, P. ampla)*	SANDBERG BLUEGRASS	Cool	Bunch	15-25"	Fair	Good soil-binder; drought tolerant; erosion control; sand stabilization; dry grassland and desert-steppe
Psuedoroegneria spicata	*Psuedoroegneria spicata*	BLUEBUNCH WHEATGRASS	Cool	Bunch	10-16"	Good winter forage	Good soil binder on slopes
Redfieldia flexuosa	*Redfieldia flexuosa*	BLOWOUT GRASS	Warm	Rhizomes	25-40"	Fair	Excellent soil binder; sandy soils; sandhills and dunes on Eastern Plains
Schizachyrium scoparium	*Schizachyrium scoparium*	LITTLE BLUESTEM	Warm	Rhizomes	20-60"	Fair	Beautiful red foliage in the fall lasting through winter
Sorghastrum nutans	*Sorghastrum avenaceum*	YELLOW INDIANGRASS	Warm	Rhizomes	48-60"	Fair	Attractive late summer grass; moist tall-grass prairie remnants on East Slope
Sporobolus airoides	*Sporobolus airoides*	ALKALI SACATON	Warm	Bunch	20-40"	Poor	Attractive for landscaping; builds a good seed bank-seeds remain viable for years; alkaline flats
Sporobolus compositus	*Sporobolus asper*	TALL DROPSEED	Warm	Bunch	20-40"	Poor for wildlife; fair for livestock	
Sporobolus cryptandrus	*Sporobolus cryptandrus*	SAND DROPSEED	Warm	Bunch	15-40"	Poor	Erosion control; sand stabilization; excellent seed producer; roadsides and dry grasslands
Sporobolus giganteus	*Sporobolus giganteus*	GIANT DROPSEED	Warm	Bunch	40-80"	Poor	southeastern Colorado on sand dunes
Sporobolus heterolepis	*Sporobolus heterolepis*	PRAIRIE DROPSEED	Warm	Bunch	12-28"	Unknown	Eastern prairie species; very fine leaves
Stipa comata	*Hesperostipa comata*	NEEDLE-AND-THREAD	Cool	Bunch	15-25"	Poor	Very attractive grass; good seed producer

Table A1: Upland Plant Characteristics - Graminoids

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	SEASONALITY	GROWTH FORM	HEIGHT	WILDLIFE AND LIVESTOCK VALUE	COMMENTS
Stipa lettermanii	*Achnatherum lettermanii*	LETTERMAN'S NEEDLEGRASS	Cool	Bunch	10-24"	Fair until sharp callus develops late in summer	Pointed callus may cause livestock loss; dry montane forests
Stipa nelsonii	*Achnatherum nelsonii*	NELSON'S NEEDLEGRASS or COLUMBIA NEEDLEGRASS or SUBALPINE NEEDLEGRASS	Cool	Bunch	12-40"	Fair until sharp callus develops late in summer	Pointed callus may cause livestock loss; dry plains, meadows, and woodlands in foothills and mountains
Stipa neomexicana	*Hesperostipa neomexicana*	NEW MEXICO FEATHERGRASS	Cool	Bunch	16-31"	Poor	Beautiful plant; rocky soils in grasslands near the front range and southeastern counties only; good seed producer; good soil binder
Stipa spartea	*Hesperostipa spartea*	PORCUPINE GRASS	Cool	Bunch	20-47"	Unknown	Very long awns; striking appearance
Trisetum spicatum	*Trisetum spicatum*	SPIKE TRISETUM	Cool	Bunch	6-20"	Good throughout growing season and into fall	Attractive grass; upper subalpine and alpine

FORBS

Table A2: Upland Plant Characteristics - Forbs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	HEIGHT	GROWTH FORM	COMMENTS
Achillea lanulosa	*Achillea lanulosa*	WOOLLY YARROW	White bunches of minute flowers	Low to tall; 8-40"	Perennial; rhizomes	Grows in disturbed areas; meadows and open sites; 8,000-12,000 feet
Agoseris aurantiaca, A.glauca	*Agoseris aurantiaca, A. glauca*	FALSE DANDELION	Burnt orange Yellow	Medium height	Perennial	Resembles the nonnative dandelion but with larger flowers
Ambrosia psilostachya	*Ambrosia psilostachya*	WESTERN RAGWEED	Inconspicuous, greenish	12-30"	Perennial	Dry prairies, barrens. loess hills
Antennaria spp.	*Antennaria* spp.	PUSSYTOES	Inconspicuous white to pink	Prostrate; < 1'	Perennial	Spreads, forming large mats
Arenaria hookeri	*Eremogone hookeri*	DESERT SANDWORT	White to yellow	Prostrate	Perennial	Sandy, rocky sites; desert-steppe; clay barrens
Argemone polyanthemos	*Argemone polyanthemos*	PRICKLY POPPY or BLUESTEM PRICKLY POPPY	White with yellow centers	Tall; 1-3'	Biennial or short-lived perennial	Sandy soils; prickly stem and foliage
Arnica cordifolia	*Arnica cordifolia*	HEARTLEAF ARNICA	Yellow	Medium to tall	Perennial; rhizomes	Attractive; dry forests, foothills, and subalpine
Arnica mollis	*Arnica mollis*	HAIRY ARNICA	Yellow	Medium to tall	Perennial	Subalpine spruce-fir forests
Artemisia carruthii	*Artemisia carruthii*	CARRUTH'S SAGEWORT	Inconspicuous	Low	Perennial; short rhizomes appearing to grows in patches	Aromatic foliage; southeastern counties only
Artemisia franserioides	*Artemisia franserioides*	RAGWEED SAGEBRUSH	Inconspicuous		Perennial	Somewhat weedy
Artemisia frigida	*Artemisia frigida*	FRINGED SAGE	Inconspicuous	Tall, 12-28"	Woody perennial	Scented foliage
Artemisia ludoviciana	*Artemisia ludoviciana*	SAGEWORT	Inconspicuous	Medium	Perennial	Aromatic silver foliage
Artemisia scopulorum	*Artemisia scopulorum*	ALPINE SAGEBRUSH	Inconspicuous		Perennial	Alpine to subalpine
Asclepias arenaria	*Asclepias arenaria*	SAND MILKWEED	Greenish-white	Tall; 8-20"	Perennial	Sandhills
Asclepias latifolia	*Asclepias latifolia*	BROADLEAF MILKWEED	Greenish-white	Tall; 2'	Perennial; rhizomes	Arkansas River drainage; short-grass prairie and disturbed areas on clay, sand, and rocky soils

Table A2: Upland Plant Characteristics - Forbs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	HEIGHT	GROWTH FORM	COMMENTS
Astragalus spp.	*Astragalus* spp.	MILKVETCH	Various	Prostrate to tall	Mostly perennial	Many species of astragalus are found across a wide elevational range and many habitat types. Identify your local species; can be poisonous to domestic livestock.
Balsamorrhiza sagittata	*Balsamorrhiza sagittata*	ARROWLEAF BALSAM-ROOT	Yellow (see comments)	Tall	Perennial	Doesn't flower until 4th or 5th year, but may live as long as 50+ years
Berlandiera lyrata	*Berlandiera lyrata*	CHOCOLATE FLOWER or GREEN EYES	Yellow rays with reddish brown center	Low sprawling	Perennial	Chocolate scented; southern counties; dry plains, hills, mesas, rocky soils
Calylophus spp.	*Calylophus* spp.	SUNDROPS	Yellow	to 8"	Perennial	Short-lived flowers
Campanula rotundifolia	*Campanula rotundifolia*	BLUEBELL BELLFLOWER	Bluish-purple	6-28"	Perennial	Attractive blue varieties; mesic, gravelly, sandy, loamy soils
Castilleja linariifolia	*Castilleja linariifolia*	WYOMING INDIAN PAINTBRUSH	Red	Medium to tall	Perennial	Many color variants
Castilleja occidentalis	*Castilleja occidentalis*	WESTERN INDIAN PAINTBRUSH	Pale yellow	to 8"	Perennial	Common tundra species
Cerastium arvense	*Cerastium arvense*	MOUSE-EAR CHICKWEED	White	Various	Annual and perennial; rhizomes	Good ground cover; matrix plant
Chamerion danielsii	*Chamerion danielsii*	FIREWEED	Pink	Tall	Perennial	Grows in disturbed areas especially after a fire
Chrysopsis canescens	*Heterotheca canescens*	GOLDEN ASTER	Yellow	Forms clumps	Perennial	Silvery foliage; mid- to late summer bloomer
Chrysopsis villosa	*Heterotheca villosa*	GOLDEN ASTER	Yellow	Low sprawling; 8-24"	Perennial	Silvery foliage; mid- to late summer bloomer
Claytonia megarhiza	*Claytonia megarhiza*	ALPINE SPRINGBEAUTY	White to pink	Low	Perennial	Extremely rocky alpine tundra sites
Corydalis aurea ssp. *occidentalis*	*Corydalis curvisiliqua*	FUMEWORT or GOLDEN SMOKE	Yellow spurred flower	Low; 4-16"	Perennial	Early spring bloomer; gravelly, sandy loam
Cryptantha cinerea var. *jamesii*	*Oreocarya suffruticosa*	JAMES' CAT EYE	Small white flowers with yellow centers	4-12"	Perennial	Gray stems and hirsute foliage; usually on sandy soil
Cryptantha thyrsiflora	*Oreocarya thyrsiflora*	CLUSTER CAT EYE	Small white flowers	Tall	Perennial	Bristly; common on plains

Table A2: Upland Plant Characteristics - Forbs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	HEIGHT	GROWTH FORM	COMMENTS
Cymopterus acaulis	*Cymopterus acaulis*	PLAINS SPRING PARSLEY or STEMLESS SPRING PARSLEY	White	Prostrate	Perennial	Early spring; sandy soils; plains and mesas
Dalea candida	*Dalea candida*	WHITE PRAIRIECLOVER	White to pink-purple	12-30"; decumbant	Perennial	Cylindrical heads; mesic to dry soil
Dalea purpurea	*Dalea purpurea*	PURPLE PRAIRIECLOVER	Purple	Medium; to 2.5'	Perennial	Blooms midsummer; many soil types
Dalea villosa	*Dalea villosa*	SILKY PRAIRIECLOVER	Pink to purple, rarely white	8-14"	Perennial	Sandhills on the eastern plains
Delphinium barbeyi	*Delphinium barbeyi*	LARKSPUR or BARBEY LARKSPUR	Dark purple	Tall	Perennial	Mesic sites
Delphinium carolinium subsp. virescens	*Delphinium carolinium subsp. virescens*	LARKSPUR or PRAIRIE LARKSPUR	Off-white to greenish-white to whitish-blue	Tall; 1-4'	Perennial	Ornate flowers; plains and sandhills
Delphinium nuttallianum	*Delphinium nuttallianum*	NUTTALL'S (OR NELSON'S) LARKSPUR	Blue purple	4-36"	Perennial	Meadows, sagebrush, open woods
Echinocereous coccineus var. *coccineus*	*Coryphantha vivipara*	NIPPLE CACTUS	Pink	Low	Perennial	Spiny
Echinocereus viridiflorus	*Echinocereus viridiflorus*	HEDGEHOG CACTUS	Yellowish-green	Low	Perennial	Common
Erigeron flagellaris	*Erigeron flagellaris*	FLEABANE DAISY	Yellow center with white and pink rays or blue rays	Low	Perennial; stolons	Spreads rapidly forming mats
Erigeron peregrinus	*Erigeron peregrinus*	SUBALPINE FLEABANE	Lavender	3.5-22"	Perennial	Open rocky slopes and subalpine meadows
Eriogonum annuum	*Eriogonum annuum*	ANNUAL BUCKWHEAT	White; rust-red in the fall	Tall; 12-40"	Annual and biennial	Mid- to late summer bloomer on sandy soils
Eriogonum cernuum	*Eriogonum cernuum*	NODDING BUCKWHEAT	Small pinkish white	Low; 6-16"	Perennial	Midsummer; outer foothills, intermountain parks
Eriogonum effusum	*Eriogonum effusum*	WILD BUCKWHEAT or BUSHY BUCKWHEAT	Very small white turning red in fall	Low shrub-like	Perennial	Broom-like in appearance; plains and Arkansas River Valley

Table A2: Upland Plant Characteristics - Forbs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	HEIGHT	GROWTH FORM	COMMENTS
Erysimum asperum	*Erysimum asperum*	WALLFLOWER or WESTERN WALLFLOWER	Yellow to orange	Medium; 8-24"	Biennial or perennial	Late spring to early summer bloomer with large attractive fruits
Gaillardia aristata	*Gaillardia aristata*	COMMON BLANKETFLOWER	Yellow with reddish-purple at the base	Medium height	Perennial; rhizomes	Midsummer bloomer; verify source of commercial varieties, many are hybrids; well-drained soils
Gaillardia pinnatifida	*Gaillardia pinnatifida*	RED DOME BLANKETFLOWER or INDIAN BLANKETFLOWER	Short yellow rays; reddish center	Medium; 8-24"	Perennial	Southern counties only
Galium spp.	*Galium* spp.	BEDSTRAW	White	Low to medium height	Perennial	Spreads easily
Gaura coccinea	*Gaura coccinea*	GAURA or SCARLET GAURA	Pinkish-white	Under 40"	Perennial; rhizomes	Variety of soils; dry sites on prairies
Geranium richardsonii	*Geranium richardsonii*	GERANIUM or RICHARDSON'S GERANIUM	White to purple	Medium height; 20-40"	Perennial	Attractive fruits, flowers, and foliage; openings in conifer forests
Geranium caespitosum	*Geranium caespitosum*	PINEYWOODS GERANIUM	White to pink-purple	6-28"	Perennial	
Geum rossii var. *turbinatum*	*Acomastylis rossii ssp. turbinata*	ROSS' AVENS	Yellow	Low; 1-7"	Perennial	Common on rocky tundra
Gilia longiflora	*Ipomopsis longiflora*	GILIA or LONG-FLOWERED GILIA	White to blue	Medium height; to 24"	Annual	Sandy soils
Helianthella quinquenervis	*Helianthella quinquenervis*	FIVENERVED HELIANTHELLA	Yellow	Tall	Perennial	Aspen understory
Helianthus petiolaris	*Helianthus petiolaris*	PRAIRIE SUNFLOWER	Yellow rays with brown center	Tall; to 6'	Annual	Attracts birds; plains, hills, roadsides; best on sandy soils
Heliomeris multiflora	*Heliomeris multiflora*	SHOWY GOLDENEYE	Yellow	Tall	Perennial	Mid- to late summer bloomer
Heliotropium convolvulaceum	*Euploca convolvulacea*	PHLOX HELIOTROPE	White	Low; 4-16"	Annual	Silver foliage; often on sandhills; sandy soils
Heterotheca villosa	*Heterotheca villosa*	HAIRY GOLDENASTER	Yellow	Tall	Perennial	Very common throughout Colorado
Hymenopappus filifolius	*Hymenopappus filifolius*	THREADLEAF HYMENOPAPPUS	Yellow	Tall	Biennial or perennial	Sandy soils
Hymenoxys richardsonii	*Picradenia richardsonii*	PINGUE HYMENOXYS	Yellow	3-16"	Perennial	Gravelly flats, intermountain parks

