# REVEGETATING COAL SURFACE-MINED LANDS IN THE WESTERN COAL REGION

The purpose of this chapter is to (1) briefly describe the coal region in the western United States, (2) list and describe plant species suitable for revegetating surface-mined lands and criteria for selecting those species, and (3) provide some guidelines for selecting species and species mixtures for different land uses.

The Western Coal Region lies primarily west of the 100th meridian. This region contains large fields of lignite, subbituminous, and bituminous coals (Figure 35). It spans 15 degrees of latitude and 24 degrees of longitude and encompasses great variation in climate, topography, and geology. Because much of the region is mountainous, local climatic variation due to differences in elevation can be greater than variation due to latitudinal differences. As a result, the native vegetation is extremely heterogeneous over the region as a whole and within localized areas. In some areas, it is possible to go in a short distance from desert shrub vegetation through conifer forest to alpine tundra.

## Geology and Physiography

Because of its size and geomorphic complexity, the geology of the Western Coal Region defies concise description. At least 15 major geomorphic provinces are included in the region and elevations range from below sea level to above 14,000 feet.

The region is extensive and diffuse, with coal being mined in portions of the Great Plains, Rocky Mountains, Great Basin, Wyoming Basin, Intermountain Basin, Colorado Plateau, and North Pacific Valley region of western Washington.

The Western Great Plains is predominantly a high, level plateau which rises gradually in elevation as one moves westward before encountering the abrupt Front Range of the Rocky Mountains. The plateau is dissected occasionally by badlands or breaks, particularly along the Missouri River drainage. The plateau is broken occasionally by small island-like mountains, of which the Black Hills of the Dakotas are the largest and best known. The parent materials of the Great Plains are primarily of Mesozoic and Cenozoic age, though they may be covered with Tertiary material where glaciation has not removed it.

The Rocky Mountains is a collective term for numerous mountain ranges extending south-southeast from Canada

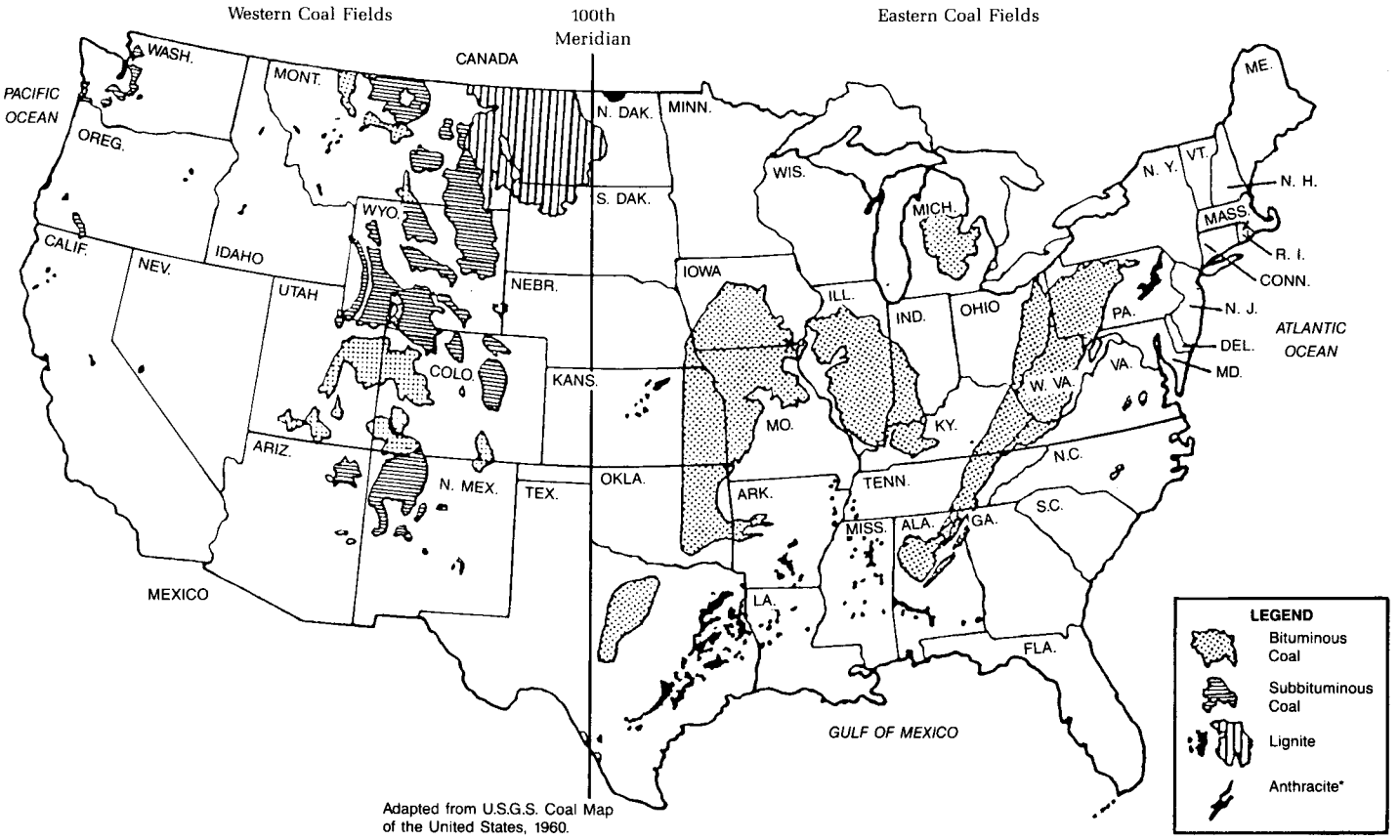


**Figure 35. Coal fields of the continental United States.**

to Mexico. The mountains are primarily the result of late Mesozoic displacement which has exposed a core of Precambrian rock as the result of block and thrust faulting. However, there are significant igneous intrusions and extrusions, primarily in the north.

Much of the Western Coal Region is best described as intermontane basin. The Wyoming Basin is a high basin formed from erosional debris of the adjacent mountains, which is primarily of the Tertiary period. In general, the Wyoming Basin is divided by remnant mountain ranges into several distinct basins.

The Great Basin is a region of scattered, small mountain ranges with wide areas of erosional flats. The geologic nature of the materials is diverse, as the mountains result from local block-faulting of rocks of all geologic ages.

The Colorado Plateau is an extensive area of high elevation, gently dipping sedimentary rock in southern Utah, western Colorado, northern Arizona and northern New Mexico. The plateau actually is composed of numerous smaller plateaus, divided by deeply incised river canyons. Variability in the hardness of the sediments has led to conspicuous formation of escarpments and benches. The rocks range in age from Precambrian to recent.

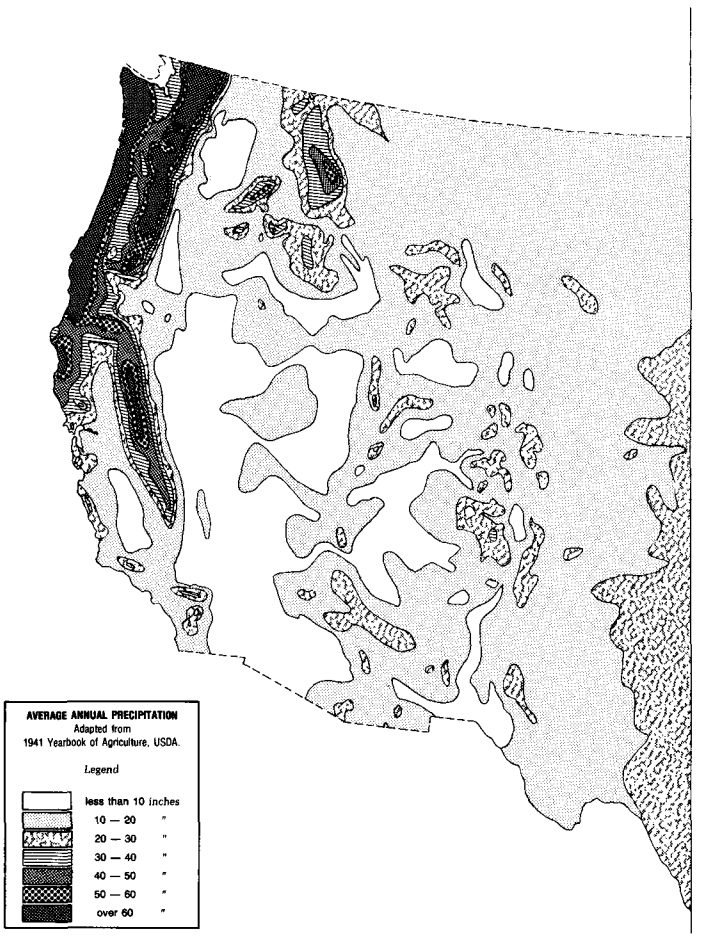


**Figure 36. Precipitation zones of the western United States.**

Subbituminous coal is found in western Washington where the Puget Trough, a narrow lowland, borders the Cascade Mountains. The associated geology is probably of the Tertiary period.

## Climate

### Precipitation

Much of the Western Coal Region is arid to semi-arid. Only the area west of the Cascade Mountains in the Pacific Northwest and high-elevation sites in the mountains receive abundant precipitation. Mean annual precipitation in the portions of the region where coal is mined ranges from 8 to 50 inches, though sites with more than 30 inches are few (Figure 36). The regional trend, disregarding local topographic effects and the North Pacific Valley area, is an increase in mean annual precipitation from about 8 inches on the western edge of the region to about 16 inches at the eastern edge. In the mountainous portions, mean annual precipitation is primarily related to elevation rather than to position in the east/west precipitation gradient. For example, in Utah, mean annual precipitation ranges from 8 inches in the valley bases to more than 40 inches in the high mountains. Thus, the effect of topography generally is much more significant than the effect of geographic location. In general, however, the vast majority of coal fields lies in the foothills or intermontane basins of the region, and does not benefit from the additional moisture available at higher elevations. In fact, most of the identified coal fields in this region receive between 10 and 16 inches of precipitation (Packer et al. 1982). Even this narrow range, however, represents a 60 percent increase in precipitation from the drier sites to the wetter, which translates into a significant difference in revegetation potential. By contrast, the coal mining area in western Washington receives about 50 inches of precipitation per year.

Mean annual precipitation can be a misleading indicator of plant growth potential because the response of the vegetation depends strongly on the seasons during which the precipitation is received. Precipitation received during the growing season usually contributes more to plant growth than precipitation received during the winter. Additionally, growing-season precipitation tends to favor grasses and other shallow-rooted forbs, whereas winter precipitation tends to favor shrubs and other deep-rooted species.

The major portion of the Western Coal Region can be divided into several areas on the basis of seasonality of precipitation (Figure 37). North and South Dakota, eastern Montana, eastern Wyoming, and eastern Colorado lie in an area where maximum precipitation occurs in late spring or early summer. Accordingly, the vegetation throughout this region is dominated by grass species, which make the best use of this growing-season precipitation.

By contrast, western Wyoming, western Colorado, Utah, and western Arizona receive precipitation that is more evenly distributed throughout the year. In response, the vegetation in these areas is dominated primarily by shrubs and, where sufficient moisture is received, by trees. In New Mexico and eastern Arizona, the months of greatest

precipitation are July, August, and September. This precipitation pattern favors shrubs or grasses that show a prominent fall green-up.

In the coal mining area of western Washington, half of the precipitation falls in winter and less than 5 percent in July and August. Trees, notably Douglas-fir, are the predominant natural vegetation.

Year-to-year variation in precipitation also affects the amount of moisture that vegetation can use effectively. For example, an area may have a long-term mean annual precipitation of 12 inches. Typically, precipitation is less than average (7 to 9 inches, for example) the majority of years, and only infrequently is it far above average (20 inches, for example). But the vegetation is predominantly of species and types adapted to survive with no more than about 8 inches of precipitation. With 20 inches of precipitation, much of the extra 12 inches may run off, depending on the intensity of the storm and soil properties, and possibly cause severe erosion. Certainly, the vegetation will show increased production in wet years, but the increase may not be proportional to the increase in precipitation. More importantly, species that require 12 inches of precipitation will fail to establish, even though the mean annual precipitation is 12 inches.

Throughout the Western Coal Region there is a trend for the year-to-year variation in precipitation to become increasingly greater from north to south. Thus, mean annual precipitation is more predictable in the north than in the south, and consequently more reliable for predicting revegetation potential in the north. In Arizona and New Mexico especially, revegetation strategies should be designed for the "typical" or low precipitation years rather than for the average year.