Table A2: Upland Plant Characteristics - Forbs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	HEIGHT	GROWTH FORM	COMMENTS
Ipomoea leptophylla	*Ipomea leptophylla*	BUSH MORNING GLORY	Pink to reddish-purple	Tall; 1-5'; Roots run 15-25' deep	Perennial	Plains; 3,500-6,500 feet; root diameter of a fence post; attractive
Ipomopsis aggregata	*Ipomopsis aggregata*	SKYROCKET GILIA	Red to pink	Medium	Perennial; possibly biennial	Early successional opportunist
Lathyrus spp.	*Lathyrus* spp.	PEA VINE	Various: white to pink	Various	Various	Aspen, oak/serviceberry, sagebrush understory
Leucelene ericoides	*Leucelene ericoides*	SAND ASTER or HEATH ASTER	White with yellow centers	Forms clumps	Perennial	Arid sites; sandy and rocky sites, 4,000-8,000 feet
Liatris punctata	*Liatris punctata*	DOTTED GAYFEATHER	Pink	Medium to tall; 1-2.5'	Perennial	Spiky tall flowers; late summer bloomer; adapts to many soil types
Ligusticum porteri	*Ligusticum porteri*	PORTER'S LICORICEROOT	Inconspicuous	Tall	Perennial	Forested ravines and aspen groves
Linum lewisii	*Adenolinum lewisii*	WILD BLUE FLAX or LEWIS FLAX	Light blue	Tall; to 2.5"	Perennial	Fragile flowers, hardy plants; well-drained soils
Lotus wrightii	*Lotus wrightii*	WRIGHT'S DEER VETCH	Yellow	Low	Perennial	Southern counties of West Slope; tendrils
Lupinus pusillus	*Lupinus pusillus*	LUPINE	Blue to purple	Erect; 4-8"	Annual	Sandy soils; seeds gathered by ants and used to cover their hills
Lupinus spp.	*Lupinus* spp.	LUPINE	Blue to white	Usually tall and erect	Perennial and annual	
Melampodium leucanthum	*Melampodium leucanthum*	BLACKFOOT DAISY	White rays with yellow center	Low bushy herb; 6-20"	Perennial	Arkansas River drainage; well-drained soils
Mentzelia nuda	*Nuttallia nuda*	BLAZINGSTAR	White to cream	Tall; to 3'	Biennial or perennial	Sandy soils; flowers open in early evening
Mertensia lanceolata	*Mertensia lanceolata*	CHIMING BELLS	Blue to pink	Medium to tall; 4-18"	Perennial	Very attractive plant with a variety of shades of blue and pink flowers on the same individual plants
Mertensia spp.	*Mertensia* spp.	CHIMING BELLS or BLUEBELLS	Various shades of blue to purple	Medium to tall	Perennial	Very attractive plant with a variety of shades of blue and pink flowers on the same individual plants
Mesynium puberulum	*Mesynium puberulum*	YELLOW FLAX	Copper-yellow	Low	Perennial	Southern counties of East Slope
Mirabilis glaber	*Oxybaphus glaber*	FOUR-O'CLOCK	Flowers nondescript; pinkish bracts	Tall	Perennial	Sandhills
Mirabilis linearis	*Oxybaphus linearis*	NARROWLEAF FOUR-O'CLOCK	Pinkish-white	Tall; 8-40"	Perennial	Common on plains

Table A2: Upland Plant Characteristics - Forbs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	HEIGHT	GROWTH FORM	COMMENTS
Oenothera spp.	*Oenothera* spp.	EVENING-PRIMROSE	Usually white	Various	Perennial	Short-lived flowers; bloom in the early evening; night pollinated
Oxytropis lambertii	*Oxytropis lambertii*	LAMBERT'S CRAZYWEED	Pink purple	Medium to tall	Perennial	Grasslands
Palafoxia sphacelata	*Palafoxia sphacelata*	OTHAKE	Pink	Low to medium in height; 3-22"	Annual	Sandy soils
Penstemon spp.	*Penstemon* spp.	BEARDTONGUE	Various: pink, white purple, lavender, red, blue	Various, usually erect	Perennial	Many species with tremendous revegetation utility
Petradoria pumila	*Petradoria pumila*	ROCK GOLDENROD	Yellow	Medium	Perennial	West Slope piñon-juniper and oak
Phlox hoodii	*Phlox hoodii*	SPINY PHLOX	Various, white, pink to blue	Low	Perennial	
Polanisia jamesii	*Polanisia jamesii*	JAMES' CLAMMYWEED	White to yellow	Medium	Annual	Attractive in flower and fruit
Polemonium spp.	*Polemonium* spp.	JACOB'S LADDER	Light to dark blue	Low	Perennial	Skunky odor
Potentilla fissa	*Drymocallis fissa*	CINQUEFOIL	Yellow	Low	Perennial; prostrate	
Potentilla spp.	*Potentilla* spp.	CINQUEFOIL	Yellow	Various	Various	
Pseudocymopterus montanus	*Pseudocymopterus montanus*	ALPINE FALSE SPRINGPARSLEY	Yellow	Medium to tall	Perennial	Fragrant foliage
Psoralea lanceolata	*Psoralidium lanceolatum*	LEMON SCURFPEA	White or cream to bluish	Bushy; 4-25"	Perennial; rhizomes	Sandy soils
Psoralea tenuiflora	*Psoralidium tenuiflorum*	SLIMFLOWER SCURFPEA	Purple to blue	Tall bushy; .5-4'	Perennial	Common on plains
Ratibida columnifera	*Ratibida columnifera*	PRAIRIE CONEFLOWER	Yellow rays	0.5-4'	Perennial	Cylindrical heads; Denver to southeastern counties
Ratibida tagetes	*Ratibida tagetes*	PRAIRIE CONEFLOWER	Maroon rays	Short; 6-16"	Perennial; rhizomes	Cylindrical heads
Rumex venosus	*Rumex venosus*	WILD-BEGONIA	Pinkish bracts; orange-red fruits	Low; to 2'	Perennial; rhizomes	Sandy to gravelly soils
Sedum lanceolatum	*Amerosedum lanceolatum*	STONECROP	Yellow	Low	Perennial	Succulent leaves
Senecio bigelovii	*Ligularia bigelovii*	HALL'S RAGWORT	Yellow	Tall	Perennial	Montane to subalpine
Senecio spp.	*Ligularia* spp.	RAGWORT	Yellow	Medium to tall	Perennial	High revegetaion potential
Senecio spp.	*Packera* spp.	GROUNDSEL	Yellow	Medium to tall	Annual to perennial	High revegetaion potential, especially *S. atratus*

Table A2: Upland Plant Characteristics - Forbs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	HEIGHT	GROWTH FORM	COMMENTS
Silene acaulis	*Silene acaulis*	MOSS CAMPION	Pink	Low	Perennial	Forms dense mats; dry tundra
Solidago spp.	*Solidago* spp.	GOLDENROD	Yellow	Medium to tall; to 6' tall	Perennial; rhizomes	Late summer to early fall bloomer
Sophora sericea	*Vexibia nuttalliana*	WHITE LOCO	White	Low; to 2'	Perennial; rhizomes	Early spring and possibly late summer if adequate moisture is present
Sphaeralcea angustifolia	*Sphaeralcea angustifolia*	NARROWLEAF GLOBE MALLOW	Orange	Tall; to 5'	Perennial	Arkansas River drainage
Sphaeralcea coccinea	*Sphaeralcea coccinea*	SCARLET GLOBE MALLOW	Burnt orange	Low	Perennial; rhizomes	Attractive; very drought tolerant
Stanleya pinnata	*Stanleya pinnata*	PRINCE'S PLUME	Yellow	Tall; to 5.5'	Perennial	Indicator of selenium rich soils
Stenotus acaulis	*Stenotus acaulis*	GOLDENWEED	Yellow	Medium to tall	Perennial	West Slope
Stenotus armerioides	*Stenotus armerioides*	GOLDENWEED	Yellow	2-6"	Perennial	Wide distribution
Tetraneuris acaulis	*Tetraneuris acaulis*	STEMLESS HYMENOXYS	Yellow	Low	Perennial	Spreading, attractive silky foliage
Tetraneuris ivesiana	*Tetraneuris ivesiana*	IVE'S FOUR-NERVED DAISY	Yellow	Low	Perennial	Spring flowering
Tetraneuris scaposa	*Tetraneuris scaposa*	STEMMY HYMENOXYS	Yellow	Low	Perennial	Spring flowering
Teucrium laciniatum	*Teucrium laciniatum*	CUTLEAF GERMANDER	White with purple streaks		Perennial	Forms bunches; Arkansas River drainage
Thalictrum alpinum	*Thalictrum alpinum*	ALPINE MEADOWRUE	Nondescript	Tall	Perennial	Attractive foliage; resembles foliage of columbine
Thalictrum fendleri	*Thalictrum fendleri*	FENDLER MEADOWRUE	Nondescript	Tall	Perennial	Attractive foliage; resembles foliage of columbine
Thalictrum spp.	*Thalictrum* spp.	MEADOWRUE	Nondescript greenish flowers		Perennial	Attractive foliage; resembles foliage of columbine
Thelesperma megapotamicum	*Thelesperma megapotamicum*	GREENTHREAD	Yellow	Tall; to 3'	Perennial; rhizomes	Flowers look like buttons
Thermopsis montana	*Thermopsis montana*	GOLDEN BANNER	Yellow	Medium to tall; 12-24"	Perennial; rhizomes	Stiff, erect fruits
Thermopsis spp.	*Thermopsis* spp.	GOLDEN BANNER	Yellow	Tall	Perennial; rhizomes	Three-leaved foliage
Tradescantia occidentalis	*Tradescantia occidentalis*	WESTERN SPIDERWORT	Blue to purple	Medium height; 0.5-1.5'	Perennial	Gravelly, sandy soil
Trifolium dasyphyllum	*Trifolium dasyphyllum*	ALPINE CLOVER	Purple	Low	Perennial	Forms mats on dry tundra

Table A2: Upland Plant Characteristics - Forbs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	HEIGHT	GROWTH FORM	COMMENTS
Vicia americana	*Vicia americana*	AMERICAN VETCH	Purple, pink, or blue	Tall slender	Perennial	Tendrils; vine-like
Zinnia grandiflora	*Zinnia grandiflora*	ROCKY MOUNTAIN ZINNIA	Yellow rays with red or orange centers	Low bush-like; to 1'	Perennial; spreads rapidly forming colonies	Papery flowers, Arkansas River drainage

TREES AND SHRUBS

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Abies concolor	*Abies concolor*	WHITE FIR or BALSAM FIR	Not applicable	Evergreen tree; 80-100'	Seeds eaten by grouse, rodents, and deer	7,500-10,000	Hillsides with ponderosa pine and Douglas-fir and in canyons with blue spruce, southern CO
Abies lasiocarpa	*Abies bifolia*	SUBALPINE FIR	Not applicable	Evergreen tree; 40-60'	Seeds eaten by birds and small mammals; sheep and deer browse twigs and foliage	8,500-12,000	Cool moist sites
Acer glabrum	*Acer glabrum*	ROCKY MOUNTAIN MAPLE	Inconspicuous-very small	Small, deciduous, multi-stemmed tree; 20-30'	Rodents eat seeds; birds eat seeds, buds, and flowers; moose, elk, and deer browse foliage	5,000-10,500	Moist sites, streams, and canyons; attractive red stems
Amelanchier alnifolia	*Amelanchier alnifolia*	SASKATOON SERVICEBERRY	Showy white flowers	Small, deciduous tree or shrub; up to 20'	Bark eaten by marmots and beaver; foliage and fruits are eaten by rodents, deer, mouse, bears, and birds	5,000-10,000	Dry, rocky slopes to moist, fertile soils
Amelanchier utahensis	*Amelanchier utahensis*	UTAH SERVICEBERRY	Showy white	Small, deciduous tree or shrub; 6-15'	Fruits and foliage eaten by over 60 species of wildlife; provides good cover for small birds and mammals	4,000-10,000	Sagebrush and pinon-juniper, western slope
Amorpha canescens	*Amorpha canescens*	LEADPLANT	Light blue to purple-red in a crowded raceme	Small deciduous, shrub; rhizomes; less than 3' tall	Excellent for livestock and wildlife	High plains; eastern most Colorado counties, tall-grass prairie remnants	Often cultivated for ornamental uses; dry, plains, hills, and prairies; nitrogen fixer

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Amorpha fruticosa	*Amorpha fruticosa*	LEADPLANT	Purple in a crowded raceme	Deciduous shrub to 6'		Foothills	Along streams
Arctostaphylos uva-ursi	*Arctostaphylos uva-ursi*	KINNIKINNICK or BEARBERRY	Small white to pinkish; attractive red fruits	Low, trailing, evergreen shrub; up to 12"	Bears and grouse eat fruits; browsed by a wide variety of wildlife	4,500-8,000	Semi-dry areas; attractive, waxy leaves and red berries; need acidic, well-drained soil
Artemisia filifolia	*Oligosporus filifolia*	SAND SAGEBRUSH or THEAD-LEAVED SAGEBRUSH or WIZENED SAGE	Inconspicuous	Deciduous shrub; 12-59"	Causes sage sickness in horses; forage for deer and antelope	6,000-10,000	Sandy soils
Artemisia spinescens	*Picrothamnus desertorum*	BUD SAGEBRUSH or BUDSAGE or SPINY SAGE	Inconspicuous (yellow)	Shrub; 2-20"	Resistant to browsing; valuable to sheep	4,500-8,000	Desert mesas and plains; alkaline soil; associated with shadscale; fragrant
Artemisia tridentata ssp. *tridentata*	*Seraphidium tridentatum*	BASIN BIG SAGEBRUSH	Inconspicuous	Shrub; 2-10'	Resistant to browsing		Strong terpene oder
Artemisia tridentata ssp. *vaseyana*	*Seriphidium vaseyanum*	MOUNTAIN BIG SAGEBRUSH	Inconspicuous	Shrub; to 4'	Eaten by sage grouse and small game and browsed by big game.	6,000-10,000	Widely distributed; more fruity oder than ssp. *tridentata*
Atriplex confertifolia	*Atriplex confertifolia*	SHADSCALE SALTBUSH or SPINY SALTBUSH	Inconspicuous	Deciduous shrub;8-40"	Important browse for cattle, sheep, and goats	4,500-7,500	Alkaline soils
Atriplex corrugata	*Atriplex corrugata*	MAT SALTBUSH	Inconspicuous	Low spreading shrub	Valuable browse plant	4,500-7,500	Self regeneration high
Atriplex gardneri	*Atriplex gardneri*	GARDNER'S SALTBUSH or SALADILLO	Inconspicuous	Low shrub; 8-20"	Important browse for livestock	2,500-6,000	Alkaline shale soils
Atriplex garrettii	*Atriplex canescens*	GARRETT'S SALTBUSH or FOUR WING SALTBUSH or CHAMISO	Inconspicuous	Shrub; 8-100"	Valuable early spring forage for livestock; seeds eaten by birds	4,000-8,000	Alkali flats, grassy uplands, sandy soils
Berberis fendleri	*Berberis fendleri*	COLORADO BARBERRY	Yellow drooping clusters	Low, deciduous shrub; 2-3'	Berries unpalatable, used only by big game	5,400-8,500	Spiny; often associated with ponderosa pine

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Brickellia californica	*Brickellia californica*	CALIFORNIA BRICKELLBUSH or PACHABA	Yellowish-white to creamy-green and tinged with purple	Deciduous shrub; up to 3'	Seeds are favorite of Gambel's quail	3,000-7,500	Dry slopes, rocky mesas; western and southern Colorado; aromatic
Brickellia grandiflora	*Brickellia grandiflora*	TASSELFLOWER BRICKELLIBUSH or SHEATH FLOWER	Yellowish white	Deciduous shrub; up to 3'	Few values; some birds eat seeds	5,000-10,000	Canyons, rocky slopes
Ceanothus fendleri	*Ceanothus fendleri*	FENDLER'S CEANOTHUS or BUCKBRUSH	Clusters of small white flowers	Deciduous shrub; 12-30"	Favorite browse of deer and porcupine	5,500 to 9,000	Spiny
Ceanothus martinii	*Ceanothus martinii*	MARTIN'S CEANOTHUS	Small white flowers	Deciduous shrub; up to 3'	Fair browse	4,500-8,500	Associated with oak scrub
Cercocarpus intricatus	*Cercocarpus Intricatus*	WESTERN MOUNTAIN MAHOGANY	Small yellow flower	Low, evergreen shrub; up to 5'	Deer and elk browse; provides cover for many small birds and mammals	4,500-8,500	Far western part of Colorado; hardwood
Cercocarpus ledifolius	*Cercocarpus ledifolius*	LITTLELEAF MOUNTAIN MAHOGANY or CURL-LEAF MOUNTAIN MAHOGANY	Small yellow flower	Large, evergreen shrub; up to 26'	Deer and elk browse; provides cover for many small birds and mammals	6,500-9,000	Northwestern quarter of Colorado; aromatic; hardwood
Cercocarpus montanus	*Cercocarpus montanus*	TRUE MOUNTAIN MAHOGANY	Small yellow flower	Shrub; sometimes evergreen; 3-20'	Extremely valuable winter browse	4,000-8,500	Open rocky woods and stony soils
Chrysothamnus nauseosus	*Chrysothamnus nauseosus*	RUBBER RABBITBRUSH	Yellow	Low to tall deciduous shrubs	Fair winter forage for deer; may be toxic to livestock	Various	Many native species of *Chrysothamnus* are found across a wide elevational range and in many habitat types. Identify your local species.
Chrysothamnus parryi	*Chrysothamnus parryi*	PARRY'S RABBITBRUSH	Yellow	Low to moderate shrub		5,000-10,000	Long flower heads
Chrysothamnus viscidiflorus	*Chrysothamnus viscidiflorus*	DOUGLAS RABBITBRUSH	Yellow	Low shrub; 4-30"		5,000- 9,500	Common in upper elevation sage zone