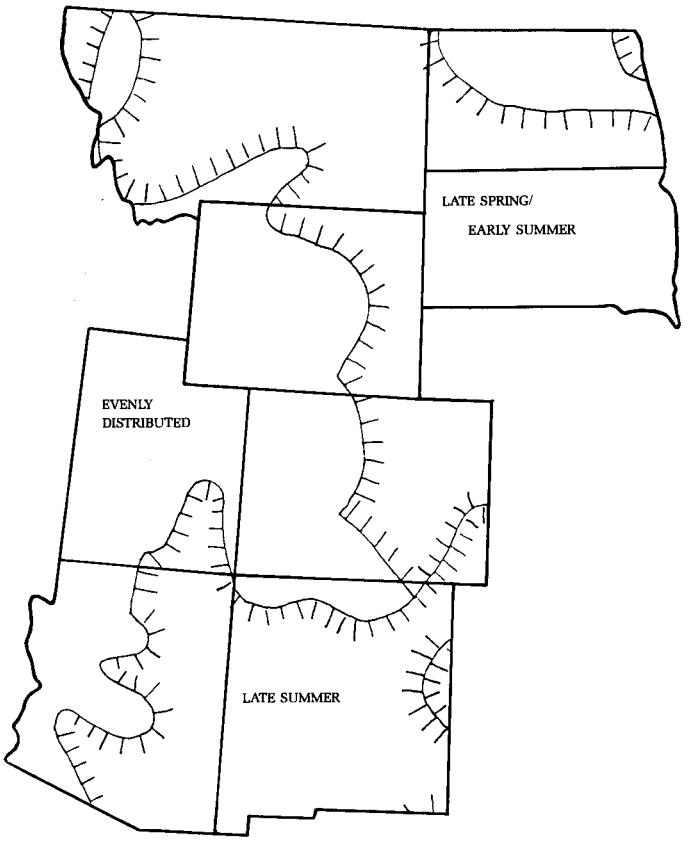


**Figure 37. Seasonal precipitation differs among regions of the western United States.**

### Available Moisture

Precipitation is one of the two primary components of the moisture budget of a given site; evaporative demand is the other. Two sites may receive identical precipitation but have different moisture relations where one site is more exposed to insolation or wind than another.

Evaporative demand is strongly determined by temperature; there is generally a strong increase in evaporative demand from north to south latitudes, and from northeast- to southwest-facing slopes, for example. Crop scientists have calculated the balance between precipitation and evaporative demand (Thornthwaite 1948, Wilsie 1962). Figure 38 shows relative moisture availability for the United States. The availability of natural water is deficient for most of the Western Coal Region.

As would be expected in a mountainous region, moisture availability is controlled largely by elevation, with high-elevation sites generally more moist than low-elevation sites. Irrespective of topography, however, there is a general trend of increasing available moisture from west to east, with least in the Great Basin in Utah and most in North and South Dakota.

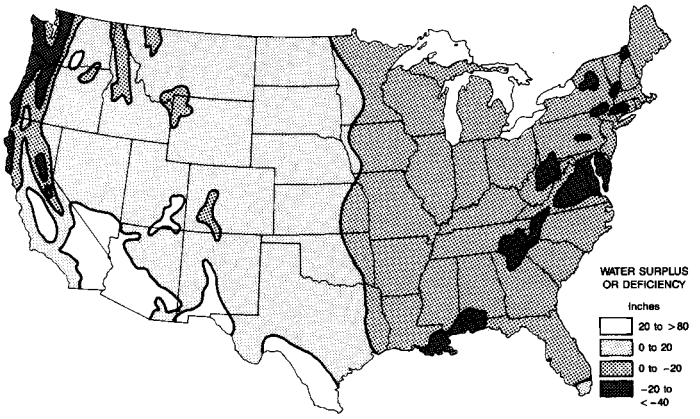


**Figure 38. Areas of natural water surplus and deficiency (computed by subtracting potential evapotranspiration from average precipitation). From U. S. Water Resources Council 1968.**

### Temperature

The growing season for plants is commonly considered to be the time between the last frost in the spring and the first frost in the fall, referred to as the frost-free season. Because the Western Coal Region extends across 15 degrees of latitude, there is a gradient from relatively short growing seasons in the north to long growing seasons in the south (Figure 39). The normal frost-free season in North Dakota and eastern Montana is about 120 days, and in Ar-

izona about 200 days. These values are for low-elevation sites. In the mountainous areas, the frost-free season is more strongly determined by elevation than by latitude. Frost-free seasons of 90 days are common throughout the Rocky Mountain area, but at the higher elevations in Wyoming and Colorado, the frost-free season may be as short as 30 days.

As noted previously, most of the known coal fields are not in the high mountains and so have moderate frost-free seasons. The range for the known coal fields is from 60 days in the mountains of Colorado to 160 days in Arizona and New Mexico (Packer et al. 1982) and 170 to 180 days in western Washington.

In the arid west, the growing season as determined by the frost-free season may not be the actual period of plant growth in a given area. Throughout much of the region, and particularly in the south, summer drought may be severe enough to prevent plant growth. Thus, there is a growing season in the spring when moisture is available, a period of aestivation in the summer when plants are dormant, and a second growing season in the fall when moisture again becomes available. Consequently, the potential period for establishing vegetation in these areas may be less than indicated by the frost-free season.

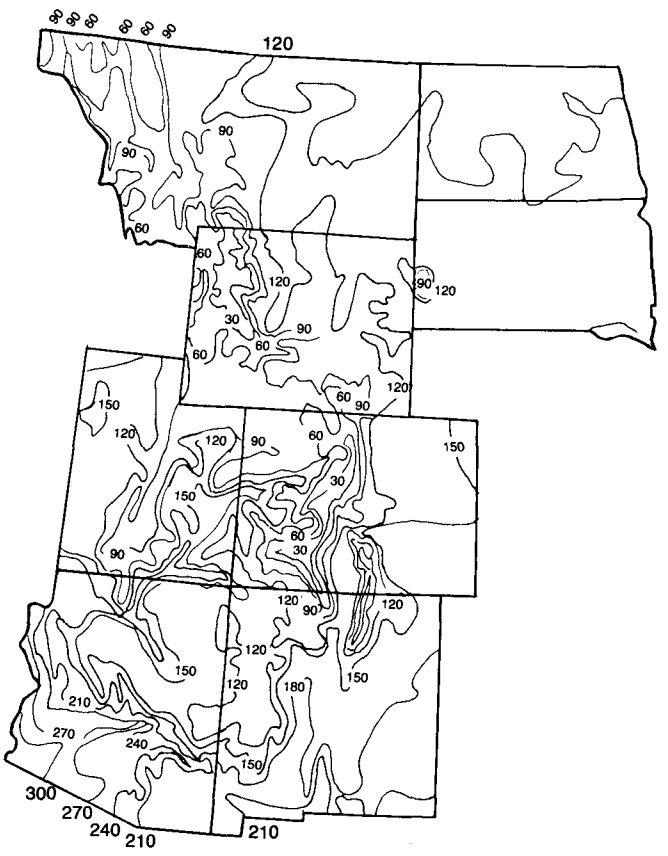


**Figure 39. Frost-free periods (length of growing season) in days for the Western Coal Region. The frost-free period in western Washington is 170-180 days. From U. S. Department of Commerce 1968.**

## Native Vegetation and Plant Communities

The pronounced climatic and geologic variability of the Western Coal Region gives rise to extremely diverse vegetation. Plant communities may be dominated by grasses, shrubs, or trees, and the species composition of the various communities may vary greatly.

Some of the vegetation diversity is attributable to regional trends in climate. In many areas, the influence of mountains on the local climate is responsible for increasing the diversity of vegetation. The nature of the exposed geologic strata and the influence of these strata on the properties of the soil derived from them are responsible for additional vegetation diversity.

For the purposes of this handbook, a classification of the vegetation of this region follows that proposed by Kuchler (1964), which divides the vegetation of the United States into many vegetation types. Sixteen of these vegetation types, exclusive of western Washington, were chosen for their regional importance and proximity to known coal fields and are described here.

Four qualitatively different climatic zones within the Western Coal Region were outlined previously. Three of these are shown in Figure 37. They are: (1) a zone with maximum late-spring and early-summer precipitation, coincident with the Great Plains; (2) a zone of fairly uniformly distributed annual precipitation, generally coincident with the Great Basin; (3) a zone with a late-summer precipitation maximum in the southeastern part of the region; and (4) winter precipitation with dry July and August coincident with the North Pacific Valleys in western Washington. The presentation of the vegetation types follows this outline, beginning with the Great Plains.

### Great Plains Vegetation Types (Maximum Precipitation in Early Summer)

There are six vegetation types characteristic of the Great Plains included in this report. In general, these types can be stratified by moisture, temperature, and topography. Four are grassland types which occur on soils typical of a prairie region. The other two are savanna or forest types which occur on rocky or upland sites in eastern Montana and the Black Hills.

*Wheatgrass-Bluestem-Needlegrass*

The wheatgrass-bluestem-needlegrass vegetation type is a minor component in the Western Coal Region, occurring primarily in central North and South Dakota. This type represents the western boundary of the tallgrass prairie and occupies the most mesic sites of the prairie types considered. It is in a 14- to 18-inch precipitation zone, with a frost-free period of 110 to 160 days.

The structural diversity of the type is low, with a strong dominance by grasses. Dominant species are big bluestem, porcupine grass, western wheatgrass, little bluestem, narrow-leaved sedge, and other sedges. Additional commonly occurring grass species include blue grama, needle-and-thread, prairie junegrass, side-oats grama, and prairie sandreed. Important shrubs and forbs include fringed sagebrush, silver sage, blazing star, and Arkansas rose (Hanson and Whitman 1938, Kuchler 1964).

*Wheatgrass-Needlegrass*

The wheatgrass-needlegrass vegetation type occupies cool, mesic sites in the northern Great Plains, and covers most of western North and South Dakota, as well as the northeast corner of Wyoming. This area receives 14 to 16 inches of precipitation annually, with a frost-free period of 110 to 150 days.

This vegetation type has low structural diversity and is dominated almost totally by grasses. The dominant species are western wheatgrass, blue grama, needle-and-thread, green needlegrass, and prairie junegrass. Other graminoids (grass and grass-like species) include thread-leaved sedge, thick-stem wheatgrass, and little bluestem. Important forbs and shrubs include fringed sagebrush, prickly pear, scarlet globemallow, showy sunflower, and several species of goldenrod and pussytoes (Hanson and Whitman 1938, Kuchler 1964, Quinnild and Cosby 1958).

*Grama-Needlegrass-Wheatgrass*

Grama-needlegrass-wheatgrass is the characteristic vegetation type of the Great Plains of Montana. It also occurs extensively in eastern Wyoming and extends into northern Colorado. This vegetation type occupies the cool dry extreme of the Great Plains, occurring in a precipitation zone of approximately 10 to 16 inches, with a frost-free period of about 100 to 140 days.

The structural diversity of this type is low, as the appearance of the community is dominated overwhelmingly by grasses. The few shrubs present generally are low-growing forms. Forbs are relatively unimportant. The dominant species in the community are western wheatgrass, blue grama, and needle-and-thread. Other graminoids are often important, especially thread-leaved sedge, prairie junegrass, and bluebunch wheatgrass. In the southern end of the type, side-oats grama also may be important. Shrubs and forbs are relatively unimportant in terms of biomass, but add some diversity to the type. Fringed sagebrush is commonly encountered, as are the forbs Drummond's milk-vetch, little sunflower, and hairy goldaster (Costello 1944, Hanson 1955, Kuchler 1964, Moir 1969, Wright and Wright 1948).

*Grama-Buffalo Grass*

The grama-buffalograss vegetation type is characteristic of the Great Plains of eastern Colorado, eastern New Mexico, and southeastern Wyoming. It occupies warm dry sites in the Great Plains, with a precipitation range from 12 to 16 inches and a frost-free period from 120 to 160 days.

As with all of the Great Plains vegetation types, structural diversity is low. The vegetation is dominated overwhelmingly by grasses, with generally only minor amounts of shrubs or forbs. Blue grama and buffalograss are the dominant species, and together constitute the vast bulk of the vegetation. Other important graminoids include western wheatgrass, galleta, thread-leaved sedge, prairie junegrass, and needle-and-thread. Fringed sagebrush, snakeweed, and prickly pear are the most common shrubs, but collectively contribute little to the biomass of the community. Forbs are relatively more important than shrubs, but still contribute little to community composition. The most important species is gumweed, which may be accompanied by sunflowers or woolly indianwheat (Beetle 1952, Branson et al. 1965, Costello 1944, Kuchler 1964).

*Black Hills Pine*

As defined here, the Black Hills pine forest includes the mesic nonsavanna pine forest of the Black Hills and mesic pine forests in southeastern Montana. The dry pine savannas of the Black Hills are included in the eastern ponderosa pine vegetation type.

The Black Hills pine vegetation type occupies mesic or moist sites on mountain slopes or foothills in the northern Great Plains. Mean annual precipitation on these sites ranges from 14 to 22 inches. Stands often are situated on cooler aspects or protected slopes which help maintain site moisture. The frost-free period ranges from 100 to 140 days.

Structural diversity is fairly high, with a moderate to dense overstory of ponderosa pine, commonly both high and low shrubs, and abundant grasses and forbs. The compositional diversity also is high. Thilenius (1972) defined 10 plant communities for the Black Hills; Pfister et al. (1977) added 2 for eastern Montana. In addition to ponderosa pine, the overstory may include quaking aspen, green ash, bur oak, and paper birch. Common understory shrubs include common juniper, Canada buffaloberry, chokecherry, Saskatoon serviceberry, western snowberry, creeping holly grape, shrubby cinquefoil, and fringed sagebrush. Grasses and forbs are numerous; important species include rough-leaved ricegrass, false melic, rough hairgrass, timber oatgrass, various species of sedge, heart-leaf arnica, wartberry fairybell, northern bedstraw, yarrow, strawberry, various species of violet, cream-flowered pea-vine, American vetch, and prairie sage (Kuchler 1964, Pfister et al. 1977, Thilenius 1972).

*Eastern Ponderosa Pine*

The eastern ponderosa pine vegetation type is a zone of savanna or open forest on breaks, foothills, and low mountain slopes in the Great Plains of southeastern Montana and northeastern Wyoming, and the Black Hills in the Dakotas. The climate is dry, and growth and establishment of ponderosa pine is slow. The mean annual precipitation in this type ranges from 12 to 18 inches, and the frost-free period is about 80 to 140 days.

Structural diversity in these communities is moderate, with generally an open overstory of ponderosa pine and occasionally Rocky Mountain juniper, an understory of grasses, and a variable shrub layer. The grass species generally are the same as in the adjacent plains; dominant species are western wheatgrass, bluebunch wheatgrass, little bluestem, blue grama, side-oats grama, prairie junegrass, needle-and-thread, and thread-leaved sedge. The shrub component is variable but often includes skunkbush sumac, prickly pear, silver sagebrush, snakeweed, chokecherry, Fendler's rose, and western snowberry. Common forbs include various species of phlox and lupine (Brown 1971, Kuchler 1964, Pfister et al. 1977, Thilenius 1972).

**Great Basin-Rocky Mountain Vegetation Types (Evenly Distributed Precipitation)**

There are seven vegetation types characteristic of this precipitation regime. Four of the types are dominated by

shrubs or shrub-like trees; three of the types occur at higher elevations and are dominated by trees.

*Mountain Mahogany-Oak Scrub*

The mountain mahogany-oak scrub vegetation type is scattered on high foothills and low mountain slopes throughout Utah and western Colorado, generally occurring on sites above juniper-pinyon communities and below conifer forest. These sites typically receive between 14 and 20 inches of precipitation annually, and have a frost-free period of 80 to 140 days.

The appearance of this vegetation type generally is a thicket of tall shrubs, with relatively few forbs or grasses. The compositional diversity may be quite high, however, as numerous shrub species may be present. The typical dominants are Gambel oak, curlleaf mountain mahogany, true mountain mahogany, and bigtooth maple. Other common shrubs include Saskatoon serviceberry, Utah serviceberry, species of snowberry, chokecherry, cliffrose, greenleaf manzanita, bitterbrush, species of buckbrush, big sagebrush, Douglas rabbitbrush, ninebark, and skunkbush sumac. Although grasses and forbs contribute relatively little to community biomass, their composition may be diverse, including yarrow, pussytoes, asters, arrowleaf balsamroot, lupines, penstemons, bedstraws, blue-eyed Mary, peavine, nemophila, starry Soloman's seal, vetches, western wheatgrass, mountain brome, sedges, and wildrye (Brown 1982b, Kuchler 1964, Nixon 1967, West 1974).

*Great Basin Sagebrush*

This vegetation type is dominant in the Great Basin, and occurs commonly in the "four corners" area of Arizona, Colorado, New Mexico, and Utah. In the Great Basin, the type occurs on bajadas and foothill midslopes above the saline flats and below the juniper-pinyon communities at higher elevations; in the four corners area, it occurs on mesa tops and benches with gravelly soils. The mean annual precipitation in the Great Basin Sagebrush type is from 6 to 20 inches, with a frost-free period of 100 to 180 days. This type is characterized by great temperature fluctuations, both diurnally and seasonally.

The great basin sagebrush type presents a rather monotonous appearance of moderately scattered shrubs with little vegetation in the interspaces. In contrast to the sagebrush steppe in the Intermountain valleys, grasses do not contribute significantly to the community biomass. The compositional diversity may be higher than expected, however, as many species or subspecies of sagebrush are potential dominants. Community dominants usually are one of the three subspecies of big sagebrush (ssp. tridentata, wyomingensis, or vaseyana), black sage, or Bigelow sage. Other common shrubs include rubber rabbitbrush, snakeweed, winterfat, four-wing saltbush, and prickly pear. Common grasses include bluebunch wheatgrass, Indian ricegrass, squirrel tail, blue grama, galleta, sand dropseed, and various species of bluegrass. Forbs generally are of little importance but may include various species of locoweed (Kuchler 1964, Turner 1982, West 1983a).

*Saltbush-Greasewood*

The saltbush-greasewood vegetation type is restricted to dry intermontane basins, primarily in Utah and Colorado. These areas commonly receive only 6 to 10 inches of precipitation annually, with high evaporative demand. The rapid evaporation of water leads to accumulation of salt in the soil, which greatly restricts the number of plant species that can occupy these sites. The temperatures on these sites are extremely variable over the course of a year, with a frost-free period of 120 to 160 days.

The structural diversity of these communities is fairly low, with most sites dominated by scattered shrubs interspersed with grasses. In a given location, the compositional diversity is quite low, but species composition varies by area. Generally, the most important species is shadscale, which may be accompanied by any of several other species of saltbush. When present, greasewood often is the dominant species, but this species is more common on extremely saline soils and occurs typically in the northern end of the type. It becomes increasingly less important in the south. Other important shrubs include bud sage, winter fat, spiny hop sage, Gardner saltbush, Nuttall saltbush, and Gray Molly. Important grasses include Indian ricegrass, galleta, and alkali sacaton (Branson et al. 1976; Costello 1944; Ibrahim et al. 1972; Kuchler 1964; Turner 1982; West 1974, 1983c; West and Ibrahim 1968).

*Sagebrush Steppe*

The sagebrush steppe vegetation type is an important, extensive type covering vast acreages of Intermountain basins and high plains in Wyoming, southern Idaho, northern Utah, and southeast Montana. As defined here, the type includes all areas of nearly equal abundance of sagebrush and grasses (following West 1983b), and includes two of Kuchler's (1964) types, sagebrush steppe and wheatgrass-needlegrass-shrubsteppe. This area receives 6 to 14 inches of precipitation annually, but is drier than expected because much of the precipitation received as snow is lost before it melts. The frost-free period is from 80 to 140 days.

In contrast to the Great Basin sagebrush type, vegetation composition in this type is divided evenly between sagebrush and grasses; consequently, the structural diversity is somewhat higher. The compositional diversity is moderate and varies by area. Throughout the type, the dominant shrub is big sagebrush, which may be joined by fringed sagebrush, black sagebrush, budsage, shadscale, winterfat, prickly pear, and silver sage. In the western end of the type, the important grasses are bluebunch wheatgrass, Idaho fescue, Indian ricegrass, and tall native bluegrass; in the eastern end, the dominant grass species are blue grama, western wheatgrass, needle-and-thread, thread-leaved sedge, and bluebunch wheatgrass. Forbs are relatively unimportant but may include scarlet globemallow and lamb's quarter (Brown 1971, Christensen 1963, Costello 1944, Kuchler 1964, Marquiss and Lang 1959, Robertson et al. 1966, West 1983b).

*Pine-Douglas-fir*

Pine-Douglas-fir is a low-elevation conifer forest type prominent in the foothills and lower mountains of the Front Range of Colorado and the southern Rocky Mountains in Arizona and New Mexico. This type occurs in a moderate precipitation zone (14 to 20 inches annually) and has a frost-free period of 80 to 140 days.

The structural diversity of the type is fairly high, though variable. Low-elevation or dry sites are characterized by somewhat open stands with a grassy understory, while higher elevation or more moist sites have closed stands with a considerable shrub layer. Compositional diversity also is fairly high. In addition to ponderosa pine and Douglas-fir, other tree species on these sites can include quaking aspen, Rocky Mountain juniper, limber pine, or pinyon pine. Shrub species common on more mesic sites include common juniper, mountain ninebark, creeping holly grape, Saskatoon serviceberry, bearberry, and species of rose, currant, and raspberry. Grass and grass-like species typical of drier sites include blue grama, Arizona fescue, prairie junegrass, mountain muhly, thread-leaved sedge, and king spike-fescue. Common forbs include hairy goldaster, yarrow, and species of geranium, cinquefoil, penstemon, pussytoes, and goldenrod (Costello 1944, Kuchler 1964, Marr 1967).

*Douglas-fir*

The Douglas-fir vegetation type is extensive at mid-elevations throughout all of the northern and central Rocky Mountains. Generally, it covers a broad elevational band on sites that are more moist than the ponderosa pine forest below and warmer or drier than the subalpine fir sites above. This type in many areas typifies the montane environment, receiving from 20 to 35 inches of annual precipitation, with a frost-free period of 60 to 120 days.

As defined by Kuchler (1964), this is an extremely widespread type, and occurs in many areas where there are no known coal fields and where the probability of surface mining is negligible. Consequently, this description focuses on the Douglas-fir communities in south-central Montana and Wyoming, which are known to occur adjacent to coal fields.

The structural diversity of Douglas-fir communities is moderately high. Depending on soil moisture conditions, stands have moderately dense to dense overstories, with grassy, low shrub, or tall shrub understories. Compositional diversity also is high due to the large number of constituent species and potential dominants in this type. In the overstory, Douglas-fir may be joined by ponderosa pine, lodgepole pine, limber pine, or quaking aspen. Common tall shrubs include mountain ninebark, mountain maple, chokecherry, and species of gooseberry. Low shrubs include creeping holly grape, common juniper, mountain snowberry, birch-leaf spirea, species of rose, big sagebrush, Canada buffaloberry, twinflower, and bearberry. Common grasses and forbs include king spike-fescue, sheep fescue, Idaho fescue, species of bluegrass, heartleaf arnica, northern bedstraw, false Soloman's seal, weedy milkvetch, and silvery lupine (Despain 1973, Hoffman and Alexander 1976, Kuchler 1964, Pfister et al. 1977, Steele et al. 1983).

*Spruce-fir*

The spruce-fir is another extensive vegetation type that occurs throughout the Rocky Mountains from mid-elevation slopes to upper timberline. Kuchler (1964) divides the spruce-fir forest into two types, western spruce-fir and southwestern spruce-fir. Because the coal area of interest in Colorado and northern Arizona is near the boundary of the two types, they are here considered as one type and the focus is on only the area of interest rather than the entire Rocky Mountains. This vegetation type occurs in a precipitation zone of 20 to 45 inches, with a frost-free period of 40 to 100 days.

The spruce-fir forests are structurally diverse. They generally are closed forest, but become increasingly open toward upper timberline and often have a grass-forb layer, a low shrub layer, and a tall shrub layer. In the overstory, important species include subalpine fir, Engelmann spruce, blue spruce, white fir, Douglas-fir, and quaking aspen. Important shrubs include mountain maple, Scouler's willow, mountain gooseberry, thimbleberry, creeping holly grape, common juniper, twinflower, Canada buffaloberry, mountain snowberry, bearberry, and species of huckleberry, primarily grouse whortleberry. Common forbs include showy fleabane, strawberry, Richardson's geranium, Canada violet, and heartleaf arnica. Common grasses include fringed brome, mountain trisetum, spreading woodrush, and species of sedge (Costello 1944, Hoffman and Alexander 1976, Kuchler 1964, Moir and Ludwig 1979, Oosting and Reed 1952, Steele et al. 1983).

**Southeast Area (Late-Summer Precipitation Maximum)**

Three vegetation types characterize this precipitation regime.

*Juniper-Pinyon*

The juniper-pinyon vegetation type is one of the most extensive in the Western Coal Region, covering large areas in Utah, Colorado, Arizona, and New Mexico. This vegetation type is common on lower mountain slopes and rolling foothills throughout the specified states. It generally occurs in a precipitation zone between 8 and 16 inches, with a frost-free period of 100 to 160 days. The climate is characterized by high daytime temperatures and high evaporative demand.

The vegetation in this type is somewhat variable by area. Junipers and pinyon pines are always dominant, but the particular species can vary. In Colorado, New Mexico, and Utah, the pine generally is true pinyon pine, while in Arizona it also may be one-leaf pine. The juniper species may be still more variable, with Rocky Mountain juniper common in Colorado, northern New Mexico, and Arizona; Utah juniper common in northwest New Mexico, western Colorado, Utah, and northern Arizona; one-seeded juniper common in central and southern Arizona; and alligator juniper found in southeastern Arizona and New Mexico.

The understory is commonly dominated by shrubs interspersed with grasses. Forbs generally are few. East of the Continental Divide, the principal species may be blue grama, Indian ricegrass, galleta, Arizona fescue, big sagebrush, snowberry, and curlleaf mountain mahogany. In Utah and Arizona, common species include Indian ricegrass, needle-and-thread, ring muhly, big sagebrush, Gambel oak, prickly pear, and bitterbrush (Brown 1982a, Costello 1944, Kuchler 1964, Jameson and Reid 1965, Mason et al. 1967, Woodin and Lindsey 1954).

*Blackbrush*

The blackbrush vegetation type is relatively minor and occurs on nonsaline soils in the lowest and driest portions

of the Colorado and Green River Basins of Utah and Arizona. This type is found in a precipitation zone of less than 8 inches annually, though yearly fluctuations can be great. The frost-free period is about 160 to 200 days, with extreme variations in diurnal and annual temperatures.