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Cornus stolonifera	*Swida sericea*	RED-OSIER DOGWOOD	Tiny white clusters	Deciduous shrub; 3-6'	Palatable all seasons for wide variety of wildlife	4,500-10,000	Attractive glossy leaves and red bark; along streams and canyon bottoms
Purshia stansburiana	*Purshia stansburiana*	STANSBURY CLIFFROSE or QUININE-BUSH	Cream-colored; rose-shaped	Shrub; stays green much of the year (semi-evergreen); up to 11'	Bitter, only eaten by deer and livestock when other browse is not available	4,500-7,500	Southwestern Colorado; attractive small shrub
Crataegus succulenta	*Crataegus macracantha* var. *occidentalis*	FLESHY HAWTHORN	Small white flowers	Small, deciduous tree or large shrub;up to 25'	Fruits eaten by turkeys and upland game birds	4,500-7,500	Spiny; mesic sites
Krascheninnikovia lanata	*Krascheninnikovia lanata*	WINTERFAT	Inconspicuous clusters become fluffy resembling lambs' tails	Shrub; 1-3'	Valuable forage plant	2,500-8,000	Fuzzy white foliage; very attractive ornamental; sandy alkaline soils
Fallugia paradoxa	*Fallugia paradoxa*	APACHEPLUME	Showy white flowers and showy fruits	Shrub; 2-5'	Browsed when other forage is scarce	3,500-8,000	Rocky slopes and washes
Fendlera rupicola	*Fendlera rupicola*	CLIFF FENDLERBUSH or FALSE MOCKORANGE	Showy white to pink	Shrub; 10-50'	Browsed when other forage is scarce	4,000-8,000	Southwestern Colorado; crevices in canyon walls and ledges
Jamesia americana	*Jamesia americana*	CLIFFBUSH or WAXFLOWER	Waxy white	Deciduous shrub; 3-6'	Browsed lightly by deer and bighorn sheep	5,500-10,000	Aromatic; cliffs and cliff bases
Juniperus communis var. *montana*	*Juniperus communis* ssp. *alpina*	COMMON JUNIPER	Not applicable	Low, prostrate, evergreen shrub less than 3'	Browsed by deer; fruits are eaten by birds and small mammals	5,000-7,500	Attractive, evergreen shrub
Juniperus monosperma	*Sabina monosperma*	ONESEED JUNIPER	Not applicable	Large, evergreen shrub to small tree; 20'	Fruits eaten by a variety of wildlife species	3,500-8,000	Dry hills and mesas; southeastern counties; alkaline soils
Juniperus scopulorum	*Sabina scopulorum*	ROCKY MOUNTAIN JUNIPER	Not applicable	Evergreen large shrub to small tree; up to 40'	Important for antelope, mule deer, and bighorn sheep; birds eat the fruits	5,000-9,000	Dry, rocky hillsides; also along streams

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Juniperus osteosperma (J. utahensis)	*Sabina osteosperma*	UTAH JUNIPER	Not applicable	Small, evergreen shrub up to 15'	Fruits are eaten by birds and small rodents	3,000-8,000	Dry, rocky places
Lonicera involucrata	*Distegia involucrata*	TWINBERRY HONEYSUCKLE	Showy reddish-purple leaf-like bracts with yellow twin flowers	Deciduous shrub; 2-7'	Fruits eaten by birds, bears, and small mammals; hummingbirds attracted to the tubular flowers	7,500-11,500	Moist soils; forests, streamsides
Mahonia repens	*Mahonia repens*	OREGONGRAPE	Small yellow in fragrant clusters; berries blue to purple	Less than 1.5' very low, prostrate, evergreen shrub; rhizomes	High forage value for big game; birds eat the fruits	6,000-10,000	Holly-like leaves; attractive ground cover
Opuntia spp.	*Opuntia* spp.	PRICKLY-PEAR	Yellow to pink; becomes orange as it fades	Low		Various	Spiny, edible fruits on many
Paxistima myrsinites	*Paxistima myrsinites*	BOXLEAF MYRTLE or MOUNTAIN LOVER	Inconspicuous	Low, spreading, evergreen shrub; up to 2'; rhizomes	Occasionally browsed	6,000-10,000	Forests at middle altitudes; shady moist sites; attractive
Pentaphylloides floribunda	*Pentaphylloides floribunda*	SHRUBBY CINQUEFOIL	Yellow	Deciduous shrub; 1-3'	Browsed by deer and domestic sheep and goats	7,500-11,500	Often cultivated as an ornamental; attractive; variety of habitats
Peraphyllum ramosissimum	*Peraphyllum ramosissimum*	SQUAWAPPLE	Pale pink	Tall, deciduous shrub; up to 6.5'	Occasionally browsed	5,500-8,000	Attractive, sturdy shrub; acid soils
Philadelphus microphyllus	*Philadelphus microphyllus*	LITTLELEAF MOCKORANGE	White, showy, fragrant	Deciduous shrub; up to 6'	Poor	4,000-8,000	This is the only native species of this type, don't confuse it with the many cultivated species found in the area and available at commercial nurseries

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Physocarpus monogynus	*Physocarpus monogynus*	MOUNTAIN NINEBARK	White to rose-colored, showy	Deciduous shrub; 20-48"; forms colonies	Winter forage; birds eat seeds	5,500-10,000	Very attractive, showy flowers; rocky canyonsides and talus slopes in south eastern Colorado and Colorado Plateau
Picea engelmannii	*Picea engelmannii*	ENGELMANN SPRUCE	Not applicable	Tall, evergreen tree; up to 130' tall	Poor forage; provides shelter and nesting for birds; good seed crop every 2-5 years	8,500-12,000	Subalpine zone throughout the state; shallow rooted
Picea pungens	*Picea pungens*	COLORADO BLUE SPRUCE	Not applicable	Tall, evergreen tree; to 100' tall	Poor forage; provides shelter and nesting for birds; birds and small mammals eat seeds	7,000-9,500	Near streamsides and canyons and in the wetlands of South Park
Pinus aristata	*Pinus aristata*	BRISTLECONE PINE	Not applicable	Tall, evergreen tree		5,000-9,000	South and West
Pinus contorta	*Pinus contorta* ssp. *latifolia*	LODGEPOLE PINE	Not applicable	Tall, evergreen tree; to 100' tall	Poor forage; provides shelter and nesting for birds; birds and small mammals eat seeds	Above 8,000	Successional in Colorado
Pinus edulis	*Pinus edulis*	TWONEEDLE PIÑON	Not applicable	Evergreen tree; less than 50'	Provides shelter and food in the form of piñon nuts to birds and small mammals	4,000-9,000	Jays spread seeds; good seed crop every 4 to 7 years
Pinus flexilis	*Pinus flexilis*	LIMBER PINE	Not applicable	Medium height, evergreen tree; to 50' tall	Rodents and birds eat seeds; big game browse foliage	5,000-9,000	Seeds spread by Clark's nutcracker; adapted to very rocky, windy sites
Pinus ponderosa	*Pinus ponderosa* ssp. *scopulorum*	PONDEROSA PINE	Not applicable	Tall, evergreen tree; to 150' tall	Rodents and birds eat seeds; big game browse foliage	5,000-9,000	Adapts to a wide range of soils, slopes, aspects, and altitudes; mature trees resistant to light fires

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Populus deltoides ssp. *monilifera*	*Populus deltoides* ssp. *monilifera*	PLAINS COTTONWOOD	Not applicable	Tall, deciduous tree; to 100' tall	Broad range of wildlife use it for forage, browse, and eat the seeds	2,500-7,000	Moist soils in riparian zones and valley floors.
Populus tremuloides	*Populus tremuloides*	QUAKING ASPEN	Not applicable	Deciduous tree; up to 100'	Broad range of wildlife use it for forage, browse, and eat the seeds	6,000-10,000	Reproduces by root suckers, rarely by seed
Prunus virginiana var. *melanocarpa*	*Padus virginiana ssp. melanocarpa*	BLACK CHOKECHERRY	Fragrant, white	Small, deciduous tree or large shrub; 10-20'; forms colonies	Loved by bears; favorite building material for beavers; important browse for a varieties of wildlife	4,500-9,000	Hillsides, canyons, and streamsides
Pseudotsuga menziesii	*Pseudotsuga menziesii*	DOUGLAS-FIR	Not applicable	Evergreen tree; up to 130'	Broad range of wildlife use it for forage, browse, and eat the seeds	4,000-11,000	On north-facing slopes at lower elevations; moist soils
Ptelea trifoliata	*Ptelea trifoliata*	COMMON HOPTREE	Greenish-white, small	Medium to large, deciduous shrub or small tree; to 20' tall	Occasionally browsed	5,000-9,000	Attractive fruit; gulches in Arkansas River Drainage
Purshia tridentata	*Purshia tridentata*	ANTELOPE BITTERBRUSH	Light yellow	Deciduous shrub; to 10'	Important source of browse; seeds for small mammals and birds	4,500-8,000	South-facing slopes; attractive, dry well-drained soils
Quercus gambelii	*Quercus gambelii*	GAMBEL'S OAK	Inconspicuous	Deciduous shrub to small tree; to 20'	Important shelter and browse for deer; acorns important food for small mammals and birds	4,000-8,500	Forms dense thickets; dry hillsides and slopes
Quercus undulata	*Quercus undulata*	DESERT OAK or WAVYLEAF OAK	Inconspicuous	Low, deciduous shrub; lower than other oaks; up to 1'; forms colonies	Shelter for jackrabbits and small rodents; acorns important food for small mammals and birds	4,000-6,500	Dry places; southern counties

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Rhus trilobata	*Rhus aromatica* ssp. *trilobata*	SKUNKBUSH SUMAC or SQUAWBUSH	Yellow in tiny clusters	Deciduous shrub; 2-6'	Wildlife eats the red-yellow fruits; rabbits eat bark	4,000-9,000	Dry hillsides canyons, valleys, and plains
Ribes cereum	*Ribes cereum*	WAX CURRANT	Pink to whitish	Deciduous shrub; 20-79"	Wildlife eats the fruits	4,000-10,000	Dry rocky, open slopes; hills and ridges; not spiny
Ribes coloradense	*Ribes coloradense*	COLORADO CURRANT	Greenish to purple	Low, deciduous shrub; prostrate stems	Wildlife eats the fruits	8,000-11,500	Not spiny
Ribes inerme	*Ribes inerme*	WHITESTEM GOOSEBERRY	Greenish to purple showy bracts	Deciduous shrub; up to 40"; forms colonies	Wildlife eats the fruits; good deer forage	5,000-11,000	Rich, moist soil along streams; with or without spines
Ribes lacustre	*Ribes lacustre*	PRICKLY CURRANT	Greenish-white	Deciduous shrub; up to 40"	Wildlife eats the fruits	8,000-10,000.	Spiny
Ribes leptanthum	*Ribes leptanthum*	TRUMPET GOOSEBERRY	Greenish-white	Deciduous shrub; 20-79"	Wildlife eats the fruits	5,500-12,000	Dry, sunny places; spiny
Ribes montigenum	*Ribes montigenum*	ALPINE PRICKLY CURRANT or GOOSEBERRY CURRANT	Pinkish to pinkish-purple	Deciduous shrub; 12-24"	Wildlife eats the fruits	7,500-11,500	Spiny; common in subalpine forests
Ribes wolfii	*Ribes wolfii*	WESTERN CURRANT	Greenish-white to reddish	Deciduous shrub; 3-5'	Wildlife eats the fruits	6,500-11,500	Not spiny
Rosa arkansana	*Rosa arkansana*	PRAIRIE ROSE	Pink with yellow center; showy	Deciduous shrub; up to 20"; rhizomes	Good browse; small mammals and birds feed on hips	3,500-9,000	Rocky slopes; dry mesas; prickly
Rosa woodsii	*Rosa woodsii*	WOOD'S ROSE	Pink showy flowers	Small, deciduous shrub; 3-10'; rhizomes	Good browse; small mammals and birds feed on hips	3,500-10,000	Thorny
Rubacer parviflorus	*Rubacer parviflorus*	THIMBLEBERRY	Showy white flowers	Deciduous shrub; 3-6.5'	Wildlife eats the fruits	7,000-10,000	Moist, shaded forests
Rubus deliciosus	*Oreobatus deliciosus*	DELICIOUS RASPBERRY or BOULDER RASPBERRY	Showy white flowers	Spreading, deciduous shrub; up to 5'	Wildlife eats the fruits	4,500-9,000	Very attractive; usually found on rocky ground
Rubus ideaus ssp. *strigosus*	*Rubus ideaus* ssp. *melanolasius*	GRAYLEAF RED RASPBERRY	Small white flowers	Deciduous shrub; usually about 5'; rhizomes	Wildlife eats the fruits; especially loved by bears	7,000-11,500	Thorny; foothills to subalpine

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Salix arctica	*Salix arctica*	ARCTIC WILLOW	in catkins	Prostrate deciduous shrub		11,000-13,000	Propagation by cuttings
Salix reticulata ssp *nivalis*	*Salix reticulata* ssp *nivalis*	SNOW WILLOW	in catkins	Prostrate deciduous shrub		10,500-12,500	Propagation by cuttings
Sarcobatus vermiculatus	*Sarcobatus vermiculatus*	GREASEWOOD	Inconspicuous	Deciduous shrub; 1-7'	Potentially poisonous to domestic sheep if it is the sole forage they consume; important for porcupines, jackrabbits, and rodents	2,000-8,500	Alkaline soils; spiny
Shepherdia canadensis	*Shepherdia canadensis*	RUSSET BUFFALOBERRY	Inconspicuous	Deciduous shrub; to 10' tall	Wildlife eats the fruits; especially birds	7,500-11,000	Attractive silvery foliage
Sibbaldia procumbens	*Sibbaldia procumbens*	CREEPING SIBBALDIA	Inconspicuous	Low deciduous shrub; forming mats		9,000-12,000	
Symphoricarpos albus	*Symphoricarpos albus*	COMMON SNOWBERRY	Small white to pinkish flowers	Deciduous shrub; less than 40"; rhizomes	Important food and cover for game birds; occasionally browsed by deer	5,500-7,500	Attractive red stems; forest foothill canyons
Symphoricarpos rotundifolius	*Symphoricarpos rotundifolius*	ROUNDLEAF SNOWBERRY	Small pinkish flowers	Deciduous shrub; up to 5'; rhizomes	Important food and cover for game birds; occasionally browsed by deer	5,000-9,000	Important species in upper elevation sage zone
Tetradymia canescens	*Tetradymia canescens*	SPINELESS HORSEBRUSH		Low shrub; to 35"	May be poisonous to livestock	4,500-9,000	Dry ridges and plains of western Colorado
Vaccinium myrtillus	*Vaccinium myrtillus* ssp. *oreophilum*	WHORTLEBERRY	Pink and white	Low, spreading, deciduous shrub; 6-12"	Berries eaten by grouse, bears and a wide variety of wildlife	8,000-12,000	In higher mountains it can form solid carpets.
Vaccinium scoparium	*Vaccinium scoparium*	GROUSE WHORTLEBERRY or BROOM HUCKLEBERRY	Pink and white	Low, spreading, deciduous shrub; 6-12"	Berries eaten by grouse, bears and a wide variety of wildlife	Higher than V. myrtillus,often above treeline; 8,500-12,000	Northwestern quarter of Colorado
Yucca baccata	*Yucca baccata*	BANANA YUCCA	Pink and white	Evergreen shrub; leaves 15-30" long	Birds eat the fruits	4,500-8,000	Wide ranging