Because the environment of this vegetation type is so severe, few species other than blackbrush are found in the community. Other widely scattered shrubs may include big sagebrush, shadscale, species of joint-fir, spiny hopsage, and snakeweed. Forbs and grasses that may be present include galleta, black grama, sand dropseed, and species of gilia (Kuchler 1964, Turner 1982, West 1983b).

*Grama-Galleta*

The grama-galleta vegetation type is characteristic of the arid high plains of northern Arizona and New Mexico. This area receives only 8 to 12 inches of precipitation annually, and is subject to intense evaporative demand. The frost-free season is long (140 to 180 days), but the growing season may be shorter due to summer drought that induces aestivation until the late-summer rains bring on fall green-up.

The structural diversity of this type is low, as generally only a grass layer with scattered low shrubs is present. Compositional diversity also is low, as few species are adapted to the rigorous environment. The dominant species are blue grama and galleta, which are joined by black grama, side-oats grama, hairy grama, and alkali sacaton. The scattered shrubs include four-wing saltbush, species of sagebrush, winterfat, species of rose, rubber rabbitbrush, and snakeweed. High abundance of shrubs indicates overgrazing (Brown 1982c, 1982d; Kuchler 1964).

**Western Washington Valley Area (Abundant Winter, Low Summer Precipitation)**

The vegetation type of Kuchler (1964) in this area is probably the redcedar-hemlock-Douglas-fir forest. The predominant tree is Douglas-fir, which often is defined as subclimax in the climax western hemlock-western redcedar forest formation. The climate is humid with abundant low-intensity winter precipitation and dry summers, especially in July and August. Mean annual precipitation is about 50 inches and the frost-free period is 160 to 180 days. Winters are relatively warm and summers cool, reflecting a marine influence.

## Agricultural Crops

### Pastures

A common goal for reclaimed land is a vegetative cover that is diverse, effective, and permanent, and composed of species native to the area, or of introduced species where desirable and necessary to control erosion and achieve the desired postmining land use. Where pasture is the reclamation objective, the primary postmine use will be livestock grazing and sometimes hay production. Other secondary uses such as wildlife habitat, recreation, and watershed functions also are available from the reclaimed pasture. Selection of the species to use on a reclaimed pasture should be based on species adaptiveness, potential for successful establishment, forage production, and ability to provide adequate cover to protect the soil resource from excessive erosion.

One need for diversity in a plant community is to provide ecological niches for the various wildlife species that may inhabit it. Since wildlife habitat is only a secondary use of pasture land, the filling of all ecological niches is not a compelling reason for the selection of large numbers of species on reclaimed pasture. Diversity of plant species may more importantly be required for long-term vegetational stability. Enough adapted species need to be present to maintain an effective vegetative cover that is productive and able to withstand climatic fluctuations. The number of species necessary to achieve this stability often is a function of the species used and the climatic zone in which they will be growing. Ries and Hofmann (1984) compared the species composition of lightly to moderately grazed reclaimed pasture consisting of introduced species with adjacent native rangeland. Both grassland types had four major species each of which made up more than 5 percent of the total composition. The four major species made up 58 percent of the total composition on the native grassland, while the major species contributed 93 percent of the vegetation on the reclaimed pasture. The native grassland had 21 minor species that contributed 42 percent of the vegetation composition while the reclaimed pasture had only three minor species that contributed 7 percent of the vegetative composition. They interpreted their data to indicate that no additional species were needed on the reclaimed pasture to meet its intended postmine use.

Monocultures sometimes have an important role in pasture and range management. Crested wheatgrass, for example, has survived and thrived in monoculture for many years in a variety of climatic conditions. Although more diversity generally is considered preferable, a monoculture may in some cases fulfill the requirements of postmine pastures.

In selecting species for planting into a given reclaimed pasture, care must be taken to choose species that are adapted to the climatic zone, elevation, and soil characteristics of the reclaimed site. In semiarid areas, the water-holding capacity of the soil affects the composition of natural vegetation and the selection of species. In extremely arid areas, other soil and site characteristics such as slope, exposure, toxic conditions, and biotic relationships become critical. Seasonal availability of water also is of critical importance in species selection. For example, basin wild rye is well adapted to the winter-wet and summer-dry climate of the Great Basin area, but is not well adapted to the summer maximum precipitation of the Great Plains. Little bluestem, a plains species, is not well adapted to the summer droughts of the Great Basin.

Literally hundreds of species of grass could be seeded into a reclaimed pasture. Many of the native species, however, are limited by the availability of seed. A multitude of seed mixtures could be planted even for those remaining species for which a seed source is available. Packer and Aldon (1978) have listed some of the important species in the various western climatic zones. Thornburg (1982) provides more detail on important species in the

major land resource areas of the West. In a given locale, the best information on specific performance and availability of seed can be obtained from the local USDA Soil Conservation Service (SCS) office or a local Extension Service office.

Some important pasture species are given below for several climatic zones in the coal mining regions of the West (Thornburg and Fuchs 1978).

*Northern Great Plains*

Cool-season grasses predominate in this region where the annual precipitation is between 10 and 24 inches. The native wheatgrasses—western, thickspike, bluebunch, streambank, and slender—are commonly seeded in pasture mixtures. Green needlegrass, little bluestem, big bluestem, and switchgrass also are commonly used. Prairie sandreed is adapted to sandy soils while "Garrison" creeping foxtail and reed canarygrass are adapted to wet sites. The introduced wheatgrasses—crested, intermediate, and pubescent—are commonly used in pastures in drier regions. Smooth brome and tall fescue are used for pasture in areas of higher precipitation. Alfalfa and sweetclover are the most commonly used legumes, usually seeded with grasses.

*Southern Plateaus*

Precipitation averages 10 to 20 inches. Among the many species that are useful in reclamation in this region are little bluestem, side-oats grama, green sprangletop, Arizona cottontop, bush muhly, plains bristle grass, vine-mesquite, blue grama, and black grama.

*Intermountain Desertic Basins*

Average annual precipitation is from 5 to 20 inches. Among the most commonly used species in reclamation are hard fescue and several of the wheatgrasses, including Siberian, crested, intermediate, pubescent, and tall.

Native grasses include bluebunch wheatgrass, beardless wheatgrass, big bluegrass, Idaho fescue, and Indian ricegrass. Shrubs that have performed well include fourwing saltbush and Nuttall saltbush.

*Desert Southwest*

Average annual precipitation in this region ranges from 5 inches or less to 10 inches. Of the grasses native to this area, big galleta and bush muhly are two that can be seeded on reclaimed land. Some of the native shrubs such as creosotebush, fourwing saltbush, and catclaw have been established.

*North Pacific Valleys*

Some of the species sown for pasture in this humid region are the same as those used in the humid Eastern States. These include the ryegrasses, tall fescue, orchardgrass, and subterannean clover.

### Field Crops

The growing of field crops on reclaimed mining operations in the West is found almost exclusively in the Northern Great Plains, particularly in North Dakota and to a lesser extent in Montana. The most important crops are small grains. Wheat, as either spring wheat or durum, is the most important of these. Other small grains used to a lesser extent are oats, barley, and rye.

Some corn is grown in western North Dakota for silage, and recently sunflowers have become an important field crop. Other crops such as flax or safflower make up a minor portion of the total cropland area in western North Dakota.

Reclamation of mined-land has the potential to convert previously noncropped land into cropland. If a source of good water can be obtained, some reclaimed land could be irrigated. In such cases, several different crops could be grown.

## Criteria for Selecting Species

Reclamation success depends on plant establishment, which, in turn, depends on selection of species that are suitable for site conditions and postmining land uses. Six major criteria for selecting plant species are discussed briefly: land use, adaptation to site, availability, genetic improvement, associated soil microorganisms, and stability and succession (see Monsen and Plummer 1978, Brown et al. 1979, Daniel et al. 1979, McArthur 1981, McKell et al. 1982, and Allen 1984).

### Land Use

A knowledge of which plant species a site can support in relation to climate and soils is the most important consideration for selecting species and determining land use. In the western United States, where most of the strippable coal lies in arid to semi-arid regions, land use is limited primarily to wildlife and domestic livestock grazing (rangeland). Thus, much of the emphasis in the Western Coal Region is on returning the land to the premining condition and land use. Another important consideration is esthetics, where a landscape similar to the premine landscape is desired. Land with higher productivity potential can be returned to cultivated crops, tame pastures, and forests.

*Wildlife and Livestock Grazing (Range)*

Criteria to consider in selecting species for wildlife and livestock grazing include productivity, palatability and nutrition, and adaptation to grazing pressure. Use of different life forms (e.g., forbs and shrubs) will increase structural and habitat diversity for increased animal diversity.

*Crop and Pasture Land*

Species chosen for cultivated crop and pasture lands need to be adapted and responsive to possible fertilization and irrigation regimes. Productivity and palatability to livestock also need to be considered.

*Forestry*

Reforestation is the primary objective on mined land in western Washington. Forestry also may be a postmining objective also on mined lands in other states where the coal seams lie in high-elevation forested zones. Such fac-

tors as productivity and potential animal use need to be considered for a forestry land use.

## Adaptation

The plant species selected need to withstand the climatic and edaphic conditions on the reclaimed mine site. In the Western Coal Region, drought is the most frequently encountered environmental extreme, but certain characteristics of the soil also may limit growth.

Both native and introduced species can be used for reclamation in the Western Coal Region. Local native species are commonly used because they are considered to be best adapted for long-term persistence and productivity. Native species can be chosen from those found on reference areas, on nearby areas with edaphic features similar to those on the reclamation site, or on old disturbances where native seral (but nonweedy) species prove to be established more readily than climax species. Introduced species are used for specific purposes such as more rapid ground cover and soil stability, increased productivity, or ability to withstand certain site conditions.

*Drought Tolerance*

A major reclamation problem in the Western States is that most of the mines lie in arid to semi-arid regions where moisture is limiting for seedling establishment and plant growth. Some of the characteristics of the plant that enable seedling establishment differ from those that enable survival of mature plants. Seedlings need fast production of root-surface area and quick penetration of roots to deeper soil moisture zones for increased water absorption. Drought resistance expressed in features, such as thick cuticles and osmotic adjustment, is not as well developed in seedlings as in mature plants. Under natural conditions in arid lands, seedlings probably establish during occasional years of adequate precipitation, known as the pulse phenomenon of seedling establishment. Irrigation often is used for the first 2 years to improve seedling establishment in areas receiving fewer than 10 inches of precipitation. A minimal amount of irrigation water should be used to simulate the natural pulse phenomenon and to reduce plant mortality when irrigation ceases.

The ability of established mature plants to avoid or tolerate drought needs to be considered. Criteria for choosing plants in the mature stage may include deep or extensive roots, stomatal control, leaf rolling, osmotic adjustment, and high efficiency of water use. However, it must be emphasized that the seedlings are the critical stage, and long-term survival on an arid site is not possible if plants cannot reproduce by natural seed establishment. Tubelings or cuttings seem to be less sensitive to drought than seedlings and have been used in problem areas, though to a limited extent because of greater expense. Drought hardening and deeper roots are responsible for the hardiness of tubelings and cuttings.

*Seasonality of Precipitation*

Seasonal precipitation patterns also are important in choosing species for a particular site. The primary choice may be between warm-season and cool-season plants. Regions that receive most of the precipitation during the summer months will support primarily warm season species. Cool-season species are adapted primarily in regions where most of the precipitation falls during the winter or the early spring months when growing temperatures are relatively cool. This generalization applies mainly to herbs and especially grasses. Some warm-season shrubs grow in areas with winter precipitation. Presumably, these shrubs are able to obtain moisture stored deep in the soil; they also are known to have cooler temperature requirements for optimum growth than most warm-season herbs.

*Temperature Regime*

Temperature also plays a role in site adaptation of plant species. Warm-season species require higher temperatures for optimum growth than cool season species and should be chosen for southern regions or areas where moisture is available during the hottest part of the growing season. Cool-season plants require lower temperatures for growth and should be chosen for northern regions or areas with winter-spring precipitation.

*Soil Nutrients*

Many western soils are low in nutrients. However, most native plants are adapted to these low nutrient regimes whereas introduced species more often have been bred and selected for soils with higher nutrient regimes. Where topsoil is replaced, fertilization may be unnecessary for species with low nutrient requirements.

*Soil Toxicity*

Salinity, sodicity, and high pH often are problems in arid mined lands. Occasionally, levels of boron, selenium, or other elements are higher than desired. Tolerance for specific soil conditions may be an important criterion for species selection.

*Soil Texture*

Although some species are adapted to a broad range of soil textures, there are some that grow best in a rather limited range of soil textures and should be chosen to reclaim areas where those soil textures cause specific problems. For instance, Indian ricegrass grows well in sandy soils, whereas western wheatgrass is found naturally and grows well in clayey soils.

## Availability

Availability of seeds and planting stock was once cited as the major limitation to revegetating with native species. This is no longer as great a problem, because increased demand has led to an increased supply of many native plant materials. But the commercial availability of certain species still is limited and prices often are high.

*Seed*

When commercially unavailable, seeds of locally adapted ecotypes can be gathered by hand in the wild. Use of some species is hindered by this inability to process seeds; for instance, the husks or awns may be difficult to remove. Limited viability, germination, or longevity of seed are other problems that reduce the potential use of some species. Small-seeded species have been used spar-

ingly in the past because the standard farm drill buries them so deeply that they cannot emerge. However, new technology in the development of drills that place seed at controlled depths has enabled successful planting of these seeds. An alternative is to broadcast small seeds after the large seeds have been drilled.

*Planting Stock*

Planting stock includes cuttings, bare-root seedlings, containerized plants, and wildlings (seedlings collected in the wild). The use of planting stock often is discouraged because of its high price relative to cost of seeding. However, planting stock may be the best choice for species that do not germinate well, or for use in certain problem areas where quick plant establishment is needed, or where relatively few plants are required or needed. The inability to propagate planting stock limits the availability of certain species. However, just as with seeds, nurseries and mine-site greenhouses currently provide a much greater variety of planting stock than in the past. Other limitations to using planting stock are related to handling and transplant stock. Stock, especially that grown indoors, should be allowed to become acclimated to the site before it is planted. Equipment to reduce the time and cost of planting is becoming available.

One source of plant material that often is available is the mature native plants growing on the mine site. These can be transplanted from an area about to be mined to one being reclaimed. A tree spade is used to transplant shrubs and small trees, while a front-end loader is used to move sod that contains grasses and forbs. This technique has the advantage of retaining species on the site that may not be available commercially. In addition, beneficial soil microorganisms are moved with the plants and need not be introduced.

*Native Hay*

Hay that is mowed on natural grasslands after most of the species have set seed occasionally is used to increase the species diversity on a reclaimed site, and as a mulch. The problems with native hay include a higher cost than straw mulch and a possible introduction of weed seeds. For this reason, only high-quality (relatively weed-free) native hay should be used. Seed collection on site is an alternative where certain species are not available commercially or where a local ecotype is desired.

## Genetic Improvement

Another consideration in choosing a species is the potential for genetic selection and breeding to improve that species (McArthur 1981). Some native plants when initially collected in the wild have characteristics such as low germination of seed, poor seedling vigor, and slow growth that are not conducive to quick establishment and survival on a mine site.

*Types of Improvement*

Genetic selection and breeding programs attempt to bring about changes, such as increased germination, production, palatability, drought tolerance, and disease resistance. The characteristics that are most conducive to establishment, survival, and land use should be known when choosing improved species and varieties.

*Ecotypes*

Ecotypes are populations with unique genotypes suited to particular environmental regimes. It is important in genetic improvement programs to maintain a range of ecotypes so that plants that are adapted to different sites can be chosen. For instance, four-wing saltbush shows a gradient in adaptation to sites with different temperature and moisture regimes. Plants of this species from the northern United States planted at a southern site may not be adapted to the hot and dry conditions. Forestry seed zones have been established to assure the selection and use of locally adapted ecotypes of tree species (Daniel et. al 1979). Similar designations may be needed for shrubs and herbs with site-specific requirements.

## Associated Soil Microorganisms

The importance of soil microorganisms in successful reclamation has become apparent from recent and past research. Plants that form mutualistic relationships with soil microorganisms are especially useful and beneficial. The classic example here is the legume-*Rhizobium* association, which is important for increased nitrogen fixation, especially for mine soils low in nitrogen. There has been a recent focus on actinorhizal and mycorrhizal associations. Actinorhizae form on a number of western shrub species and are responsible for nitrogen fixation. Mycorrhizae improve nutrient and water uptake, the latter being especially important in arid-soil situations. Where mycorrhizal fungi are absent, species with low dependence on them, such as some grass species, can be planted initially (Allen 1984). Species with a higher dependence on mycorrhizal fungi for their survival, such as most shrub and trees species, may need to be planted after the soil mycorrhizal inoculum has built up over time. Survival of trees, especially conifers on mine spoil, is precluded if they are not or do not become inoculated with ectomycorrhizal fungi. Seedlings and tubelings of tree and shrub species associated with endomycorrhizal fungi are inoculated usually by growing them in soils that are inoculated naturally with the desired fungal associates.

## Stability and Succession

Stability of soils and vegetation often are the primary goals of reclamation. Where vegetation similar to the native vegetation is the goal, successional changes that lead to that goal are expected.

*Soil Stability*

A stable soil is one where postmining erosion is no greater than erosion on an appropriate reference area. Complete lack of erosion often is not a realistic goal in arid lands where the natural vegetation cover is sparse. To maximize protection of the watershed, it is important that soils be stabilized during the first few years following recontouring and seeding. Mulching and crimping often are used to reduce soil movement, but on some western mines, a nurse crop or standing mulch is used. Annual

grains often are chosen as the nurse crop, not because they are especially adapted or will persist, but because they will disappear after a year and allow the perennial vegetation to establish. When choosing perennial species to increase soil stability, consideration must be given to the root system. Deep and spreading roots are more effective stabilizers than shallow, short-root systems.

*Stability of Vegetation*

For postmining land uses, the stability of vegetation can be defined as persistence of a canopy cover that is similar in extent to a reference area, combined with persistence of a desired species composition. The plants must be able to reproduce by seeds or vegetatively for long-term persistence, so species must be chosen for their ability to reproduce in a given environment. Changes in species composition over time, or by succession, are expected if the site is to simulate a native plant community. It is important that a compatible mixture of species be chosen so that, for instance, one highly productive or aggressive species does not dominate the site. It may be desirable to encourage colonization by native species from outside the site for increased diversity.

## Plant Species for Revegetating Surface-Mined Sites

The following species in Table 24 are alphabetized by common name within life forms (i.e., grasses, sedges, forbs, shrubs, and trees). Species referred to in the text are included in this list. In addition, a detailed description follows for species indicated. These are species most recommended for appropriate sites.

**Table 24. Plant species for revegetating coal surface-mined lands in the Western Region. Detailed information on those species in bold face type is given on the following pages of this chapter.**

| *Common Name* | *Scientific Name and Authority** |
|---|---|
| GRASSES | |
| **Alkali sacaton** | *Sporobolus airoides* (Torr.) Torr. |
| Annual ryegrass | *Lolium multiflorum* Lam. |
| Arizona cottontop | *Trichachne californic* (Benth.) Chase |
| Arizona fescue | *Festuca arizonica* Vasey |
| Barley | *Hordeum vulgare* L. |
| **Basin wild-rye** | *Elymus cinereus* (Scribn. & Merr.) |
| Beardless wheatgrass | *Agropyron inerme* (Scribn. & Smith) Rydb. |
| **Big bluegrass** | *Poa ampla* Merr. |
| **Big bluestem** | *Andropogon gerardi* Vitman. |
| Big galleta | *Hilaria rigida* (Thurb.) Benth. |
| Black grama | *Bouteloua eriopoda* (Torr.) Torr. |
| **Blue grama** | *Bouteloua gracilis* (H.B.K.) Lag. ex Steud. |
| Blue panicgrass | *Panicum antidotale* Retz. |
| Blue wild-rye | *Elymus glaucus* Buckl. |
| **Bluebunch wheatgrass** | *Agropyron spicatum* (Pursh) Scribn. & Smith |
| Bluegrass | *Poa* spp. |
| **Buffalograss** | *Buchloe dactyloides* (Nutt.) Engelm. |
| Buffelgrass | *Pennisetum ciliare* (L.) Link |
| Bush muhly | *Muhlenbergia porteri* Scribn. |
| Caucasian bluestem | *Bothriochloa Caucasica* (Trin.) C.E. Hubb |
| Corn | *Zea mays* L. |
| **Crested wheatgrass** | *Agropyron desertorum* (L.) Gaertn. |
| False melic | *Schizachne purpurascens* (Torr.) Swallen |
| Fringed brome | *Bromus ciliatus* L. |
| **Galleta** | *Hilaria jamesii* (Torr.) Benth. |
| Garrison creeping foxtail | *Alopecurus arundinaceus* Poir. |
| **Green needlegrass** | *Stipa viridula* Trin. |
| Green sprangletop | *Leptochloa dubia* (H.B.K.) Nees. |
| Hard fescue | *Festuca ovina duriuscula* (L.) Koch |
| Hairy grama | *Bouteloua hirsuta* Lag. |
| **Idaho fescue** | *Festuca idahoensis* Elmer |
| **Indian ricegrass** | *Oryzopsis hymenoides* (Roem. & Schult.) Ricker |
| **Indiangrass** | *Sorghastrum nutans* (L.) Nash |
| **Intermediate wheatgrass** | *Agropyron intermedium* (Host.) Beauv. |
| King spike-fescue | *Hesperochloa kingii* (S. Wats.) Rydb. |
| Kleingrass | *Panicum coloratum* L. |
| **Little bluestem** | *Schizachyrium scoparius* (Michx.) Nash |
| **Mountain brome** | *Bromus marginatus* Nees. |
| Mountain muhly | *Muhlenbergia montana* (Nutt.) Hitchc. |
| Mountain trisetum | *Trisetum montanum* Vasey |
| **Needle-and-thread** | *Stipa comata* Trin. & Rupr. |
| Oats | *Avena sativa* L. |
| Orchardgrass | *Dactylis glomerata* L. |
| Perennial ryegrass | *Lolium perenne* L. |
| Plains bristlegrass | *Setaria macrostachya* (H.B.K.) |
| Porcupine grass | *Stipa spartea* Trin. |
| Prairie junegrass | *Koeleria cristata* (L.) Pers. |
| **Prairie sandreed** | *Calamovilfa longifolia* (Hook.) Scribn. |
| **Pubescent wheatgrass** | *Agropyron trichophorum* (Link.) Richt. |
| **Reed canarygrass** | *Phalaris arundinacea* L. |
| Ring muhly | *Muhlenbergia torreyi* (Kunth) Hitchc. ex Bush |
| Rough hairgrass | *Agrostis scabra* Willd. |
| Rough-leaved ricegrass | *Oryzopsis asperifolia* Michx. |
| Rye | *Secale cereale* L. |
| **Sand bluestem** | *Andropogon hallii* Hack. |
| **Sand dropseed** | *Sporobolus cryptandrus* (Torr.) A. Gray |
| **Sand lovegrass** | *Eragrostis trichodes* (Nutt.) Wood |
| **Sandberg bluegrass** | *Poa secunda* Presl. |
| Sheep fescue | *Festuca ovina* L. |
| Siberian wheatgrass | *Agropyron sibiricum* (Willd.) Beauv. |
| **Side-oats grama** | *Bouteloua curtipendula* (Michx.) Torr. |
| **Slender wheatgrass** | *Agropyron trachycaulum* (Link) Malte |
| **Smooth brome** | *Bromus inermis* Leyss |
| Squirreltail | *Sitanion hystrix* (Nutt.) J.G. Smith |
| **Streambank wheatgrass** | *Agropyron riparium* Scribn. & Smith |
| **Switchgrass** | *Panicum virgatum* L. |
| **Tall fescue** | *Festuca arundinacea* Schreb. |
| Tall native bluegrass | *Poa fendleriana* Nutt. |
| **Tall wheatgrass** | *Agropyron elongatum* (Host) Beauv. |
| **Thickspike wheatgrass** | *Agropyron dasystachyum* (Hook.) Scribn. |
| Thickstem wheatgrass | *Agropyron dasystachyum* (Hook.) Scribn. |
| Timber oatgrass | *Danthonia intermedia* Vasey |
| **Timothy** | *Phleum pratense* L. |
| Vine-mesquite | *Panicum obtusum* H.B.K. |
| **Western wheatgrass** | *Agropyron Smithii* Rydb. |
| Wheat | *Triticum aestivum* L. |
| Yellow bluestem | *Andropogon ischaemum* L. |
| Yellow Indiangrass | *Sorghastrum nutans* (L.) Nash |

*Names and authorities mostly follow Terrell 1977 and Little 1979. Another source is L. H. Bailey Hortorium 1976.