Table A3: Upland Plant Characteristics - Trees and Shrubs

SCIENTIFIC NAME (KARTESZ)	SCIENTIFIC NAME (WEBER)	COMMON NAME	FLOWER COLOR	GROWTH FORM AND HEIGHT	WILDLIFE VALUE	ELEVATIONAL RANGE (feet)	COMMENTS
Yucca glauca	*Yucca glauca*	SMALL SOAPWEED	Whitish green; on stalk up to 100 cm tall	Evergreen shrub with broad, stiff leaves; up to 2.5'	Pollinated by night flying pronuba moth	4,000-8,500	Sharp foliage
Yucca harimanniae	*Yucca harimannieae*	SPANISH BAYONET	White to greenish white	A small yucca; 2'	Birds eat the fruits	Below 6,500	SW Colorado

APPENDIX II: CHARACTERISTICS OF COMMON WETLAND & RIPARIAN SPECIES

Key for Wetland/Riparian Plant Characteristics Tables A4 and A5 below:

Salinity/Acidity Tolerance
L = Low (mild)
M = Medium
H = High+

Wetland Indicator Status
FACU = facultative upland
FAC = facultative
FACW = facultative wetland
OBL = obligate

Wildlife Value
BGC = Big Game Cover
BGF = Big Game Food
WFC = Waterfowl Cover
WFF = Waterfowl Food
SMC = Small Mammal Cover
SMF = Small Mammal Food
UBC = Upland Bird Cover
UBF = Upland Bird Food
U = Unknown

Table A4: Wetland/Riparian Plant Characteristics, Common Species - Herbaceous

Scientific Name	COMMON NAME	Nationwide Wetland Indicator	Elevational Range (ft.)	Hydrologic Regime	Salinity Tolerance	Acidity Tolerance	Height	Rate of Spread	Wildlife Value	Comments
Asclepias incarnata	MARSH MILKWEED	FACW+/ OBL	3000-6000	seas. sat.	M	-	up to 4'	slow	UBF, SMF, UBC	tolerates drought, partial shade
Beckmannia syzigachne	SLOUGHGRASS	OBL	4500-11500	seas. flood.	-	-	36"	rapid	WFF, SMF	palatable forage grass
Calamagrostis canadensis	BLUE-JOINT REED GRASS	FAC/ OBL	4500->11500	seas. sat.	L	M	24-36"	medium	SMF, UBF	excellent soil stabilizer
Calamagrostis stricta	NORTHERN REED GRASS	FACW/ FACW+	4500->11500	seas. sat.	L	M	12-14"	medium	SMF, UBF	commonly found in subalpine willow bogs (*C. inexpansia*)
Carex aquatilis	WATER SEDGE	OBL	4500->11500	up to 3	L	M	6-24"	medium	WFC, WFF	good streambank/pond edge
Carex bebbii	BEBB'S SEDGE	OBL	3000-11500	seas. sat.	L	-	10-20"	medium	WFC	
Carex lanuginosa	WOOLLY SEDGE	OBL	3000-11500	seas. flood.	L	L	12-30"	medium	WFC	will tolerate drought, streambank stabilizer
Carex microptera	SMALL WINGED SEDGE	FAC/ FACW	4500->11500	moist sat.	-	-	8-16"	medium	WFC, SMC	
Carex nebrascensis	NEBRASKA SEDGE	OBL	3000-11500	seas. sat.	M	L	10-24"	medium	WFF, WFC, SMC	tolerates heat if provided adequate moisture
Carex scopulorum	ROCKY MOUNTAIN SEDGE	FACW	9000->11500	seas. flood	-	-	8-16"	medium	U	limited to high altitude habitats
Carex utriculata	BEAKED SEDGE	OBL	4500->11500	seas. sat.	L	M	10-40"	rapid	WFF, WFC, SMC	(*C. rostrata*)

Table A4: Wetland/Riparian Plant Characteristics, Common Species - Herbaceous

Scientific Name	COMMON NAME	Nationwide Wetland Indicator	Elevational Range (ft.)	Hydrologic Regime	Salinity Tolerance	Acidity Tolerance	Height	Rate of Spread	Wildlife Value	Comments
Deschampsia cespitosa	TUFTED HAIRGRASS	FACW	4500->11500	up to 3	L	M	18-30"	medium	SMC	good for mine reclamation
Distichlis spicata	INLAND SALTGRASS	FAC+/FACW+	3000-7500	seas. sat.	H	-	4-12"		U	
Eleocharis acicularis	SPIKERUSH	OBL	3000-11500	up to 3	L	L	6-18"	rapid	WFF	stabilize pond margins
Eleocharis palustris	CREEPING SPIKERUSH	OBL	up to 11500	up to 6	M	L	6-30"	rapid	WFF	excellent sediment stabilizer
Glyceria striata	MANNAGRASS	OBL	up to 11500	seas. flood.	L	-	24-36"	rapid	WFF, BGF	rapid growing, streambank stabilizer
Helianthus nuttallii	MARSH SUNFLOWER	FAC/ FACW	3000-6000	seas. flood.	M	-	up to 6'	medium	UBF	
Iris missouriensis	WILD IRIS	FACW-/ OBL	4500->11500	temp. flood.	M	L	18-24"	slow	U	poisonous to livestock
Juncus balticus	BALTIC RUSH	FACW/ OBL	3000-11500	moist to sat.	M	M	6-30"	medium	SMC	tolerates wide range of hydrologic conditions
Juncus confusus	COLORADO RUSH	FAC+	3000-11500	moist to sat.	L	-	6-12"	medium	WFF, WFC	
Juncus hallii	HALL'S RUSH	FAC	9000->11500	moist to sat.	-	M	8-16"	medium	U	limited to high altitude habitats
Juncus longistylis	LONGSTYLE RUSH	FACW/ FACW+	4500->11500	moist to sat.	-	-	8-24"	medium	U	
Juncus mertensianus	MERTEN'S RUSH	OBL	9000->11500	saturated	-	-	4-16"	medium	U	streambank and shoreline stabilizer
Juncus nodosus	KNOTTED RUSH	OBL	3000-6000	seas. sat.	M	-	8-24"	rapid	U	creeps rapidly with tuberous roots
Juncus saximontanus	ROCKY MTN. RUSH	FACW+	4500->11500	seas. sat.	-	L	6-18"	slow	U	
Juncus tenuis	POVERTY RUSH	FAC-/ FACW	4500-9000	moist to sat.	-	-	6-12"	medium	U	
Juncus torreyi	TORRY'S RUSH	FACW/ FACW+	up to 9000	saturated	-	-	6-18"	rapid	U	can tolerate drought conditions
Juncus triglumis	THREE-FLOWER RUSH	FACW+	>11500	seas. sat.	-	L	6-12"	rapid	U	limited to high altitude habitats
Poa palustris	FOWL BLUEGRASS	FACU/ FACW+	1000->11500	saturated	-	-	12-18"	medium	SMC, SMF, UBF, WFF	seeds eaten by a variety of wildlife
Polygonum persicaria	LADY'S THUMB SMARTWEED	FAC/ OBL	1000-9000	up to 6	M	-	up to 3'	rapid	WFF, WFC, UBF	requires light (*Persicaria maculata*)
Polygonum pensylvanicum	SMARTWEED	FACW/ OBL	1000-9000	up to 6	M	-	up to 4'	rapid	WFF, UBF, WFC	tolerates poor soils, requires light (*Persicaria pennsylvanicum*)
Puccinellia nuttalliana	ALKALI GRASS	FAC-OBL	3000-6000	temp. flood.	H	L	6-12"	medium	SMC	reservoir shoreline stabilizer

Table A4: Wetland/Riparian Plant Characteristics, Common Species - Herbaceous

Scientific Name	Common Name	Nationwide Wetland Indicator	Elevational Range (ft.)	Hydrologic Regime	Salinity Tolerance	Acidity Tolerance	Height	Rate of Spread	Wildlife Value	Comments
Sagittaria latifolia	ARROWHEAD	OBL	1000-6000	up to 12	M	L	6-18"	rapid	SMF, WFF	underground 'potato' highly palatable to ducks
Scirpus acutus	HARD-STEM BULRUSH	OBL	1000-11500	up to 36	M	L	up to 6'	rapid	WFF, SMF, WFC, SMC	good sediment stabilizer
Scirpus californicus	GIANT BULRUSH	OBL	<1000	up to 36	M	-	up to 12'	rapid	WFF, SMF, WFC, SMC	Southwestern low elevation species
Scirpus microcarpus	SMALL FRUITED BULRUSH	OBL	3000-11500	up to 6	-	-	up to 3'	medium	WFC	
Scirpus maritimus	ALKALI BULRUSH	OBL	1000-11500	up to 6	H	-	24-36"	medium	WFC	found in alkaline, closed basins *(S. paludosus)*
Scirpus pungens	THREE-SQUARE BULRUSH	OBL	1000-11500	up to 6	M	L	24-48"	rapid	WFC, SMC, UBF	tolerates some hydrologic drawdown
Sparganium eurycarpum	BURREED	OBL	3000-6000	up to 12	M	-	24-48"	rapid	WFF, WFC	becoming rare in its western range
Spartina pectinata	PRAIRIE CORDGRASS	FACW/ OBL	3000-6000	seas. flood.	M	L	36-60"	rapid	BGC, SMC	sod forming
Sporobolus airoides	ALKALI SACATON	FAC-/ FAC+	<1000-6000	seas. flood.	H	L	6-12"	medium	SMC	occupies alkaline flats
Triglochin maritima	ARROWWEED	OBL	3000-6000	seas. flood.	M	-	12-18"	slow	U	occupies alkaline flats
Typha domingensis	GIANT CATTAIL	OBL	<1000-4500	up to 24	M	L	up to 12'	rapid	WFF, SMF, WFC, SMC, BGC	grows in dense clumps
Typha latifolia	CATTAIL	OBL	3000-6000	up to 12	H	M	up to 6'	rapid	WFF, SMF, WFC, SMC, BGC	forms dense stands, can be invasive
Verbena hastata	BLUE VERVAIN	FAC/ FACW+	3000-6000	seas. sat.	L	-	18-30"	slow	UBF, SMF	very fibrous root system

Table A5: Wetland/Riparian Plant Characteristics, Common Species - Woody

Scientific Name	COMMON NAME	Nationwide Wetland Indicator	Elevational Range (ft.)	Hydrologic Regime	Mature Height	Aerial Spread	Wildlife Value	Comments
Acer glabrum	ROCKY MOUNTAIN MAPLE	FACU,FAC	6500-10000	moist to sat.	to 15'	10'	U	multiple stemed shrub
Alnus incana ssp. *tenuifolia*	THINLEAF ALDER	FACW	4500-11500	seas. flood.	25'	20'	UBC, BGC	tolerates shade *(A. tenuifolia)*
Amorpha fruticosa	LEADPLANT	FAC/OBL	3000-6000	irr. flood.	5'	8'	SMC, UBC	nitrogen fixer
Betula occidentalis	WATER BIRCH	FAC/FACW	4500-11500	seas. flood.	30'	20'	UBC, BGC	streambank stabilizer *(B. fontinalis)*
Betula nana	BOG BIRCH	FAC/OBL	6000->11500	saturation	4'	4'	SMC, UBC	tolerates acidity *(B. glandulosa)*
Cornus sericea	RED-OSIER DOGWOOD	FAC/FACW+	3000-11500	moist to sat.	10'	10'	BGF, SMF, UBF	tolerates partial shade *(C. stolonifera)*
Lonicera involucrata	TWINBERRY	FAC	6000->11500	moist	5'	5'	UBF, SMC, UBC	suckers freely and forms thickets
Populus acuminata	LANCELEAF COTTONWOOD	FAC/FACW	3000-9000	seas. flood	50'	35'	UBC, BGC	native hybrid cross *of P. deltoides* and *P. angustifolia*
Populus angustifolia	NARROWLEAF COTTONWOOD	FAC/FACW	3000-11500	seas. flood	50'	35'	UBC, BGC	streambank stabilizer
Populus deltoides	PLAINS COTTONWOOD	FAC/FACW	3000-6000	seas. flood	80'	50'	UBC, BGC	riparian shade species *(P. sargentii)*
Prunus americana	AMERICAN PLUM	FACU	3000-6000	dry to moist	12'	10'	BGF, SMF, UBF, UBC	yummy fruit
Prunus virginiana	CHOKECHERRY	FACU-/FAC	4500-11500	seas. moist	25'	20'	BGF, SMF, UBF, UBC	drought tolerant *(Padus virginiana)*
Ribes aureum	GOLDEN CURRENT	FACW	3000-9000	seas. moist	5'	5'	BGF, SMF, UBF, SMC	drought tolerant
Rosa woodsii	WOODS ROSE	UPL/FAC-	3000-11500	seas. moist	4'	4'	UBF, SMF	rose hips persist into winter
Salix amygdaloides	PEACHLEAF WILLOW	FACW	3000-9000	seas. flood.	30'	40'	UBC	assumes both shrub and tree form
Salix brachycarpa	BARRENGROUND WILLOW	FAC/FACW+	7500-12000	moist-wet	5'		U	moist meadows and stream banks
Salix drummondiana	DRUMMOND'S WILLOW	FACW/OBL	6000-11000	moist-wet	to 20'		U	stream banks and swamps
Salix exigua	SANDBAR WILLOW	FACW/OBL	up to 11500	irr. flood.	15'	6'	UBC, SMC, BGC, BGF	suckers readily
Salix geyeriana	GEYER'S WILLOW	FACW+/OBL	6000-11000	wet	to 20'		U	moist meadows and stream banks
Salix planifolia	PLANELEAF WILLOW	FACW/OBL	7000-12000	wet	5'		U	subalpine bogs and streams
Salix wolfii	WOLF'S WILLOW	FACW+/OBL	7000-11000	moist-wet	3'		U	boggy meadows and slopes
Sheperdia canadensis	BUFFALOBERRY	not rated	4500-11500	dry to moist	10'	6'	UBF, SMF	grows best in alkaline soil
Symphoricarpos occidentalis	SNOWBERRY	not rated	3000-11500	seas. moist	3'	5'	UBC, SMC	prefers shade
Symphoricarpos oreophilus	MOUNTAIN SNOWBERRY	not rated	4000-11500	dry to moist	5'	3'	UBC, SMC	can grow on slopes

APPENDIX III: WEED LISTS

COLORADO PROHIBITED NOXIOUS WEED SEEDS

Table A6: Colorado Prohibited Weed Seeds

(none allowed for certified seed)

	COMMON NAME	SCIENTIFIC NAME
*	ANODA, SPURRED	*Anoda cristata*
	BINDWEED, FIELD	*Convolvulus arvensis*
*	BOUNCINGBET	*Saponaria officinalis*
*	CAMELTHORN	*Alhagi pseudalhagi*
*	CHAMOMILE, SCENTLESS	*Anthemis arvensis*
*	CINQUEFOIL, SULFER	*Potentilla recta*
*	CLAMATIS, CHINESE	*Clematis orientalis*
*	DAISY, OXYEYE	*Chrysanthemum leucanthum*
	GOATGRASS, JOINTED	*Aegilops cylindrica*
	HALOGETON	*Halogeton glomeratus*
	HORSENETTLE, CAROLINA	*Solanum carolinense*
	HORSENETTLE, WHITE	*Solanum elaeagnifolium*
*	HOUNDSTONGUE	*Cynoglossum officinale*
	JOHNSONGRASS	*Sorghum halepense*
*	KNAPWEED, BLACK	*Centaurea nigra*
	KNAPWEED, DIFFUSE	*Centaurea diffusa*
	KNAPWEED, RUSSIAN	*Acroptilon (Centaurea) repens*
	KNAPWEED, SPOTTED	*Centaurea maculosa*
*	KNAPWEED, SQUAROSE	*Centaurea virgata*
	LOOSESTRIFE, PURPLE	*Lythrum salicaria* and *Lythrum virgatum*
*	MALLOW, VENICE	*Hibiscus trionum*
*	MEDUSAHEAD	*Taeniatherum caput-medusae*
*	MILLET, WILD PROSO	*Panicum miliaceum* ssp. *ruderale*
*	NUTSEDGE, YELLOW	*Cyperus esculentus*
	PEPPERWEED, PERENNIAL	see Whitetop, tall
	POVERTYWEED, SILVERLEAF	*Ambrosia tomentosa (Franseria discolor)*
	POVERTYWEED, WOOLLYLEAF	*Ambrosia grayi (Franseria tomentosa)*
+	ROCKET, DAME'S	*Hesperis matronalis*
*	RUE, AFRICAN	*Peganum harmala*
*	SAGE, MEDITERRANEAN	*Salvia aethiopis*
*	SALTCEDAR	*Tamarix parviflora* and *Tamarix ramosissima*
*	SKELETONWEED, RUSH	*Chondrilla juncea*
	SORGHUM, ALMUM	*Sorghum almum*
	SOWTHISTLE, PERENNIAL	*Sonchus arvensis*
*	SPURGE, CYPRESS	*Euphorbia cyparissias*
	SPURGE, LEAFY	*Euphorbia esula*
*	SPURGE, MYRTLE	*Euphorbia myrsinites*
	ST. JOHNS WORT, COMMON	*Hypericum perforatum*

Table A6: Colorado Prohibited Weed Seeds

(none allowed for certified seed)

	COMMON NAME	SCIENTIFIC NAME
	STARTHISTLE, YELLOW	*Centaurea solstitialis*
*	TARWEED, COAST	*Madia sativa*
	THISTLE, CANADA	*Cirsium arvense*
	THISTLE, MUSK	*Carduus nutans*
	THISTLE, PLUMELESS	*Carduus acanthoides*
	THISTLE, SCOTCH	*Onopordum acanthium* and *Onopordum tauricum*
	TOADFLAX, DALMATIAN	*Linaria dalmatica*
	TOADFLAX, YELLOW	*Linaria vulgaris*
	WHITETOP	*Cardaria draba*
	WHITETOP, HAIRY	*Cardaria pubescens*
	WHITETOP, TALL	*Lepidium latifolium*
	WOAD, DYER'S	*Isatis tinctoria*

* These weeds are added to the prohibited noxious weed list effective January 1, 1999.
\+ Dame's rocket shall not be considered a prohibited noxious weed until January 1, 2001.