**Table 24. Plant species for revegetating coal surface-mined lands in the Western Region. Detailed information on those species in bold face type is given on the following pages of this chapter.**

| Common Name | Scientific Name and Authority* |
|---|---|
| GRASS-LIKES | |
| Narrow-leaved sedge | *Carex muricata* L. |
| Spreading woodrush | *Luzula divaricata* Wats. |
| Thread-leaved sedge | *Carex filifolia* Nutt. |
| FORBS | |
| **Alfalfa** | *Medicago sativa* L. |
| **American vetch** | *Vicia americana* Muhl. |
| **Arrowleaf balsamroot** | *Balsamorhiza sagittata* (Pursh) Nutt. |
| Aster | *Aster* spp. |
| Bedstraw | *Galium* spp. |
| **Birdsfoot trefoil** | *Lotus corniculatus* L. |
| Blazing star | *Liatris punctata* Hook. |
| Blue-eyed mary | *Collinsia parviflora* Lindl. |
| Canada violet | *Viola canadensis* L. |
| **Cicer milkvetch** | *Astragalus cicer* L. |
| Cinquefoil | *Potentilla* spp. |
| Cream-flowered peavine | *Lathyrus ochroleucus* Hook. |
| **Crownvetch** | *Coronilla varia* L. |
| Drummond's milk-vetch | *Astragalus drummondii* Hook. |
| False Soloman's seal | *Smilacina racemosa* (L.) Desf. |
| Flax | *Linum usitatissimum* L. |
| Geranium | *Geranium* spp. |
| Goldenrod | *Solidago* spp. |
| **Gooseberry globemallow** | *Sphaeralcea grossulariaefola* (H.&A.) Rydb. |
| Gumweed | *Grindelia squarrosa* (Pursh) Dunal |
| Hairy goldaster | *Chrysopsis villosa* (Pursh) Nutt. |
| Heartleaf arnica | *Arnica cordifolia* Hook. |
| **Illinois bundleflower** | *Desmanthus illinoensis* (Michx.) MacM. |
| Joint-fir | *Ephedra* spp. |
| Lamb's quarter | *Chenopodium album* L. |
| **Lewis flax** | *Linum lewisii* Pursh |
| Little sunflower | *Helianthus pumilus* Nutt. |
| Lupine | *Lupinus* spp. |
| **Maximillian sunflower** | *Helianthus maximiliani* Schrad. |
| Nemophila | *Nemophila* spp. |
| Northern bedstraw | *Galium boreal* L. |
| **Northern sweetvetch** | *Hedysarum boreale* Nutt. |
| Peavine | *Lathyrus* spp. |
| Penstemon | *Penstemon* spp. |
| Phlox | *Phlox* spp. |
| Prairie sage | *Artemisia ludoviciana* Nutt. |
| **Purple prairie clover** | *Petalostemon purpureum* (Vent.) Rydb. |
| Pussytoes | *Antennaria* spp. |
| Richardson's geranium | *Geranium richardsonii* Fisch. & Trautv. |
| **Rocky mountain penstemon** | *Penstemon strictus* Benth. |
| Safflower | *Carthamus tinctorius* L. |
| **Sainfoin** | *Onobrychis viciaefolia* Scop. |
| **Scarlet globemallow** | *Sphaeralcea coccinea* (Nutt.) Rydb. |
| Showy fleabane | *Erigeron superbus* Greene ex Rydb. |
| Showy sunflower | *Helianthus rigidus* (Cass.) Desf. |
| Silvery lupine | *Lupinus argenteus* Pursh |
| **Small burnet** | *Sanguisorba minor* Scop. |
| Starry Soloman's seal | *Smilacina stellata* (L.) Desf. |
| Strawberry | *Fragaria* spp. |
| Subterranean clover | *Trifolium subterraneum* L. |
| Sunflower | *Helianthus* spp. |
| Sweetclover | *Melilotus* spp. |
| Vetch | *Vicia* spp. |
| Violet | *Viola* spp. |
| Wartberry fairybell | *Disporum trachycarpum* (Wats.) Benth. & Hook. |
| Weedy milkvetch | *Astragalus miser* Dougl. |
| **Western yarrow** | *Achillea millefolium lanulosa* (Nutt.) Piper |
| **White clover** | *Trifolium repens* L. |
| White sweetclover | *Melilotus alba* Desr. |
| Wooly Indian-wheat | *Plantago purshii* Roem. & S.A. Schultes |
| Yarrow | *Achillea millefolium* L. |
| **Yellow sweetclover** | *Melilotus officinalis* (L.) Lam. |
| SHRUBS | |
| **Antelope bitterbrush** | *Purshia tridentata* (Pursh) DC. |
| **Apache-plume** | *Fallugia paradoxa* (D. Don) Endl. |
| Arkansas rose | *Rosa arkansana* Porter |
| Atriplex (saltbush) | *Atriplex* spp. |
| Bearberry | *Arctostaphylos uva-ursi* (L.) Spreng. |
| **Big sagebrush** | *Artemisia tridentata* Nutt. |
| Bigelow sage | *Artemisia bigelovii* Gray |
| Bigtooth maple | *Acer grandidentatum* Nutt. |
| Birch-leaf spirea | *Spiraea betulifolia* Pall. |
| Bitterbrush | *Purshia tridentata* (Pursh.) DC. |
| **Black greasewood** | *Sarcobatus vermiculatus* (Hook.) Torr. |
| **Black sagebrush** | *Artemisia arbuscula* var. *nova* (A. Nels.) Cronq. |
| Blackbrush | *Coleogyne ramosissima* Torr. |
| Buckbrush | *Ceanothus* spp. |
| Budsage | *Artemisia spinescens* (DC.) Eat. |
| Canada buffaloberry | *Shepherdia canadensis* (L.) Nutt. |
| **Catclaw acacia** | *Acacia greggii* A. Gray |
| **Chokecherry** | *Prunus virginiana* L. |
| Cliffrose | *Cowania stansburiana* Torr. |
| Common juniper | *Juniperus communis* L. |
| Creeping hollygrape | *Berberis repens* Lindl. |
| **Creosotebush** | *Larrea divaricata* Cav. |
| **Cuneate saltbush** | *Atriplex cuneata* A. Nels. |
| **Curlleaf mountain-mahogany** | *Cercocarpus ledifolius* Nutt. |

*Names and authorities mostly follow Terrell 1977 and Little 1979. Another source is L. H. Bailey Hortorium 1976.

**Table 24. Plant species for revegetating coal surface-mined lands in the Western Region. Detailed information on those species in bold face type is given on the following pages of this chapter.**

| Common Name | Scientific Name and Authority* |
|---|---|
| SHRUBS, continued | |
| Currant (gooseberry) | *Ribes* spp. |
| **Desert bitterbrush** | Purshia glandulosa |
| **Douglas rabbitbrush** | *Chrysothamnus viscidiflorus* (Hook.) Nutt. |
| Fendler's rose | *Rosa woodsii* var. *Fendleri* Rydb. |
| **Four-wing saltbush** | *Atriplex canescens* (Pursh.) Nutt. |
| **Fringed sagebrush** | *Artemisia frigida* Willd. |
| **Gambel oak** | *Quercus gambelii* Nutt. |
| **Gardner saltbush** | Atriplex gardneri (Moq.) Standl. |
| Gilia | *Gilia* spp. |
| **Golden currant** | *Ribes aureum* Pursh. |
| **Gray molly summer cypress** | *Kochia americana* var. *Vestita* S. Wats. |
| **Green ephedra** | *Ephedra viridis* Coville. |
| Greenleaf manzanita | *Arctostaphylos patula* Greene |
| Grouse whortleberry | *Vaccinium scoparium* Leiberg |
| Huckleberry | *Vaccinium* spp. |
| **Leadplant amorpha** | *Amorpha canescens* Pursh. |
| **Longleaf snowberry** | *Symphoricarpos longiflorus* Gray |
| **Martin ceanothus** | *Ceanothus martinii* M. E. Jones |
| **Mat saltbush** | *Atriplex corrugata* |
| **Mexican cliffrose** | *Cowania mexicana* Don. |
| Mountain gooseberry | *Ribes montigenum* McClatchie |
| Mountain maple | *Acer glabrum* Torr. |
| Mountain ninebark | *Physocarpus monogynus* (Torr.) Coult. |
| Ninebark | *Physocarpus malvaceus* (Greene) Kuntze |
| **Nuttall saltbush** | *Atriplex nuttallii* Wats. |
| Prickly pear | *Opuntia polyacantha* Haw. |
| **Prostrate kochia or prostrate summer-cypress** | *Kochia prostrata* (L.) Schrad. |
| Raspberry | *Rubus* spp. |
| Rose | *Rosa* spp. |
| **Rubber rabbitbrush** | *Chrysothamnus nauseosus* (Pall.) Britt. |
| Sagebrush | *Artemisia* spp. |
| **Saskatoon serviceberry** | *Amelanchier alnifolia* Nutt. |
| Scouler's willow | *Salix scouleriana* Barratt |
| **Shadscale** | *Atriplex confertifolia* (Torr. & Frem.) S. Wats. |
| Shrubby cinquefoil | *Potentilla fruticosa* L. |
| **Siberian pea shrub** | *Caragana arborescens* Lam. |
| **Silver buffaloberry** | *Shepherdia argentea* (Pursh) Greene. |
| **Silver sagebrush** | *Artemisia cana* Pursh. |
| **Skunkbush sumac** | *Rhus trilobata* Nutt. |
| Snakeweed | *Xanthocephalum sarothrae* (Pursh) Shinners |
| Snowberry | Symphoricarpos spp. |
| **Spineless hopsage** | *Grayia brandegei* |
| **Spiny hopsage** | *Grayia spinosa* (Hook.) Moq. |
| **Spiny sagebrush or bud sage** | *Artemisia spinescens* (DC.) Eat. |
| Thimbleberry | *Rubus parviflorus* Nutt. |
| **True mountain mahogany** | *Cercocarpus montanus* Raf. |
| Twinflower | *Linnaea borealis* L. |
| **Utah serviceberry** | *Amelanchier utahensis* Koehne |
| **War currant or squaw currant** | *Ribes cereum* Dougl. |
| **Western snowberry** | *Symphoricarpos occidentalis* Hook. |
| **Western virginsbower** | *Clematis ligusticifolia* Nutt. |
| **Winterfat** | *Ceratoides lanata* (L.) C.A. Mey. (Eurotia lanata) |
| **Woods rose** | *Rosa woodsii* Lindl. |
| TREES | |
| Alligator juniper | *Juniperus deppeana* Steud. |
| **Arizona cypress** | Cupressus Arizonica Greene |
| **Bigtooth maple** | *Acer grandidentatum* Nutt. |
| Blue spruce | *Picea pungens* Engelm. |
| **Bur oak** | *Quercus macrocarpa* Michx. |
| **Desert willow** | *Chilopsis Linearis* (Cav.) Sweet |
| **Douglas-fir** | *Pseudotsuga menziesii* (Mirb.) Franco |
| Engelmann spruce | *Picea engelmannii* Parry |
| **Green ash** | Fraxinus pennsylvanica Marsh. |
| Limber pine | *Pinus flexilis* James |
| Lodgepole pine | *Pinus contorta* Dougl. |
| **New Mexico locust** | *Robinia neomexicana* A. Gray |
| One-leaf pine | *Pinus monophylla* Torr. & Frem. |
| One-seeded juniper | *Juniperus monosperma* (Engelm.) Sarg. |
| Paper birch | *Betula papyrifera* Marsh. |
| **Pinyon pine** | *Pinus edulis* Engelm. |
| **Ponderosa pine** | *Pinus ponderosa* Laws. |
| **Quaking aspen** | *Populus tremuloides* Michx. |
| **Rocky Mountain juniper** | *Juniperus scopulorum* Sarg. |
| **Rocky Mountain maple** | *Acer glabrum* Torr. |
| **Russian olive** | *Elaeagnus Angustifolia* L. |
| Subalpine fir | *Abies lasiocarpa* (Hook.) Nutt. |
| **Utah juniper** | *Juniperus osteosperma* (Torr.) Little |
| White fir | *Abies concolor* (Gord. & Gled.) Lindl. |

*Names and authorities mostly follow Terrell 1977 and Little 1979. Another source is L. H. Bailey Hortorium 1976.

## Species Descriptions

### GRASSES

#### ALKALI SACATON
(*Sporobolus airoides* (Torr.) Torr.)

*Propagation/Reproduction:*
Natural: Season of growth April-October. Matures in August.
Artificial Establishment: Poor to fair from seed. Improves with supplemental irrigation. Very good for transplanting. Planting season: late fall, early spring, winter.
Colonizing Ability: Fair persistence, tillers well in moist conditions. Natural spread is good.
Habit: Coarse, densely tufted bunchgrass. Warm season. Height of seed stalk about 90 cm (3 ft). Spread 20 to 45 cm (8 to 18 in) long (basal). Coarse fibrous roots, good rooting depth.

*Habitat:*
Soil: Clayey soils, poor in sandy conditions.
Distribution: Intermountain West, saline bottomlands.
Precipitation Range: 15 to 46 cm (6 to 18 in).
Tolerances: Tolerant of drought, flooding and saline-alkaline conditions. Moderately tolerant to close grazing.

*Uses:* Erosion control, grazing, and wildlife. Poor winter forage, palatable summer growth, spring growth has poor palatability.

*Comments:* Use local seed source, closely cropped grass affords good grazing.

#### BASIN WILD-RYE
(*Elymus cinereus* Scribn. & Merr.)

*Propagation/Reproduction:*
Artificial Establishment: Readily established from seed.
Colonizing Ability: Competitive against weeds, slightly spreading.
Habit: Cool season, bunchgrass. Up to 3 m tall (10 ft). Leaves flat and coarse up to 2 ft long. Extensive root system with short, thick, perennial root stocks.

*Habitat:*
Soil: Medium to fine textures, dry to wet conditions. Moist preferred.
Distribution: All Western States.
Tolerances: Fair to good flooding. Fair drought, fair to good saline, low tolerance to close grazing, moderately tolerant to shade.

*Uses:* Grazing, erosion control, hay, cover for upland game birds, wildlife. Moderate palatability.