COLORADO RESTRICTED NOXIOUS WEED SEEDS

Table A7: Colorado Restricted Noxious Weed Seeds

(Up to 6 per lb allowed for Certified Seed)

	COMMON NAME	SCIENTIFIC NAME
	BLUEWEED	*Helianthus ciliaris*
*	BURDOCK, COMMON	*Arcticum minus*
	BUTTERPRINT OR VELVET LEAF	*Abutilon theophrasti*
	DOCK, CURLY	*Rumex crispus*
	DODDER	*Cuscuta* spp.
	FOXTAIL, GIANT	*Setaria faberi*
	GROUNDCHERRY, PURPLE	*Quincula lobata (Physalis lobata)*
*	HEMLOCK, POISON	*Conium maculatum*
*	HENBANE, BLACK	*Hyoscyamus niger*
	LETTUCE, BLUE	*Lactuca tatarica* ssp. *pulchella (Lactuca pulchella)*
	MUSTARD, BLACK	*Brassica nigra*
	MUSTARD, INDIA	*Brassica juncea*
	MUSTARD, WILD	*Sinapsis arvensis*
	OAT, WILD	*Avena fatua*
	PLANTAIN, BUCKHORN	*Plantago lanceolata*
	POVERTYWEED, MOUSE-EAR	*Iva axillaris*
	PUNCTUREVINE	*Tribulus terrestris*
	QUACKGRASS	*Elytrigia repens (Agropyron repens)*
*	SANDBUR, LONGSPINE	*Cenchrus longispinus*
*	THISTLE, BULL	*Cirsium vulgare*

* These weeds are added to the prohibited noxious weed list effective January 1, 1999.

PLANTS TO AVOID

Plants to Avoid (modified from Plant Species Not To Use in Gardening, Reclamation, and Restoration by the Colorado Native Plant Society, Boulder Chapter. November, 1995.) This is not a complete list. New species are continually identified that have escaped cultivation to become weed problems.

FORBS

Bellflower, **Creeping** (*Campanula rapunculoides*) - Stoloniferous plant that displaces native vegetation. Found in the foothills and plains in shady places.

Bindweed, **Field** (*Convovulus arvensis*) - Perennial with extensive root system and stems that climb or form dense tangled mats. Difficult to control. Common on disturbed sites.

Bouncing Bet or **Soapwort** (*Saponaria officinalis*) - Escapes from gardens and displaces native vegetation. Occurs on roadsides, trails, and homestead sites on mesas and in the foothills.

Burdock (*Arctium minus*) - Biennial that competes with native vegetation. Often disperses by sticking to the hair of livestock and wildlife. Found on roadsides, trails, ditches, and streambanks.

Butter-and-Eggs (*Linaria vulgaris*) - Escaped ornamental with yellow, snapdragon like flowers. Highly invasive in natural areas and very difficult to control.

Carrot, **Wild** or **Queen Anne's Lace** (*Daucus carota*) - Escapes from gardens, spreading by seeds. Found along roadsides in the plains and foothills.

Chamomile, **Scentless** (*Matricaria perforata = Anthemis arvensis*) - Adventive plant that competes with native vegetation. Found along roadsides, pastures, and townsites in the mountains.

Chicory (*Cichorium intybus*) - Adventive weed that competes with native vegetation. Occurs on roadsides, trails, and open areas.

Cinquefoil, **Sulfur** (*Potentilla recta*) - Adventive perennial. Found in disturbed areas, along roadsides and in pastures.

Clematis, **Oriental** (*Clematis orientalis*) - Adventive plant that competes with native vegetation. Found in the foothills and montane areas especially along Clear Creek.

Crambe (*Crambe cordifolia*) - Escapes from gardens. Produces abundant seeds. Found on disturbed sites.

Daisy, **Ox-eye** (*Leucanthemum vulgare = Chrysanthemum leucanthum*) - Escapes from gardens and spreads easily by seeds. Displaces native plants. In wildflower seed mixes and used in roadside reclamation. Establishes in natural areas. Found from the plains to the alpine.

Dame's Rocket or **Sweet Rocket** (*Hesperis matronalis*) - Escaped from gardens displacing native vegetation. Occurs in riparian areas and wet meadows.

Dyer's Woad (*Isatis tinctoria*) - Escapes from cultivation. Occurs on disturbed sites. Invades natural areas.

Field bindweed (*Convolvulus arvensis*) - Competitive perennial weed. Widespread in cultivated areas, pastures, lawns, gardens, roadsides, and waste areas.

Hoary Cress (see Whitetop)

Hemlock, **Poison** (*Conium maculatum*) - All plant parts are poisonous, including the large, white taproot. Biennial that tolerates poorly drained soils. Frequently found on streambanks.

Horehound (*Marrubium vulgare*) - Escapes from cultivation. Found on disturbed sites.

Hound's Tongue (*Cynoglossum officinale*) - Escapes from cultivation. The prickly seeds travel on fur and clothing. Found on disturbed areas, trails, and logging sites.

Knotweed, **Japanese** or **Buckwheat** (*Reynoutria japonica*) - Escapes cultivation. Spreads by long rhizomes. Found in populated areas at the base of the foothills.

Knapweed, **Diffuse*** (*Centaurea diffusa*) - Highly competitive annual that is found along roadsides, waste areas, and dry rangelands.

Knapweed, **Russian*** (*Centaurea repens*) - Perennial that spreads by black, deep growing roots along roadsides, pastures, orchards, and cultivated fields.

Knapweed, **Spotted*** (*Centaurea maculosa*) - Short-lived perennial. Found along roadsides, waste areas, and rangelands.

Kochia (*Kochia scoparia*) - Annual introduced weed that reproduces by seeds. Grows in cultivated fields and waste places.

Loosestrife, **Purple** (*Lythrum salicaria*) - Attractive, perennial garden plant that is extremely invasive and threatens cattail marshes and other wetlands. Spreads by seeds in mud and water and by pieces of stems.

Mustard, **Jim Hill** or **Tumble** (*Sisymbrium altissimum*) - Adventive plant that breaks at the soil level and tumbles with the wind spreading its seed over a wide area. Common in fields, rangeland, waste areas and along roads.

Pepperweed, **Perennial*** (*Lepidium latifolium*) - Perennial with deep rootstocks that make the plant difficult to control. Found in wetland and riparian areas.

St. John's Wort (*Hypericum perforatum*) - Competes with and displaces native vegetation. Poisonous to animals. Found in open areas on mesas in the foothills.

Sage, **Mediterranean** (*Salvia aethiopis*) - Escapes from cultivation forming pure stands that out compete natives. Winter tumbleweed. Found in grasslands, pastures, meadows and rangelands.

Spurge, **Leafy*** (*Euphorbia esula*) -Perennial that reproduces by vigorous rootstocks and seed. Milky sap is irritating to the skin and detrimental to cattle. Grows in disturbed sites and along riparian corridors.

Spurge, **Myrtle** or **Mercer's** (*Euphorbia myrsinites*) - Escapes from gardens and displaces native vegetation. Xeriscape plant with poisonous sap. Found on trails and meadows in the plains and foothills. Also occurs in logged or disturbed forest areas of the mountains.

Starthistle, **Yellow** (*Centaurea solstitialis*) - Not common in Colorado yet, but is considered a serious threat in our northern and western neighboring states.

Sweetclover, **White** (*Melilotus albus*) - Reclamation escapee. Found along roadsides, trails, and disturbed sites.

Sweetclover, **Yellow** (*Melilotus officinalis*) - Reclamation escapee. Found along roadsides, trails, and disturbed sites.

Sweetpea, **Perennial** (*Lathyrus latifolius*) - Escapes from cultivation. Spreads by explosive seed pods. Commonly found on urban fringes.

Tansy, **Common** (*Tanacetum vulgare*) - Used as a medicinal herb, escapes and spreads by seeds and rootstocks. Found on roadsides, streambanks, and pastures.

Teasel (*Dipsacus fullonum*) - Biennial with a taproot. Occurs on moist soils.

Thistle, **Bull** (*Cirsium vulgare*) - Has a short, fleshy taproot. Occurs on disturbed sites.

Thistle, **Canada*** (*Cirsium arvense*) - Aggressive weed, extremely difficult to control because breaking up the roots just increases the number of plants. Commonly found in moist to wet disturbed areas.

Thistle, **Musk*** (*Carduus nutans*) - Biennial that spreads rapidly forming dense stands and crowds out desirable forage plants. Grows in pastures, roadsides, and waste areas.

Thistle, **Russian** (*Salsola iberica* and *S. collina*) - Annual with stiff, spiny leaves. At maturity, plant breaks off at the base, and tumbles with the wind, scattering the seed. Grows on dry plains, in cultivated fields and waste places.

Thistle, **Scotch** (*Onopordum acanthium* and *O. tauricum*) - Biennial with very large coarsely lobed, hairy leaves with a velvety-gray appearance. It is increasing in densities throughout Colorado.

Toadflax, **Dalmatian** (*Linaria genistifolia* ssp. *dalmatica*) - Perennial with extensive and deep root system. Difficult to control. Found on disturbed, open areas, roadsides, and trails in the plains, foothills and montane areas.

Toadflax, **Yellow** (see Butter-and-Eggs)

Whitetop (*Cardaria draba, C. Chalepensis, C. latifolia*) - Perennial that reproduces from root segments and seeds. Common on disturbed, alkaline soils.

GRASSES

Some of the grasses listed here, including **crested wheatgrass** (*Agropyron cristatum*), **smooth brome** (*Bromus inermis*), **orchardgrass** (*Dactylis glomerata*), and **timothy** (*Phleum pratense*), are planted for hay or pasture grass, or are used for erosion control or reclamation projects where the use of native species is not a priority. These species are listed in the weed section because they can be detrimental to the establishment of native species.

Barnyard Grass (*Echinochloa crusgalli*) - An annual grass that spreads by seeds. Found in croplands and disturbed areas.

Brome, **Smooth** (*Bromus inermis*) - Competes with native vegetation via extensive underground roots. Found in planted grasslands and roadsides, especially on moister sites. It has escaped from planted areas and invaded disturbed native ecosystems.

Cheatgrass* (*Bromus tectorum*) - An aggressive winter annual that out competes native plants and is a fire hazard. Widespread along roadsides, in waste areas, and in disturbed pastures and rangelands.

Johnsongrass (*Sorghum halepense*) - Vigorous perennial that reproduces from seed or creeping, robust rhizomes. Grows in cultivated fields and neglected areas.

Orchardgrass (*Dactylis glomerata*) - Widely used in pastures. It has escaped and invaded roadsides and disturbed habitats.

Reedgrass, **Canary** (*Phalaris arundinacea*) - Stout perennial which regenerates from large rootstocks. Found along streams, ditches, and in marshes. It has escaped from intentional plantings to establish on disturbed riparian and wetland habitats.

Rye, **cereal** (*Secale cereale*) - Annual. Escapes cultivation and can become established on roadsides, waste places, and even open rangeland.

Timothy (*Phleum pratense*) - Escapes from pasturelands and competes with native vegetation. A habitat generalist, it is found in dry to wet soils.

Wheatgrass, **Crested** (*Agropyron cristatum*) - Persistent reclamation grass that out competes native grasses, and can cause soil erosion between individual plants. Found along roadsides, trails, and disturbed areas.

SHRUBS

Buckthorn (*Frangula alnus*) - Escapes from gardens and competes with native vegetation. Found in riparian areas in the plains, especially in urban areas.

Tamarisk or **Salt Cedar*** (*Tamarix ramosissima* and *T. parviflora*) - Very aggressive shrub or small tree. Has displaced the native willows along riparian corridors especially on the Western Slope and lower Arkansas River valley.

TREES

Elm, **Siberian** (*Ulmus pumila*) - Widely planted, hardy tree that escapes cultivation. Found along roadsides and floodplains.

Russian Olive* (*Elaeagnus angustifolia*) - Extremely invasive tree that displaces native willows and cottonwoods throughout the plains and Western Slope. Seed commonly dispersed by birds. Found along riparian corridors.

Willow, **Crack** (*Salix fragilis*) - Originally cultivated along streams. Displaces native cottonwoods and willows. Found in riparian corridors along the plains and lower foothills.

Willow, **White** (*Salix alba* var. *vitellina*) - Displaces native willows and cottonwoods. Found in riparian corridors.

* Discussed in more detail in **Appendix IV: Managing The Most Common And Aggressive Weeds Of Colorado**.

APPENDIX IV: MANAGING THE MOST COMMON AND AGGRESSIVE WEEDS OF COLORADO

FORBS

Diffuse knapweed (*Centaurea diffusa*)

Description: This usually biennial weed has finely divided leaves and numerous solitary flower heads. It is distinguished from other knapweeds by the comb-like, spiny bracts under the flower heads. This introduced weed invades disturbed and undisturbed ground with dry, light soils. It spreads rapidly as it breaks off at the ground level and blows into new areas. The dry seed heads can also easily attach to animals' fur, tire tread and hiking boots. It typically has white flowers.

Management Methods: The key to controlling this weed is to prevent seed production.

Cultural Control: The most effective way to prevent invasion of this noxious weed is to revegetate disturbed areas as soon as possible.

Chemical Control: Transline (clopyralid) is an effective chemical control for diffuse knapweed when applied at the rosette to early bolting growth stage. This herbicide is only effective on four plant families. Other herbicides such as Banvel (dicamba), Tordon (picloram), or tank mixes of Banvel plus 2,4-D, Banvel plus Tordon, and others are also effective against diffuse knapweed.

Biological Control: The root-boring beetle (*Sphenoptera jugoslavica*) has the best potential for success against diffuse knapweed, although further research needs to be done. Two seedhead flies (*Urophora* spp.), and several species of seedhead weevil have been released against diffuse knapweed with marginal control success. Grazing with sheep, goats and cattle will also reduce knapweed seed set and release grasses from competition. Spring grazing can be effective for reducing seed formation especially when a large number of animals have been grazed in a small area for a short time.

Russian knapweed (*Acroptilon repens = Centaurea repens*)

Description: This purple-flowered perennial spreads by seeds and creeping roots. The extensive roots can grow to 23 feet (7 meters) deep within two years of establishment. Russian knapweed differs from other knapweeds by having broad, round bracts with papery margins under the flower head. In Colorado, an estimated 50,000 acres (20,235 hectares) has been infested by this noxious weed. Abandoned farmlands are the most frequently invaded habitats.

Control Measures: The most effective weed control plan combines cultural control methods with mechanical and/or chemical control methods. Mowing or applying herbicide alone is usually not sufficient.

Cultural Control: Planting an area with grasses helps prevent the establishment and spread of Russian knapweed.

Mechanical Control: Mowing the area two to three times per season for two or more seasons helps prevent seed production and stresses the plant. Mow after the plant has bolted, but before the seeds have matured (usually six to eight week intervals). More than one season of mowing is recommended because mowing for only a year may actually increase Russian knapweed density.

Chemical Control: Herbicides alone will rarely manage this weed effectively. Curtail, Tordon 22K or Transline can be sprayed at the bud to flower growth stage. Then a month to six weeks before seeding, disk the area. Plant grass seed, especially cool season grasses.

Spotted knapweed (*Centaurea maculosa*)

Description: Very similar to diffuse knapweed, this short-lived perennial reproduces from seed. It typically has purple flowers. The distinguishing physical character of spotted knapweed is a small, dark spot at the end of the bracts underneath the flower head. This noxious weed invades disturbed ground with light, well drained, often calcareous soils. It survives in slightly more moist soils than diffuse knapweed.

Management Measures: Spotted knapweed can be managed in the same manner as diffuse knapweed.

Leafy spurge (*Euphorbia esula*)

Description: This Eurasian native forms dense patches in riparian corridors. It can invade dry as well as moist sites. This plant has leafy stems supporting bright yellow-green flowers. This perennial grows from seeds and root stock. The extensive root system may grow 15 feet (4.5 meters) deep or more. It is extremely difficult to control, much less eradicate this weed, once it has become established. Leafy spurge grows rapidly, taking moisture and nutrients from native plants before they have had a chance to grow. It also produces a white milky sap that is irritating to skin and detrimental to grazing wildlife, horses and cattle.

Management Measures: Attempts to kill this plant with herbicides will be more effective if the plants are stressed before herbicides are applied.

Prevention: The most effective management technique is to prevent this weed's establishment. All other methods are difficult and require great persistence.

Cultural Control: Having a good cover of grasses, especially early in the growing season, helps prevent an infestation of leafy spurge from spreading.

Mechanical Control: It is difficult to control leafy spurge with mowing alone. However, mowings at 14 to 21 day intervals throughout the summer can be combined with herbicide control to decrease the amount of herbicide needed. Caution: leafy spurge's milky sap may gum up the mower.

Chemical Control: Timing herbicide application is critical, and all treatments may need to be repeated for several years. Roundup (Glyphosate) needs to be applied at one month intervals (1 quart per acre) beginning in June, and works best when combined with fall grass seedings. Other herbicides such as Banvel (dicamba) and Tordon 22K (picloram) require fewer applications. Neither Tordon or Banvel should be used under woody vegetation or where ground water is more than six feet (1.8 meters) below.

Biological Control: Sheep and goats can graze on leafy spurge to help stress control (but not eradicate) the plant. Other livestock avoid the plant. The Colorado Department of Agriculture has four varieties of flea beetle available to feed on and help control leafy spurge. The appropriate type of beetle depends on the soil type, moisture regime, and cover of the area.

Canada thistle (*Cirsium arvense*)

Description: This aggressive weed forms large dense patches of prickly plants along the bottoms of intermittent drainages and other areas with moist soil. This thistle, however, does not do as well in continually saturated or inundated soils (although, it does grow in seasonally saturated or inundated sites). It is extremely difficult to eradicate because it has an extensive root system and new plants can grow from even a small piece of root. One plant can colonize an area up to six feet (1.8 meters) in diameter in one or two years. Canada thistle grows to three to five feet (1-1.5 meters) tall, has spine-tipped leaves, smooth stems, and small lavender flowering heads.

Management Measures: In addition to prevention, the critical management measure is to stress the plant by forcing it to use stored root nutrients. The most effective way to prevent this species is to revegetate moist bare soil.

Cultural Control: After establishment, competition with other plants is helpful, but not completely effective in controlling this weed. Reseeding is often necessary after the thistle has been removed from an area.

Mechanical Control: Mowing can be effective when combined with herbicide treatments, especially in areas with competition from established grasses. Mow throughout the growing season and then treat with herbicides in the fall. Mowing alone, without herbicides, can be effective if done at one-month intervals over several years. Late spring burning will also stress the plant if sufficient dead plant material is available to carry a fire hot enough to kill spring rosettes. Burning will have to be repeated annually for several years or at three year intervals.

Chemical Control: Herbicides can be effective, especially when combined with mowing, tilling, and competition from other plants. Mow two or three times in the summer at monthly intervals (beginning at bolt to early bud-growth stage) and follow with a fall application.

Biological Control: The larvae of the weevil *Ceutorhyncus litura* bores into Canada thistle, weakening the plant. This weevil alone will not effectively control thistle but it can be combined with other methods. *Urophora cardui* is another insect that helps to control this weed. Grazing can be used in the spring and early summer to help control Canada thistle in riparian areas as well.

Musk thistle (*Carduus nutans*)

Description: This biennial weed is a prolific seed producer and reproduces rapidly. It establishes in moist, bare ground. Reaching up to 6 feet (1.8 meters) tall, musk thistle has spiny marginated leaves and rose pink clusters of flowers growing at the top of the stem.

Management Measures: In addition to prevention, the key to controlling this weed is to prevent seed production.

Cultural Control: Because seeds need open moist ground to germinate, the most effective control method is to keep an area vegetated. Do not allow a grassland to degrade into open areas of bare soil.

Mechanical Control: Tilling can effectively remove musk thistle. Cut the weed below the soil line before the bud stage. Mowing when the terminal flower head is in the late-flowering stage can be effective. However, musk thistle (like many biennials) will often continue to live until it is afforded the opportunity to flower and produce seed. Mowed debris should be gathered and burned to destroy any seeds.

➲ Be aware that tilling may promote the germination of other weeds in the seed bank.

Chemical Control: Several different herbicides (e.g. Banvel, Tordon, Curtail, Transline, 2,4-D) can be applied to the musk thistle rosettes in the spring or fall before the flowering stems are produced (bolting). Apply Escort in early spring when the thistle is in the bolting to early-flower growth stages.

Biological Control: The most successful and widespread biological control insect for weed management has been the musk thistle seed head weevil, *Rhinocyllus conicus*. It infests developing terminal flowers on most areas of the state. However, this seed head weevil has been found to attack native thistles as well. Another musk thistle weevil is *Trichosirocalus horridus*. Instead of reducing seed production, this insect feeds on the developing thistle rosette.

Perennial Pepperweed (*Lepidium latifolium*)

Description: Creeping perennial mustard that reproduces from seed and roots. It is highly competitive in wetland and riparian areas often forming pure stands.

Management Measures: Prevention is the best method. Soon after disturbance, sow perennial grasses that grow early in the season.

Cultural Control: When battling an existing infestation, combine grass seeding with the other methods described below.

Mechanical Control: Mowing may reduce seed set but will not control established stands.

Chemical Control: Telar or Escort are very effective and should be applied in late spring, bud to flower growth stage. Landmaster/Campaign can also be applied at the flower growth stage. Desirable seed can be sown into the residues of these herbicides in the fall following late spring application. When restoring an infested site, disk lightly. Landmaster/Campaign may need to be sprayed for two consecutive seasons; the area should be seeded in the fall following the second application.

GRASSES

Cheatgrass or Downy Brome (*Bromus tectorum*)

Description: This winter annual grass grows from seed to a height of 4 to 30 inches (10 to 76 centimeters). Growing in early spring and summer, this weed effectively competes with more desirable native grasses for moisture and nutrients. As the plant dries in summer, it becomes a fire hazard.

Cultural Control: Several native grasses, including bottlebrush squirreltail and western wheatgrass have been shown to compete well with cheatgrass.

Mechanical Control: Grazing, mowing and controlled burning may be used to control cheatgrass. If the weed has been in the area for many years, the soil probably has a large bank of cheatgrass seeds. The plant will continue to sprout and control will require several years of effort. The most effective intensity and timing of efforts for grazing, mowing and burning have not been well established and may vary with geographic setting and habitat type. The guiding principle is to limit the cheatgrass infestation without damaging native warm season grasses. The most commonly used prescribed burn approach is to burn in early spring when the cheatgrass is 1-1.5" tall. Burning later in the summer after cheatgrass seedset but before seedset of warm season grasses has also been effective in some areas (T. Nauman, personal communication).

Chemical Control: Several different herbicides can kill cheatgrass. However, they may also kill the desired native plants. Pronamide applied in late fall will control cheatgrass selectively in stands of slender wheatgrass, western wheatgrass, and other grasses (although, this does not mean it is harmless to all grasses). The label for Pronamide prohibits grazing of treated grass. Pronamide also will control seedlings shortly after they germinate. Glyphosate is another herbicide that when applied in the early spring or late winter (mid-to late February along the Front Range) does not reduce the cover of western wheatgrass, blue grama and needlegrasses. This treatment can be pushed a little later in the season (early March along the Front Range) and still not harm the desirable grasses especially warm season grasses. Glyphosate affects only the living plant and does not affect the seeds that may be in the ground.

TREES/SHRUBS

Russian-olive (*Elaeagnus angustifolia*)

Description: This fast-growing tree has silvery green leaves and long thorns. The fruit is olive-shaped. A European native, Russian-olive has been widely sold in Colorado as an ornamental shade tree. Along some streams, Russian olive has completely replaced native woody vegetation such as cottonwoods, thus reducing the amount and quality of wildlife habitat.

Management Methods: Russian olive trees can be controlled by either cutting the trees down and treating the stumps with herbicide, or pulling the tree out of the ground when it is young. The cutting method should be used on trees larger than two inches (5 centimeters) in diameter. Cut the Russian olive trees within four inches (10 centimeters) of the ground. Within five minutes of cutting, treat the stumps with an herbicide. Appropriate herbicides to use would include Garlon, the premixed product Pathfinder and Rodeo. Garlon decomposes rapidly after application, in a day or less in sunlit water and approximately two weeks to two months in soil. Rodeo (glyphosate) is specified for use in riparian or wetland habitats. Monitor and implement follow-up treatment as needed. Follow-up treatments are best completed the following June before any possible resprouts have time to grow. Retreated areas should be monitored every 6 months until complete mortality is ensured. Care should be taken not to introduce any herbicide into adjoining waters.

Trees less than about two inches (5 centimeters) in diameter can be wrenched out of the soil by means of a weed winch. Removal of small Russian olive trees will be easier when the soil is moist so that the majority of roots can be extracted.

Tamarisk or Salt Cedar (*Tamarix ramosissima* and *T. parviflora*)

Description: This shrub grows from 5 to 20 feet (1.5 to 6 meters) tall. Tiny scale-like leaves grow on slender reddish-brown stems. Originally introduced for erosion control purposes, tamarisk has become naturalized along many of the streams and canals of the West. It forms dense stands that replace native vegetation and degrade wildlife habitat.

Management Methods: The recommended management method is the same as described for Russian Olive.

APPENDIX V: REGIONAL VENDORS OF PLANT MATERIALS

Table A8: Colorado Plant Material Vendors		
Anderson Seed	2410 10th St., Greeley, CO 80631	(970) 353-0188
Applewood Seed Co.	5380 Vivian St., Arvada, CO 80002	(303) 431-6283
Applewood Seed Co.	P.O. Box 270, Rocky Ford, CO 81067	(719) 254-7460
Aquatic and Wetland Nurseries	1655 Walnut St., Suite 205, Boulder, CO 80302	(303) 442-5770
Arbor Valley Nursery	P.O. Box 932, Brighton, CO 80601	(303) 654-1682
Arkansas Valley Seeds, Inc.	4333 Hwy. 66, Longmont, CO 80504	(303) 535-4481
Bookcliff Gardens	755 26 Rd., Grand Junction, CO 81506	(970) 242-7766
Camelot Gardens	16612 S. Hwy 550, Montrose, CO 81401	(970) 249-6109
Carhart Feed and Seed	Dove Creek, CO 81324	(970) 677-2233
Colo-Hydro Inc.	5555 Ute Highway, Longmont, CO 80501	
Colorado State Forest Service	CSU-Foothills Campus, Ft. Collins, CO 80523	(970) 491-8429
Colorado Alpines, Inc.	P.O. Box 2708, Avon, CO 81620	(970) 949-6464
Country Lane Wholesale Nursery	2979 North Hwy 83, Franktown, CO 80116	(303) 688-2442
Earth, Wind, and Rock	5899 Co. Rd. 24, Ridgeway, CO 80143	
Farmers Marketing Assoc.	4545 Madison St., Denver, CO 80216	
Farmers Pride Seed Co.	916 19 1/2 Rd., Fruita, CO 81521	
Ft. Collins Nursery	2224 N. Shields, Ft. Collins, CO 80524	(970) 484-1289
Green Acres Nursery	4990 McIntyre St., Golden, CO 80403	(303) 279-8204
Hydro-Garden, Inc.	P.O. Box 9707, Colorado Springs, CO 80932	
Iliff Gardens	4750 East Iliff, Denver, CO 80222	(970) 858-9134
Kroh Nursery	Loveland, CO 80537	
Little Valley Nursery	13022 E. 136 Ave., Brighton, CO 80524	(800) 221-3241 or (303) 659-6708
Longmont Seed Co.	P.O. Box 2298, Longmont, CO	(970) 776-1560
Mile High Seed Co.	Box 1988, Grand Junction, CO 81501	(970) 242-3122
Neco, Inc.	Box 1178, Cahone, CO 81320	
Northrup-King and Company	1621 West Twelfth Ave., Denver, CO 80204	
Northrup-King and Company	Box 998, Longmont, CO 80501	
Pawnee Buttes Seed Inc. (formerly Southwest Seed)	P.O. Box 1604 605 25TH Street Greeley, CO 80632	(970) 356-7002 (800) 782-5947
Rocky Mountain Native Plants, Co.	2730 Snowmass Creek Road, Snowmass, CO 81654 bigsky@aspeninfo.com native@aspeninfo.com	(970) 927-0925

Table A8: Colorado Plant Material Vendors		
Rocky Mountain Rare Plants	P.O. Box 200483, Denver, CO 80220	
San Juan Native Nursery	Box 302, Pagosa Springs, CO 89117	
Sharp Brothers Seed	101 East 4th St., Greeley, CO 80631	(970) 356-4710
Steamboat Landscaping, Inc.	Box 1521, Steamboat Springs, CO 80477	
Sunchaser Natives	14290 W. 54th Ave., Arvada, CO 80002	
Dean Swift	Box 24, Jarosa, CO 81138	
Timberline Tree Seed	Rye Star Route, Box 145, Pueblo, CO 81104	
Treehouse Nursery	7450 Velmont Road, Boulder, CO 8030	
Upper CO Environ. Plant Center	P.O. Box 448, 5538 Rio Blanco County Rd. 4, Meeker, CO 81641	(970) 878-5003
Western Evergreen, Inc.	14201 West Forty-fourth Ave., Golden, CO 80401	
Western Native Seed	P.O. Box 1463, Salida, CO 81201	
Yellow Pine Nurseries	Box 192, Kiowa, CO 80117	(719) 539-1071

Table A9: Idaho Plant Material Vendors		
All Seasons Landscape Nursery	3376 E. Overland Rd., Meridian, ID 83642	(208) 888-6268
Allied Seed, Inc.	1917 E. Fargo Ave., Nampa, ID 83651	(208) 466-9218
Aloha Landscape and Nursery	4291 S. Cloverdale Rd., Boise, ID 83704	(208) 362-2062
Asgrow Seed Co.	1811 E. Florida Ave., Nampa, ID 83651	(208) 466-3351
Bakker Bros. of Idaho	Eastland Dr. South, Twin Falls, ID 83301	(208) 459-1900
W.R. Baxter Wholesale Nursery	2615 Pioneer Ave., Emmett, ID 83617	(208) 365-6011
Baxter Wholesale Nursery	P.O. Box 621Meridian, ID 83642	
Boise Valley Seed, Inc.	R.R.10, Darrow Land, Caldwell, ID 83651	(208) 459-7211
Brown King Nursery	1407 Arthur Street, Caldwell, ID 83605	
Clayton Wholesale Nursery Co.	6622 Joplin Road, Nampa, ID 83651	(208) 286-7801
Clifty View Nursery	Route 1, Box 509, Bonners Ferry, ID 83805	
Cloverdale Nursery	2528 N. Cloverdale Rd., Boise, ID 83704	
Coeur d'Alene Landscaping	Box 1556, Coeur d'Alene, ID 83814	
Crookham Company	301 Warehouse Avenue, Caldwell, ID 83651	
D&G Turf Farm and Nursery	1267 N. Cloverdale Rd., Boise, ID 83704	
Dahlin's Landscape Nursery	Route 1, Box 304, Priest River, ID 83856	
Donnelly Nursery	11911 Franklin Rd., Boise, ID 83709	(208) 375-2000