*Comments:* Numerous varieties; moderate, early grazing is essential to good stands. Best adapted to wet winter, dry summer climates.

#### BIG BLUEGRASS
(*Poa ampla* Merr.)

*Propagation/Reproduction:*
Natural: Growth begins in very early spring. Matures in early summer at lower elevations.
Artificial Establishment: Fair ease of establishment. Can be transplanted. Moderate seedling vigor.
Colonizing Ability: Fair persistence. Very good rate of natural spread. Moderate competitor.
Habit: Cool season, bunchgrass. Tufted. 60 to 120 cm (2 to 4 ft) tall. Leaf blades are pale green, flat and 20 to 40 cm (8 to 16 in) long. Deep, fibrous root system.

*Habitat:*
Soil: Loamy sand to loamy clay textures. Slightly acid to slightly alkaline soils.
Distribution: All Western States
Precipitation Range: > 30 cm (> 12 in).
Tolerances: Moderate drought, poor salt, poor high water table, moderate shade and grazing.

*Uses:* Grazing, wildlife.

#### BIG BLUESTEM
(*Andropogon gerardi* Vitman)

*Propagation/Reproduction:*
Natural: Growth starts in late spring and continues through summer. Seed matures in late September or October.
Artificial Establishment: Fair to difficult ease of establishment from seed. Restricted to mesic sites. Prefers moist conditions.
Colonizing Ability: Rhizomatous. Seldom produces seed yearly. Requires plentiful moisture and moderate temperatures during bloom.
Habit: Warm season, up to 2 m (6 ft) tall. Leaf blades 30 cm (12 in). Deep, extensive root systems, sod former.

*Habitat:*
Soil: Adapted to all soil types. Prefers moist, well-drained loams.
Distribution: Great Plains, central and southern Rocky Mountains.
Precipitation Range: > 40 cm (> 15 in).
Tolerances: Fair tolerance to flooding, fair drought, poor to fair salt tolerance.

*Uses:* Grazing, native hay. Erosion control. Use in reclamation is limited to favorable sites.

*Comments:* Several varieties. Use adapted seed source.

## BLUE GRAMA
(*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.)

*Propagation/Reproduction:*
Natural: Seed matures in August. Growth begins in late spring. Seed ripens rapidly near maturity.
Artificial Establishment: Ease of establishment is poor to good; seems to depend on available moisture and use of adapted seed. Can be drilled or broadcast.
Colonizing Ability: Spreads by tillering, relatively persistent, competes well after establishment.
Habit: Warm season, bunchgrass, leaves 8 to 15 cm (3 to 6 in). Flowering stems are 30 to 45 cm (12 in to 18 in) tall. Becomes sod former under heavy grazing.

*Habitat:*
Soil: All soils, prefers loamy to clayey textures.
Elevation: > 1,250 m (> 4,000 ft).
Distribution: Northern and Central Great Plains, central and southern Rocky Mountains, northern and central Intermountain Desert Basins, Southern Plateaus (West Texas to Montana to eastern Utah and Arizona).
Precipitation Range: 20 to 50 cm (8 to 20 in).
Tolerances: Very good drought, fair salinity, poor flooding on high water table.

*Uses:* Important range species, erosion control. High forage value in winter and summer. Wildlife.

*Comments:* Use adapted seed sources. Noted varieties include Lovington, NM-118, Woodward.

## BLUEBUNCH WHEATGRASS
(*Agropyron spicatum* (Pursh) Scribn. & Smith)

*Propagation/Reproduction:*
Natural: Growth begins in early spring dependent on moisture. Seed ripens July through August.
Artificial Establishment: Propagated by seed only. Prominent divergent awns must be removed for handling in seed drills. Grazing at seed maturity for scattering is successful.
Colonizing Ability: Climax herbaceous species of the Pacific Northwest and Intermountain Regions. Good rate of natural spread.
Habit: Cool season bunchgrass. Up to 1.3 m (4 ft) tall. Leaves are 15 to 25 cm (6 to 10 in) long. Midgrass. Seed heads 15 cm (6 in) long.

*Habitat:*
Soil: Sandy loam to clay loam. Shallow and gravelly. Calcareous.
Elevation: < 2,700 m (< 8,500 ft).
Distribution: Northern Great Plains, north and central Rocky Mountains, Palouse Prairie, Columbia Basin and Plateau, Snake River Plain, Great Basin Intermontane, northern and central Intermountain, Cascade-Sierra Nevada.
Precipitation Range: 12 to 50 cm (5 to 20 in); optimum ≥ 30 cm (12 in).
Tolerances: Good drought, fair salt, poor flooding or high water table. Low to close grazing.

*Uses:* Erosion control, wildlife, and grazing. High palatability. Abundant.

*Comments:* Generally adapted to sagebrush foothill and Pinyon-Juniper areas. Seed production in natural stands is erratic and depends on moisture and cool temperatures during the bloom.

## BUFFALOGRASS
(*Buchloe dactyloides* (Nutt.) Engelm.)

*Propagation/Reproduction:*
- Natural: Growth begins in late spring and continues through summer until October. Seed ripens from June through September.
- Artificial Establishment: Moderate ease of establishment. Propagated by seed or sod transplant. Plants are unisexual. Customary to plant 10 females to 1 male. Seed is enclosed in burs. Soaking, chilling, and processing improves germination.
- Colonizing Ability: Spreads rapidly by surface runners. Aggressive and persistent under heavy use.
- Habit: Warm season, sod former. Short grass. 10 to 15 cm (4 to 6 in) tall. Leaves narrow and 8 to 15 cm (3 to 6 in) long. Forms dense, matted turf.

*Habitat:*
- Soil: Prefers loamy and clayey textures. Not suited for sands.
- Distribution: Great Plains, Southern Plateaus (New Mexico and Arizona)
- Tolerances: Good drought, fair salt, fair to good high water table. Tolerant to grazing.

*Uses:* Valuable forage species but low production. Erosion control and wildlife. Lawn and recreation in arid areas.

*Comments:* Recommended for seed mixtures only. Noted varieties are Texoka and mesa.

## CRESTED WHEATGRASS
(*Agropyron desertorum* (L.) Gaertn.)

*Propagation/Reproduction:*
- Natural: Season of growth begins in early spring. Matures in early to midsummer. Fair regrowth in fall with moisture.
- Artificial Establishment: Easily established from seed. Good germination. Chilling or soaking in water improves germination.
- Colonizing Ability: Long-lived. Good persistence where growing season is less than 120 days. Moderate to highly competitive. Good seedling vigor.
- Habit: Cool season, bunchgrass. Midgrass. Culms 30 to 100 cm (1 to 3 ft) tall. Deep, finely branched, fibrous root system.

*Habitat:*
- Soil: All textures, prefers moderately deep, loamy soils. Slightly acid to moderately alkaline.
- Elevation: 1,500 m to 2,700 m (5,000 to 9,000 ft).
- Distribution: Montana, Wyoming, western edge of Dakotas, Colorado, Utah, Idaho. Parts of Arizona and New Mexico.
- Precipitation Range: 20 to 45 cm (8 to 18 in).
- Tolerances: Good drought, fair salt, poor to fair high water table. Moderate shade.

*Uses:* Commonly used for roadside stabilization, upland bird cover, grazing and hay. Good palatability. Similar species are crested wheatgrass (Fairway) (*A. cristatum*) and Siberian wheatgrass (*A. sibiricum*). Both introduced. Slight differences in appearances and adapted habitats.

## GALLETA
(*Hilaria jamesii* (Torr.) Benth.)

*Propagation/Reproduction:*
- Natural: Season of growth begins with spring moisture. May produce 2 seed crops, 1st in June, 2nd from August to October depending on moisture.
- Artificial Establishment: May be difficult to establish. Reports vary from poor to good for seed germination.
- Colonizing Ability: Rhizomatous spreading grass. Long-lived. Good persistence.
- Habit: Warm season, bunchgrass, sod former. Erect 8 to 50 cm (3 to 20 in) tall. Deep spreading root system.

*Habitat:*
- Soil: Coarse to fine textures. Basic and saline.
- Elevation: 1,500 to 2,100 m (5,000 to 7,000 ft).
- Distribution: Wyoming to California, south to New Mexico and Arizona.
- Precipitation Range: > 10 cm (4 in).
- Tolerances: Good drought, fair salt, poor to fair high water table. Good grazing after establishment. Winter-hardy. Poor shade tolerance.

*Uses:* Grazing, erosion control, and wildlife. Incompatible with grama grasses.

## GREEN NEEDLEGRASS
(Feather Bunchgrass) (*Stipa viridula* Trin.)

*Propagation/Reproduction:*
Natural: Growth starts in early spring and continues through fall depending on available moisture. Seed matures in early July.
Artificial Establishment: Propagate by seed or transplanting. Seed should be scarified or dry stored for 1 year prior to planting. Average ease of establishment.
Colonizing Ability: Good persistence. Excellent seedling vigor and high resistance to disease and insects.
Habit: Cool season, bunchgrass. Midgrass. Up to 1 m (3 ft) tall. Leaves mostly basal, 20 to 30 cm (8 to 12 in) long. Awns on seeds. Deep, fibrous root system.

*Habitat:*
Soil: Sandy loams to clays. Prefers loams and clay loams.
Distribution: Northern and Central Great Plains, central Rocky Mountains, Great Basin Intermontane, northern and central Intermountain Basins.
Precipitation Range: 30 to 50 cm (12 to 20 in).
Tolerances: Fair to good drought, fair salt, fair high water table, moderate shade tolerant, moderate to grazing.

*Uses:* High forage quality with good yield. High value to songbirds and rodents. Native grass hay.

*Comments:* Varieties include Green Stipa grass, Lodorm. Seldom occurs in pure stands except where additional moisture is supplied or abandoned croplands.

## IDAHO FESCUE
(*Festuca idahoensis* Elmer)

*Propagation/Reproduction:*
Natural: Growth begins in March or April. Matures in mid to late summer.
Artificial Establishment: Fair ease of establishment. Can be transplanted. Seedling vigor is fair. Stands develop 2nd or 3rd year.
Colonizing Ability: Mature plants strong competitors. Seedlings are weak. Poor seed production. Good persistence.
Habit: Cool season, bunchgrass. Upright culms 30 to 100 cm (1 to 3 ft) tall. Numerous fine basal leaves with narrow inrolled blades. Dense, fibrous root system.

*Habitat:*
Soil: Sandy loam to clay loam textures.
Elevation: 250 to 3,600 m (800 to 12,000 ft).
Distribution: West of Rocky Mountains.
Precipitation Range: 25 to > 50 cm (10 to > 20 in). Prefers > 37 cm (15 in).
Tolerances: Moderate drought, moderate salt, poor high water table or flooding, moderate grazing.

*Uses:* Grazing, soil stabilization. Similar native species are Arizona Fescue (*F. arizonica*) and sheep fescue (*F. ovina*). Introduced species is hard fescue (*F. Ovina duriuscula*).

## INDIAN RICEGRASS
(*Oryzopsis hymenoides* (Roemer & Schultes) Ricker.)

*Propagation/Reproduction:*
Natural: Vegetative division in fall or early spring.
Artificial Establishment: Seed needs scarification, plant seed shallow.
Colonizing Ability: Typically one of the first species to become established on sandy sites.
Habit: Height: 30 to 50 cm (12 to 20 in). Spread: 20 to 30 cm (8 to 12 in). Bunchgrass with deep, fibrous root system. Cool season.

*Habitat:*
Soil: Sandy to medium textures, shallow.
Elevation: 610 to 3,050 m (2,000 to 10,000 ft).
Distribution: Western United States.
Precipitation Range: 10 to 30 cm (4 to 12 in).
Tolerances: Fair salt and drought tolerance.

*Uses:* Excellent forage, good erosion control. Dove use seed.

*Comments:* Considerable ecotypic variation. Adapted seed sources should be used.

**INDIANGRASS** (Yellow Indiangrass)
(*Sorghastrum nutans* (L.) Nash)

*Propagation/Reproduction:*
Natural: Growth begins in mid to late spring. Matures in late summer or fall.
Artificial Establishment: Easily established from seed. Seedlings have good vigor. Can be transplanted by sprigs. Stands form quickly.
Colonizing Ability: Decreases with grazing use. Spreads by seed and possibly rhizomes.
Habit: Warm season, bunching, sod former. Culms 100 to 160 cm (3 to 5 ft) tall. Short scaley rhizomes. Leaf blades wide, flat, and up to 60 cm (2 ft) long.

*Habitat:*
Soil: Fine sand to clay loam textures.
Elevation: < 2,100 m (< 7,000 ft).
Distribution: Eastern Montana and Wyoming, Colorado (except northwest corner), New Mexico, and northeastern half of Arizona.
Precipitation Range: > 40 cm (> 16 in).
Tolerances: Fair drought, moderate salt, good on periodic or brief flooding.

*Uses:* Grazing, wildlife, erosion control. Good palatability.