Table A9: Idaho Plant Material Vendors		
Double D Feed and Seed, Inc.	215 Broadway Ave., Melba, ID 83641	
Down to Earth Garden Shop	1615 N. Woodruff, Idaho Falls, ID 83401	
Du-Rite Nursery and Landscaping	5321 W. Cherry Lane, Meridian, ID 83642	
Eagle Landscaping and Nursery	P.O. Box 8, 988 East State Street, Eagle, ID 83616	(208) 939-8723
Erico Nursery	P.O. Box 209, Plummer, ID 83851	
Fantasy Farms Nursery	Route 2, Lenore, ID 83541	
Ferry Morse Seed Co.	3015 E. Comstock, Nampa, ID 83651	
Forest Tree Nursery	c/o College Forestry, Wildlife and Range Science, University of Idaho, Moscow, ID 83843	
Fruitland Nursery	P.O. Box 332, Fruitland, ID 83619	
Garden and Landscape Nursery	2900 N. 32nd, Boise, ID 83703	(208) 343-0755
Garden Center West, Inc.	11500 Fairview Ave., Boise, ID 83704	(208) 376-3322
Garden Square	Lewiston, ID 83501	
Globe Seed and Feed Company	224 4th Ave., Twin Falls, ID 83301	(208) 733-1373
Gooding Seed Company	Box 57, Gooding, ID 83330	
Graft Nursery and Landscaping	1602 East 16th, Burley, ID 83318	
Grassland West Company	Box A, Culdesac, ID 83524	(208) 843-5121
Greenhurst Nurs. and Garden Cntr.	3209 S. Happy Valley Rd., Nampa, ID 83651	
Green Things Nursery	P.O. Box 1900, 2230 Michigan, Orofino, ID 83544	
Green Thumb, Inc.	2113 Idaho Avenue, Caldwell, ID 83605	(208) 459-3349
Grimm Alfalfa Growers Assn.	Box 269, Blackfoot, ID 83221	(208) 785-0830
Harker Bros.	Southside Blvd., Nampa, ID 83651	(208) 495-2308 or(208) 466-5783
Hash Company Nurs. and Lndsc.	Troy Highway, Moscow, ID 83843	
Hash Tree Co.	Box 72A, Princeton, ID 83857	(208) 875-1030
High Altitude Gardens	P.O. Box 1048, Hailey, ID 83340	(208) 788-4363
Hillcrest Farms, Inc.	Route 1, Grangeville, ID 83530	
Hillside Nursery	2350 Hill Road, Boise, ID 83702	
Hoffmans Greenhouse and Nurs.	3332 Caldwell Blvd., Nampa, ID 83651	(208) 466-1977
Howards Nursery and Greenh.	7106 Ustick Rd., Boise, ID 83704	(208) 322-6000
Inland Gardens	2124 Longmont Ave., Boise, ID 83705	(208) 342-6953
Intermountain Landscape Co.	P.O. Box 1087, Hailey, ID 83333	
Jacklin Seed Company	17300 Jacklin Ave., Post Falls, ID 83854	(208) 773-7581
Jayker Tree Farms, Inc.	801 E. Beacon Light Rd., Eagle, ID 83616	(208) 939-0014
John's Gourmet Gardens	9010 Burnett Dr., Boise, ID 83709	(208) 362-4439
Johnson's Quality Evergreens	HCR 68, Box 293, Cocolalla, ID 83813	
Kellog Mills	223 Roedel Ave., Caldwell, ID 83605	(208) 459-0777

Table A9: Idaho Plant Material Vendors		
Ketchum Garden Center	P.O. Box 229, Sun Valley, ID 83353	
Kimberly Nurseries	Route 3, Twin Falls, ID 83301	
Leland Plato	Star Route 1, Bonners Ferry, ID 83805	
Levig Nursery	Star Route 1, Kings Row, Bonners Ferry, ID 83805	
McDonald's Garden Store	Route 2, Public Avenue, Moscow, ID 83843	
Mountain Seed Nursery	Route 1, Box 271, Moscow, ID 83843	
Mountain View Nursery	Route 3, Box 170, Sandpoint, ID 83864	
Musser Seed Co., Inc.	301 Fourth Ave. South, Caldwell, ID 83605	(208) 459-8243
Native Seed Foundation	Star Route, Moyie Springs, ID	(208) 267-7938
Nishek Nursery	Route 1, Box 516, Bonners Ferry, ID 83805	
Nishitani Greenhouse	P.O. Box 325, Caldwell, ID 83606	
North American Plant Breeders	2323 11th Ave., North Ext., Nampa, ID 83651	(208) 467-2191
Northern Natives Nursery	903 E. Lincoln, Emmett, ID 83617	
Northplan Seed Producers	P.O. Box 9107, Moscow, ID 83843	
Northrup-King and Company	Box 124, Twin Falls, ID 83605	
Northrup-King and Company	223 Roedel Ave., Caldwell, ID 83605	(208) 459-0844
Northwest Nursery	P.O. Box 455, Sandpoint, ID 83864	
Northwest Turf and Garden	843 Lilac, Meridian, ID 83642	(208) 888-4467
NRCS Plant Materials Cntr	P.O. Box 296, 1691 A South 2700 West Aberdeen, ID 83210	(208) 397-4133
Pickle Butte Farms	Route 4, Box 344, Caldwell, ID 83605	
Ponderosa Garden Cntr. and Nurs.	6305 North Black Cat Rd., Meridian, ID 83642	
Providence Nursery	Route 1, Box 588, Sandpoint, ID 83864	
Puffer-Ridge Farms	Baldy Road, P.O. Box 132, Sandpoint, ID 83864	
Purple Sage Farms, Inc.	11741 Bullock Lane, Middleton, ID 83644	(208) 585-6140
Reggear & Sons	Route 3, box 102-A, Orofino, ID 83544	
Rick's College	Landscape and Horticulture Dept. 500 South Center, Rexburg, ID 83440	
Riteway Industries	Route 1, Box 31-B, Potlatch, ID 83855	
Steve Rogan Co.	32121 Ave., Caldwell, ID 83605	(208) 632-3001
Rogers Bros. Seed Co.	Madison Ave., Nampa, ID 83651	(208) 467-1159
Sand Hollow Nursery	R.R.7, Caldwell, ID 83605	(208) 459-7389
Seeds BLUM		(208) 342-0858
Sherwood Forest Nursery	244 N. 2nd East, P.O. Box 781, Rexburg, ID 83440	
Shields of Nampa, Inc.	1618 Avenue South, Nampa, ID 83651	(208) 466-3584
Silver Springs Nursery	HCR 62, Box 86, Moyie Springs, ID 83845	(208) 267-5753
Simplot Soilbuilders	Box 342, Meridian, ID 83642	

Table A9: Idaho Plant Material Vendors		
Smith Garden Square, Inc.	415 North 22nd Street, Lewiston, ID 83501	
Smith Tree Plantation	Route 1, Box 131-A, Idaho Falls, ID 83401	
Spencer Mountain	P.O. Box 3, Cocalalla, ID 83813	
Stonetree Landscaping	3226 Garrity Blvd., Nampa, ID 83651	
Storey Feed and Seed Co.	503 E. 1st., Meridian, ID 83642	(208) 888-4436
Sunseeds, Inc.	1832 Garrity Blvd., Nampa, ID 83651	(208) 466-4679
The Green Ranch	P.O. Box 2597, Boise, ID 83701	(208) 336-3312
The Hothouse	563 North 3rd Street, Montpellier, ID 83254	
The Rudy-Patrick Company	Box 1130, Nampa, ID 83651	
The Silva Star Co.	R.R. 1, Box 64-A, Potlatch, ID 83855	
Twin Butte Evergreens	416 N. Blaine Street, Moscow, ID 83843	
Union Farm and Garden, Inc.	250 No. Orchard Ave., Boise, ID 83704	(208) 466-3568
Western Premium Seed, Inc.	4696 Overland Rd., Boise, ID 83705	(208) 343-0871
Franz Witte, Lndsc. Contr./Nurs.	9770 W. State St., Boise, ID 83703	
Young's Nursery and Landsc.	Orchard and Ramsey Rds., P.O. Box 570, Hayden Lake, ID	

Table A10: Kansas Plant Material Vendors		
Buskirk Horticultural Service	1621 East Kansas Ave., McPherson, KS 67460	
Beachner Seed Co.	Box 128, St. Paul, KS 66771	449-2286
Creek Side Farm	Rt. 1, Box 19, Fowler, KS 67844	
Delange Seed House, Inc.	P.O. Box 7, Gerard, KS 66743	(316) 724-6223
Gamagrass Seed Co.	Rt. 1, Box 45, Hiawatha, KS 66434	(913) 742-3699
Mott Ranch, Inc.	579 Parkway, Pratt, KS 67124	(316) 672-2341
NRCS Plant Materials Cntr.	3800 S. 20th St., Manhattan, KS 66502	(913) 539-8761
Sharp Bros. Seed Co.	Healy, KS 67850	(316) 398-2231
J.H. Skinner Co. Nursery	P.O. Box 8068, Topeka, KS 66608	
Glen Snell	300 N. Adams, Medicine Lodge, KS 67104	(316) 886-5075 or (800) 279-5841
Sommer Bros. Seed Co.	Box 19021, Topeka, KS 66619	
Star Seed Inc.	128 South First, Osborne, KS 67473	(913) 346-5447
Star Seed Inc.	Highway 14, Beloit, KS 67420	(913) 738-2422
Valley Feed and Seed, Inc.	1903 S. Meridian, Wichita, KS 67213	
Willis Nursery Co., Inc.	P.O. Box 530, Ottawa, KS 66067	

Table A11: Montana Plant Material Vendors		
Adsit Farm and Ranch Service	Decker, MT 59025	(406) 757-2223
Agribasics	100 S. Broadway, Belgrade, MT 59714	(406) 388-4232
Agribasics	900 16th North, Great Falls, MT 59403	(406) 453-4321
Agrineeds	Box 622, Livingston, MT 59047	(406) 222-0332

Table A11: Montana Plant Material Vendors		
A.L. Bruce Seed Company	Townsend, MT 59664	(406) 266-3835
Alpine Nursery	1763 Highway 2 East, Kalispell, MT 59901	
Amsterdam Store	6680 Amsterdam Rd., Manhattan, MT 59741	(406) 282-7223
Badland Nursery	P.O. Box 1615, Havre, MT 59501	
Barber Seed Service, Inc.	HC 76, Box 62, Denton, MT 59430	(406) 567-2211
Beartooth Grain and Feed	Box 1088, Red Lodge, MT 59068	(406) 446-1418
Beebe Grain	712 E. Front, Butte, MT 59701	
Big Sky Wholesale Seeds	P.O. Box 852, Shelby, MT 59474	(406) 434-5011
Billings Nursery	7900 Frontage Rd., Billings, MT 59101	
BitterRoot Nursery	521 East Side Hwy., Hamilton, MT 59828	(406) 961-3806
BitterRoot Nursery	445 Quast Lane, Corvallis, MT 59828	(406) 961-4991
Blake Nursery	Otter Creek Rd., Big Timber, MT 59011	(406) 826-3405
Bridger Tree Farm	8860 Bridger Canyon Rd., Bozeman, MT 59715	
Buffalo Bill Nursery	Route 2, Box 66, Plains, MT	
Bud Burta	Rd. 2, #2241, Lewistown, MT 59457	(406) 538-8397
Canyon Creek Nursery	Billings, MT 59101	
Del Carey	Box 1, Volborg, MT 59351	(406) 421-5562
Cashman Nursery	P.O. Box 242, Bozeman, MT 59715	(406) 587-3406
Cenex Seed Co.	P.O. Box 1748, Billings, MT 59103	
Cenex/Farmers Union Oil	Box 339, Chinook, MT 59523	
Cenex Seed Plant	Box 956, Miles City, MT 59301	(406) 232-4760
Cenex/Farmers Union Oil	1820 St. Charles, Fort Benton, MT 59422	(800) 497-8295
Cenex/Farmers Union Oil	105 2nd Ave. North, Froid, MT 59226	(406) 766-2339
Cenex/Farmers Union Oil	Box 2483, Great Falls, MT 59403	
Cenex/Farmers Union Oil	1545 Northern Ave., Worden, MT 59058	(406) 967-3100
Cenex/Power Farmers Elev. Co.	Box 215, Power, MT 59468	(406) 463-2281
Cenex Supply and Marketing	4570 N. Reserve, Missoula, MT 59802	(406) 543-8383
Cenex Supply and Marketing	1408 Hwy 93 So., Ronan, MT 59864	(406) 676-2201
Central Feed Co.	220 East Main, Lewistown, MT 59457	(406) 538-5451
Chadwick Landscape Nursery	2101 East Custer Ave., Helena, MT 59601	
Circle S Seeds	Box 130, Three Forks, MT 59752	(406) 285-3269
Co-op Supply, Inc.	700 North Montana St., Dillion, MT 59725	(406) 683-2308
Co-op Supply Inc.	Box 36, Valier, MT 59486	(406) 279-3277
Cramer Irrigation and Seed	Box 432, Hysham, MT 59038	(406) 342-5281
CX Ranch, Inc.	341 Rd. 422, Circle, MT 59215	
Dept. of State Lands, For. Div.	2705 Spurgin Rd., Missoula, MT 59801	
Chip Dye	HC 50, Box 4, Alzada, MT 59311	(406) 828-4487

Table A11: Montana Plant Material Vendors		
Earth and Wood Craftsman, Inc.	3204 Highway 93 South, Stevensville, MT 59870	
Eastern Montana Seeds	HC Box 3050, Forsyth, MT 59327	(406) 356-2374
Eisenman Seed Co.	P.O. Box 129, Fairfield, MT 59436	(406) 467-2521
Farmers Exchange	115 Main St., Stevensville, MT 59870	(800) 240-5441
Forestry Seeds	Lewistown, MT 59457	
Forsyth Seed Co.	Box 185 Forsyth, MT 59327	(406) 356-7627
Four Winds Nursery	5853 E. Shore Rd., Polson, MT 59860	
Gallatin Farmers Co.	114 Northern Pacific, Belgrade, MT 59714	(406) 388-6242
Garden City Seeds	1324 Red Crow Rd., Victor, MT 59875	
Grain Growers Oil Co.	Box 847, Scobey, MT 59263	(406) 487-2741
R.M. Gregor Landscaping	1310 Greene St., Helena, MT 69501	
Harding Land and Cattle Co.	Box 3022, Miles City, MT 59301	(406) 232-2754
Hardy Trees	P.O. Box 9346, Kalispell, MT 59904	
Loyd A. Harris	3921 Springhill Rd., Bozeman, MT 59715	(406) 587-5696
Harvest States Co-op	Box 66, Valier, MT 59486	(406) 279-3615
Hi-Mountain Farm	Route 1, Box 29, Seligman, MT	
Heartland, Inc.	Belgrade, MT 59714	(406) 388-4232
Heisel Nursery	4463 Springhill Rd., Bozeman, MT 59715	
K and K Seed Co.	Route 3, Conrad, MT 59425	
K-W Feed and Grain, Inc.	Box 1389, Big Timber, MT 59011	(406) 932-5132
Lake Milling, Inc.	Box 288, Hamilton, MT 59840	(406) 363-2334
Lawsons Greenhouse	1405 Hillside Dr., Bozeman, MT 59715	
Lawyer's Nursery	950 Hwy. 200 West, Plains, MT 59859	(406) 826-3229
Laurel Co-op Assn.	Box 7, Edgar, Mt 59026	(406) 962-3792
Lone Pine Ranch	HC 31, Box 3125, Wolf Point, MT 59201	(406) 525-3390
Mannakee Seed Co.	Box 68, Cascade, MT 59421	
Marchie's Nursery	1845 South Third West, Missoula, MT 59801	
Mecklenberg Gardens	4141 Sringhill Rd., Bozeman, MT 59715	
Mo's Greenhouse	185 Swan River Rd., Bigfork, MT 59911	
Montana Bitterroot Gardens	1990 Lower Valley Rd., Kalispell, MT 59901	
Montana Merchandising Co.	Box E, Great Falls, MT 59405	(800) 332-1812
Montana Seeds, Inc.	Route 3, Conrad, MT 59425	(406) 278-5547
Mountain Brooks Nursery	P.O. Box 1114, Eureka, MT 59917	
Mountain Home Nursery	Deborgia, MT 59830	
Hugo Muggli, Inc.	Tongue River Stage, Miles City, MT 59330	(406) 232-5578
Northern Ag Service	HC65, Box 5500, Hwy 2 East	(406) 654-2022

Table A11: Montana Plant Material Vendors		
Northland Seed Co.	418 Albert St., Billings, MT 59101	(406) 252-0568
Northrup-King and Co.	Box 398, Billings, MT 59103	(406) 252-0508
NRCS Plant Materials Cntr.	Route 1, Box 1189, Bridger, MT 59014-9718	(406) 662-3579
Patrick Seed Farms, Inc.	HC 72, Box 7300, Malta, MT 59538	(406) 654-1958
Ed Peterson	Rt. 1, Box 2908, Troy, MT 59935	
Pioneer Hi-Bred Int'l	Box 400, Wibaux, MT 59353	(406) 654-1958
Powder River Seed Co.	Box 673, Broadus, MT 59317	
Quality Seed Co.	P.O. Box 31, Lewistown, MT 59457	(406) 538-8738
Renn's Blue Spruce Nursery	6305 Highway 2 East, Columbia Falls, MT 59912	
Reynolds Feed and Seed	Box 201, Winnett, MT 59087	(406) 429-7821
Shades of Green Nursery	3403 Cooney Dr., Helena, MT 59601	
Bill Skorupa	Rt. 1, Box 1211, Bridger, MT 59014	(406) 662-3358
Snow Line Tree Co., Inc.	Highway 93 South, Kalispell, MT 59901	
Spanish One	Conrad, MT 59425	(406) 627-2329
State Nursery Company	Helena, MT 59601	
Townsend Seeds, Inc.	P.O. Box 1338, Townsend, MT 59644	(406) 266-4444
Treasure State Seed, Inc.	Box 698, Farifield, MT 59436	(406) 467-2557
Tri-Valley Feed	Rt. 62, Box 3252, Livingston, MT 59047	(406) 222-1132
Two Dog Seed Co.	800 Steel Bridge Rd., Kalispell, MT 59901	(406) 752-3656
Valley Feed	Rt. 62, Box 3252, Livingston, MT 59047	
Valley Nursery	Box 4845, Helena, MT 59601	
Wanner Nursery	Corvallis, MT 59828	
West Butte Ranch	Box 32, Sweetgrass, MT 59484	(406) 937-2281
West Feeds/Agribasics	1420 Minnesota Ave., Billings, MT 59101	(406) 252-5196
Western Seed and Supply, Inc.	P.O. Box 57, Charlo, MT 59824	
Western Seed and Supply, Inc.	Box 67 Ronan, MT 59864	(406) 676-3900
Westland Seed, Inc.	Box 57, Charlo, MT 59824	(406) 644-2202
Westland Seeds, Inc.	1308 Round Butte Road W., Ronan, MT 59864	(800) 547-3335
Wild Flower Seeds	16000 Hwy 10A West, Anaconda, MT 59711	
Wildwood Landscaping	P.O. Box 322, Big Sky, MT 59716	

Table A12: Nebraska Plant Material Vendors		
Arrow Seed Co., Inc.	Box 722, Broken Arrow, NE 68822	
Kendall Atkins	HC89, Box 52, Dix, NE 69133	
Bluebird Nursery	P.O. Box 460, Clarkson, NE 68629	(402) 892-3457
Cenex Seed Co.	Box 279, Gering, NE 69341	
Clarke-McNary	Univ. of NE. Campus, Lincoln, NE	(402) 472-6640

Table A12: Nebraska Plant Material Vendors		
	68583	
Cole Seed Farm	Route 1, Box 119, Plattsmouth, NE 68048	(402) 298-8169 or (402) 298-8387
Condon Farms	Route 2, Creighton, NE 68729	(402) 358-3614
Coronolla Hills	9201 McKinley St., Omaha, NE 68122	
Engel Farms	4816 35th Street, Columbus, NE 68601	(402) 503-2186
Flatland Scenes	1219 16th St., Aurora, NE 68818	
Fragrant Path	P.O. Box 328, Ft. Calhoun, KE 68023	
Gamagrass Seed. Co	Route 1, Box 111A, Falls City, NE 68355	(800) 367-2879
Horizon Seeds Inc.	P.O. Box 81823, 1540 Columbus Ken Hwy Lincoln, NE 68501	(402) 475-1232
Laux Seed Farm	HC 85, Box 48, Bridgeport, NE 69336	
Marshall Nurseries	205 North 2nd, Arlington, NE 68002	
Miller Seed Co.	Box 81823, 1540 Cornhusker Hwy, Lincoln, NE 68501	(402) 432-1232
Osler Seed Farms	HCR 55, Box 123, Elsie, NE 69134	
Plumfield Nurseries	210 North Nye Street, Box 410, Fremont, NE 68025	
Prairie Plains Seed, Inc.	Route1, Box 112, Faribury, NE 68352	(402) 446-7312
Ruse Farm	Route A, Box 8, Gordon, NE 69343	(308) 282-0786
Stock Seed Farms	R.R. 1, Box 112, Murdock, NE 68407	(402) 867-3771
Trojan Seed Co.	Route 2, Lyman, NE 69352	
Willow Creek Nursery	R.R. 1, P.O. Box 485, Chappell, NE 69129	
Wilson Seed Farms	Polk, NE 68654	

Table A13: New Mexico Plant Material Vendors		
Agricultural Seed Co.	Drawer A, Mesquite, NM 88048	
Agua Fria Nursery	1409 Agua Fria St., Santa Fe, NM 87501	(505) 983-4831
Bar V 3 Enterprises	P.O. Box 306, Alamogordo, NM 88311	(505) 434-5210
Bernardo Beach Native Plant Farm	520 Montano N.W., Albuquerque, NM 87107	(505) 345-6248
Cactiflor	Box 787, Balew, NM 87002	
Curtis and Curtis, Inc.	Box 8A - Star Route, Clovis, NM 88101	(505) 762-4759
Desert Moon Nusery	Box 600, Veguita, NM 87062	(505) 864-0614
C.H. Diebold	Box 330, RFD 3, Los Lunas, NM 87031	(505) 869-2517
Grassland Resources, Inc.	Santa Fe, NM 87501	
Malone Farms, Ltd.	Route 1, Box 76, Lake Arthur, NM 88253	
Mesa Gardens	P.O. Box 72, Belen, NM 87002	(505) 864-3131
Mountain Valley Nursery	Box 81, Lincoln, NM 88338	
Nature's Way Wholesale Nursery	8905 Edity Blvd. N.E., Albuquerque,	(505) 898-9258

Table A13: New Mexico Plant Material Vendors		
	NM 87113	
New Mexico Cactus Research	P.O. Box 787, Belen, NM 87002	
New Mexico Native Plant Nursery of S.W.S.H.	309 West College Ave., Silver City, NM 88061	(505)537-2165
NRCS Plant Materials Cntr	1036 Miller Street, S.W., Los Lunas, NM 87031	(505) 865-4684
Plants of the Southwest	1570 Pacheco St., Santa Fe, NM 87501	(505) 983-1548
Rowland Nursery	540 Telshor Blvd., Las Cruces, NM 88001	(505) 522-4227
Santa Ana Pueblo	Hwy. 44 and Jemez Dam Rd., Bernalillo, NM 87004	(505) 867-1322
Santa Fe Greenhouses	2904 Rufina St., Santa Fe, NM 87501	(505) 473-2700
Sierra Vista Growers	P.O. Box 225, Chamberino, NM 88027	
Wildland Native Seeds Found.	2402 Hoffman Dr. NE, Albuquerque, NM 87110	

Table A14: North Dakota Plant Material Vendors		
Agassiz Seed and Supply	4121 1/2 So. University Dr., Fargo, ND 58104	
Cenex Land O'Lakes Seed	Box 155, 111 11th Ave West, Williston, ND 58802	
Chesak Seed House	220 North 23rd St., Bismark, ND 58501	
Kutzer's Nursery	Rt. 2, Box 154A, Oakes, ND 58474	(701) 742-2747
Lincoln-Oaks Nursery	P.O. Box 1601, Bismark, ND 58502	
NDSU Agronomy Seed Farm	15449 37th St., Bismark, ND 58012	
NRCS Plant Materials Center	3308 University Drive, Bismark, ND 58504-7564	(701) 223-8536
Rogne-Schumacher Seed Farm	R.R. 2, Box 231, Kindred, ND 58051	
S & B Landscaping and Nursery	1400 Airport Rd., Bismark, ND 58504	
Barry Voilek Farms	222 Denver Dr., Crete, ND 58040	

Table A15: South Dakota Plant Material Vendors		
Bertsch Ranch	HC 76, Box 137, Miller, SD 57362	
Den Besten Seed Co.	Box 896, Platte, SD 57369	
Cammack Ranch Supply	Box 2, Union Center, SD 57787	
Clinton Fuerst	Box 417, Tripp, SD 57376	
Domestic Seed and Supply	P.O. Box 466, Madison, SD 57042	
Gene Graves	1109 E. Main St., Chamberlain, SD 57325	
Hansmeier and Son, Inc.	P.O. Box 136, Bristol, SD 57219	
Leo Kratovil	P.O. Box 55, Batesland, SD 57716	
Brad Magness	R.R. 1, Box 140, Huron, SD 57350	
Milborn Feed and Seeds, Inc.	3127 Hwy. 14 Bypass, Brookings, SD 57006	
Roger McCulloch	R.R.1, Box 151, Big Stone City, SD	

Table A15: South Dakota Plant Material Vendors		
	57216	
Pearl View Seeds	R.R. 1, Box 151, Cavour, SD 57324	
Wm. Scott Phillips	Box 17, New Underwood, SD 57761	
Eugene Raap	R.R. 1, Box 72, Pierpont, SD 57408	
Rethke Nurseries	47030 149th St., Twin Brooks, SD 57324	
SD Crop Improv. Found.	Box 2207-A, Brookings, SD 57007	
Sexauer Co.	Box 58, Brookings, SD 57007	
Robert Weiss	41963 275th St., Parkston, SD 57366	
Wilbers Feed and Seed Co.	P.O. Box 41, Miller, SD 57362	

Table A16: Utah Plant Material Vendors		
C & S Intermtn. Seed Enter.	Box 74 or Box 62, Ephraim, UT 84627	(801) 283-4383
Coble Seed Co.	P.O. Box 175, Gunnison, UT 84634	(801) 528-3234
Granite Seed	1697 West 2100 North, Lehi, UT 84043	(801) 768-4422
Hillview Water Gardens	1044 East Hillview Dr., Salt Lake City, UT 84124	(801) 261-4912
Charles Inouye	Box 396, Gunnison, UT 84634	
Lone Peak State Nursery	Utah Dept. of Natural Resources, 14650 South Prison Rd., Draper, UT 84020	(801) 571-0900
Maple Leaf Industries	Box 496, Ephraim, UT 84627	
Mountain Wildland Seed Co.	Box 3201, Logan, UT 84321	(801) 283-4701
Progressive Plants	9180 S. Wasatch Blvd., Sandy, UT 84093	(801) 942-7333
Steve Regan Co.	451 South 400 West, Salt Lake City, UT 84101	
Stevens Bros Wldlnd Sds & Nurs	Box 496, Ephraim, UT 84627	
William Roger Steward and Sons	Box 124, Ephraim, UT 84627	
Porter Walton Co.	Box 1919, 522 South Third West, Salt Lake City, UT 84110	

Table A17: Wyoming Plant Material Vendors		
Dean Anderson	2527 Hwy. 215, Pine Bluffs, WY 82082	
Carroll Riggs Seed Co.	Shoshoni, WY 82649	(307) 856-3004
Clouds Seed Co.	P.O. Box 937, Sheridan, WY 82801	
Etheridge Seed Farms	2028 Lane 11, Powell, WY 82435	
Faxon Farms	598 Rd. 11, Powell, WY 82435	
Parko Farms	Star Route, Box 162A, Powell, WY 82435	(307) 754-3080
Riggs Seed Co., Inc.	Shoshoni, WY 82649	(307) 856-2278
Spiering Farms	1170 Road 19, Powell, WY 82435	(307) 754-4349
Wind River Seed Co.	Rt. 1, Box 97, Manderson, WY 82432	(307) 568-3361
Yoder Grain and Lumber Co.	Torrington, WY 82240	

APPENDIX VI: EROSION CONTROL PRODUCTS AND SUPPLIERS

Listing of these vendors and products does not constitute endorsement by the State of Colorado, the authors of this manual, or sponsoring agencies.

American Excelsior Company 6475 North Franklin Street Denver, Colorado 80229 303-287-3261	Curlex blankets, erosion control netting, Enkamat, Am Tak tackifier
Bowman Construction Supply, Inc. 2310 So. Syracuse Way Denver, Colorado 80231 303-696-8960	PPS Excelsior blankets, Greenfix straw and coconut blankets, mat fiber and Thermoguard Co. hydromulches. R-Tack tackifier. Soil Guard bonded fiber matrix, Soil Master soil binder, Koirmat, and Jute Netting.
Buckley Powder Company 42 Inverness Drive East Englewood, Colorado 80112 303-766-2000	Xcel Excelsior blankets (biodegradable netting available), Aspen Turbo & Conwed hydraulic mulches, Plantago and Marloc tackifiers, Conwed erosion control netting
Nilex Corporation 6810 South Jordan Road Englewood, Colorado 80111 303-766-2000	North American Green straw blankets, coconut blankets, straw/coconut blankets, synthetic blankets
REVEX (Revegetation Exchange, Inc.) 8941 Woodland Road Longmont, Colorado 80503 303-772-4335 1-800-666-4050	PPS Excelsior blankets, Greenfix straw and coconut blankets, mat fiber and Thermoguard Co. hydromulches. R-Tack tackifier. Soil Guard bonded fiber matrix, Soil Master soil binder, Koirmat, and Jute Netting.
Vance Bros. Inc. 3313 Moline Street Aurora, Colorado 80040 303-341-260	straw blankets, Excelsior blankets, EcoAegis bonded fiber matrix, Ecofiber hydromulch
Western Excelsior 901 West Grand Avenue Mancos, Colorado 970-533-7412	Xcel Excelsior erosion control blankets

The distributors above sell and ship directly to consumers. All have specialists who can help in selecting the right material for your project. Many also sell to local garden centers, hardware, building supply, and other stores that sell graminoid seed.

APPENDIX VII: FEDERAL AGENCY CONTACTS

U S Army Corps of Engineers

Omaha District (Platte River drainage)
Tri-Lakes Project Office
9307 State Hyw 121
Littleton, Colorado 80218-6901
303-976-4120

Albuquerque District (Arkansas and Rio Grande River drainages)
Southern Colorado Regulatory Office
710 N. Main Street, Ste. 205
Pueblo, Colorado 81003-3046
719-543-9459

Sacramento District (Colorado river drainage)
Western Colorado Regulatory Office
402 Rood Avenue, Rm 142
Grand Junction, Colorado 81501-2563
970-243-1199

Environmental Protection Agency

Environmental Protection Agency
Region VIII
999 18th Street, #500
Denver, Colorado 80202-2466
1-800-227-8917
1-303-312-6312

APPENDIX VIII: INDEX OF PLANT LISTS AND TABLES

UPLAND PLANT FINDERS

WETLAND & RIPARIAN PLANT FINDERS

ROCKY MOUNTAIN REGION

WESTERN PLATEAU AND CANYON REGION

OTHER TABLES