**INTERMEDIATE WHEATGRASS**
(*Agropyron intermedium* (Host.) Beauv.)

*Propagation/Reproduction:*
Natural: Season of growth begins in early spring. Matures in mid to late summer.
Artificial Establishment: Easily established from seed. Prechilling and soaking in water hastens germination. Strong seedling vigor. Moderate grazing essential once established. Can be sodded.
Colonizing Ability: Medium longevity. Aggressive spread from rhizomes and seed.
Habit: Cool season, open, sod former. Erect culms 60 to 130 cm (2 to 4 ft) tall. Clumped, basal leaves and short spreading rhizomes. Dense mat of roots and rhizomes at surface and deep, extensive fibrous roots.

*Habitat:*
Soil: Sandy loams to clay loams. Prefers finer textures. Slightly acid to basic reaction.
Elevation: 300 to 3,000 m (1,000 to 10,000 ft).
Distribution: Dakotas, Nebraska west to Sierra Nevadas. From northern New Mexico and Arizona to Canada.
Precipitation Range: 32 to > 50 cm (13 to > 20 in).
Tolerances: Fair drought, fair salt, fair high water table (at 3 ft) and short-term flooding.

*Uses:* Pasture, hay, soil stabilization. Wildlife plantings.
Varieties: Amur, Greenar, Oahe, Tegmar, Slate, Chief.

**LITTLE BLUESTEM**
(*Schizachyrium scoparius* (Michx.) Nash)

*Propagation/Reproduction:*
Natural: Growth begins in late spring and continues through summer. Seed matures in late September and October.
Artificial Establishment: Fair ease of establishment. Propagate by seed. No information on transplanting. "Trashy" seed requires cleaning before use in seed drills.
Colonizing Ability: Spreads by seed and tillers. Vigorous and long-lived.
Habit: Warm season, bunchgrass. Midgrass. Usually 30 cm to 1 m (1 to 3 ft) tall. Leaf blades 10 to 20 cm (4 to 8 in) long. Dense root system.

Habitat:
Soil: All soils most common on well-drained, coarse to loamy textures. Shallow and calcareous soils.
Elevation: Range not determined. < 1,982 m (6,500 ft) reported.
Distribution: Great Plains, central and southern Rocky Mountains, and Southern Plateaus.
Precipitation Range: 30 to > 50 cm (12 to > 72 in). Best at > 40 cm (16 in).
Tolerances: Fair to good drought, poor salt, fair high water table.

Uses: Grazing, excellent erosion control, wildlife. Palatability and forage quality decrease as plant matures.

Comments: In native stands, seed development depends on favorable moisture and temperatures.

**MOUNTAIN BROME**
(*Bromus marginatus* Nees)

*Propagation/Reproduction:*
Natural: Season of growth not determined.
Artificial Establishment: Easily established by seed. Easily transplanted.
Excellent seedling vigor. Prechill seeds.
Colonizing Ability: Short-lived (3 to 5 years). Good spread by seed. Moderate persistence.
Habit: Cool season, bunchgrass. Culms 30 to 130 cm (1 to 4 ft) tall. Coarse basal and cauline leaves. Tufted with fibrous shallow roots.

*Habitat:*
Soil: Sandy to clay loam textures.
Elevation: 1,500 to 3,000 m (5,000 to 10,000 ft).
Distribution: All western States.
Precipitation Range: > 45 cm (> 18 in).
Tolerances: Weakly moderate drought, fair salt, poor high water table.

*Uses:* Revegetating rangelands, wildlife. Surface covering for erosion control. Good palatability.

## NEEDLE AND THREAD
(*Stipa comata* Trin. & Rupr.)

*Propagation/Reproduction:*
Natural: Growth begins in early spring and continues through summer. Growth resumes after drought. Flowers in June, seed matures in July.
Artificial Establishment: Moderate ease of establishment. Propagate by seed. No information on transplanting. Awns on seeds create handling difficulties with drills.
Colonizing Ability: Exists in almost pure stands as an invader on abandoned disturbed lands.
Habit: Cool season, bunchgrass. Midgrass. Seed stalks 30 cm to 1.3 m (1 to 4 ft) tall. Leaves are narrow and 20 to 30 cm (8 to 12 in) long. Awns average 15 cm (6 in) long. Deep rooted.

*Habitat:*
Soil: Coarse to coarse loamy textures. Shallow and calcareous soils.
Distribution: Northern and Central Great Plains, Rocky Mountain States. Intermountain areas, east of Sierra Nevadas and Cascades.
Precipitation Range: 25 to 41 cm (10 to 17 in). Rapid establishment 35 to 41 cm (15 to 17 in).
Tolerances: Good drought, fair salt, poor high water table, moderately tolerant to close grazing.

*Uses:* Grazing. Awns may cause injury to livestock during seed development. Good forage prior to and after early summer.

## PRAIRIE SANDREED
(*Calamovilfa longifolia* (Hook.) Scribn.)

*Propagation/Reproduction:*
Natural: Season of growth begins in late spring. Flowers between July and September.
Artificial Establishment: Fair ease of establishment. Prechill for 2 weeks to improve germination. May require irrigation. Stands develop slowly.
Colonizing Ability: Vigorous rhizomes. Long-lived. Strongly competitive when established.
Habit: Warm season sod former. Midgrass. Culms 60 to 160 cm (2 to 5 ft) tall. Attached to stout scaley, spreading rhizomes. Leaves rigid 30 cm (1 ft) or longer. Tapered. Coarse, fibrous root system.

*Habitat:*
Soil: Best on sandy textures. Grows on loamy textures. Well-drained soils.
Elevation: 600 to 1,800 m (2,000 to 6,000 ft).
Distribution: Eastern Wyoming and Montana, western Dakotas and Nebraska.
Precipitation Range: 25 to > 50 cm (10 to 20 in).
Tolerances: Fair to good drought, poor salt, poor high water table. Low shade and close grazing.

*Uses:* Grazing and erosion control. Dune stabilization. Noted variety is Goshen.

## PUBESCENT WHEATGRASS (Stiffhair wheatgrass)
(*Agropyron trichophorum* (Link.) Richt.)

*Propagation/Reproduction:*
Natural: Season of growth begins in early spring. Matures in mid to late summer.
Artificial Establishment: Easily established from seed. Good growth rate. Strong seedling vigor. Good germination and growth rate.
Colonizing Ability: Medium longevity. Spreads aggressively from seed and rhizomes. Strong competitor.
Habit: Similar to intermediate wheatgrass (*A. intermedium*). Distinguishing difference is dense pubescence on spikes, spikelets, glumes, and lemmas. Cool season, sod former. 60 to 130 cm (2 to 4 ft) tall.

*Habitat:*
Soil: All textures. Prefers loamy sand to loam.
Elevation: 300 to 3,000 m (1,000 to 10,000 ft).
Distribution: Western Great Plains to Sierra Nevadas.
Precipitation Range: 25 to > 50 cm (10 to > 20 in). Best at 30 to 45 cm (12 to 18 in).
Tolerances: Fair to good drought, fair salt, fair high water table and flooding. More drought, heat, and salt tolerant than intermediate wheatgrass.

*Uses:* Erosion control, grazing, wildlife. Not as palatable as intermediate wheatgrass. Varieties: Greenleaf, Luna, Mandan 759, Topar.

## REED CANARYGRASS
(*Phalaris arundinacea* L.)

*Propagation/Reproduction:*
Natural: Most growth during cool spring months. Growth period October through May.
Artificial Establishment: Difficult to average ease of establishment. Propagate by seed or culm cutting or sprigging. Easy to handle.
Colonizing Ability: Persistent, moderate seedling vigor, slow growth.
Moderate rate of spread. Winter-hardy.
Habit: Cool season, sod former. Tall grass. Grows in clumps up to 1 m across. Seed heads 5 to 20 cm (2 to 8 in) long.

*Habitat:*
Soil: All soils. Prefers loamy to clayey textures.
Distribution: North and Central Great Plains, Intermountain Basins, Oregon and Washington.
Precipitation Range: > 40 cm (16 in) reported.
Tolerances: Fair drought, poor salt, very good high water table. Will not survive continuous close grazing. Tolerant of acidic conditions. Not tolerant of sodic conditions.

*Uses:* Native hay, pasture, silage, erosion control, grassed waterways, wildlife. Moderate palatability. Best used in drainages, i.e., moist conditions, but will survive on uplands.

*Comments:* Several varieties available.

## SAND BLUESTEM
(*Andropogon hallii* Hack.)

*Propagation/Reproduction:*
Natural: Season of growth is April through October. Seed matures in October.
Artificial Establishment: Easy to establish by seed. Seed needs to be processed to use seed drills.
Colonizing Ability: Invades blow-out areas. Spreads by heavy creeping rhizomes. Good lateral spread.
Habit: Warm season, sod former. Tall grass.

*Habitat:*
Soil: Sand to loam textures. Prefers sandy conditions.
Elevation: Up to 1,312 m (4,300 ft) reported for New Mexico.
Distribution: Dakotas to Texas.
Precipitation Range: 35 to > 50 cm (14 to > 20 in).
Tolerances: Fair drought, poor salt, fair to high water table. Not tolerant of close grazing.

*Uses:* Grazing, erosion control on sandy soils. Palatable. Varieties are Elida, Garden, Goldstrike and Woodward. Important species for controlling erosion in sandy conditions.

## SAND DROPSEED
(*Sporobolus cryptandrus* (Torr.) A. Gray)

*Propagation/Reproduction:*
Natural: Season of growth is April through October. Seed matures September to October.
Artificial Establishment: Reports vary from difficult to easy. Moderate growth rate. Propagate by seed. Plant shallow. Seeds require scarification or dry storage. Protect seedlings.
Colonizing Ability: Prolific seed production. Invades disturbed areas. Increases on depleted range.
Habit: Warm season, bunchgrass. Midgrass. 60 to 90 cm (2 to 3 ft) tall. Leaves 10 to 30 cm (4 to 12 in) long. Roots are coarse, fibrous, and penetrating.

*Habitat:*
Soil: Sandy to clayey textures. Prefers coarse textures. Shallow calcareous soils.
Distribution: Central and southern Great Plains and Rocky Mountains. From southwestern deserts to eastern Washington.
Precipitation Range: 20 to > 50 cm (8 to 20 in). Best at 25 to 45 cm (10 to 18 in).
Tolerances: Good drought, fair salt, fair high water table. Not tolerant of shade. Not tolerant of heavy use.

*Uses:* Grazing on depleted ranges. Revegetation of disturbed lands. Fair palatability (decreases with age). Fair winter forage.

## SAND LOVEGRASS
(*Eragrostis trichodes* (Nutt.) Wood)

*Propagation/Reproduction:*
Natural: Season of growth is March through November. Seed ripens in September through October.
Artificial Establishment: Easily established by seed. Mechanical seed harvesting from native stands may be difficult due to presence of brushy plants.
Colonizing Ability: Readily reseeds. Short to medium longevity. May increase in size by tillering. Persistence decreases under heavy grazing. Volunteers aggressively.
Habit: Warm season, bunchgrass. Mid to tall grass. 1 to 2 m (3 to 6 ft) tall. Leaves up to 30 cm (12 in) long. Roots are vigorous, spreading, and deeply penetrating.

*Habitat:*
Soil: Sand to fine loamy textures. Prefers coarser textures. Calcareous soils. Well-drained soils only.
Distribution: Great Plains (southern portion of the north region)
Precipitation Range: 32 to > 50 cm (13 to > 20 in). Best at > 40 cm (16 in.).
Tolerances: Good drought, poor salt, poor high water table. Not tolerant of heavy, close grazing.

*Uses:* Grazing, stabilization of sandy soils. Very palatable and nutritious. Frequently suffers from overuse. Varieties in use: Bend, Mason, and Nebraska 27.

## SANDBERG BLUEGRASS
(*Poa secunda* Presl.)

*Propagation/Reproduction:*
Natural: Growth begins in early spring before other native cool season grasses. Matures in early summer. Renews growth in fall.
Artificial Establishment: May be difficult to establish from seed. Seedling vigor is weak. Poor stands generally reported.
Colonizing Ability: Increases with grazing use on most rangelands. Poor seed production. Competitive when established.
Habit: Cool season, bunchgrass. Culms 20 to 40 cm (8 to 16 in) tall. Short, mostly basal leaves. Densely tufted. Shallow to deep, finely branched fibrous root system.

*Habitat:*
Soil: All textures. Dominant on shallow, rocky soils.
Elevation: < 2,100 m (7,000 ft).
Distribution: Western Dakotas to eastern Washington, Nevada, Utah, California, western Colorado.
Precipitation Range: > 25 cm (> 10 in).
Tolerances: Good drought, fair salt, poor on prolonged flooding. Moderate shade, good grazing.

*Uses:* Grazing, erosion control. Similar species is Canby bluegrass (*P. canbyi*), which is native, taller, longer leaved, later maturing, and more productive. Use adapted seed source.

## SIDE-OATS GRAMA
(*Bouteloua curtipendula* (Michx.) Torr.)

*Propagation/Reproduction:*
Natural: Season of growth is April through October. Seed matures in August through October.
Artificial Establishment: Fair ease of establishment from seed. Seed should be cleaned prior to use of normal seed drills. No information on transplanting.
Colonizing Ability: Good persistence. Underground stems. Long-lived.
Habit: Warm season, bunchgrass. Sod former under heavy grazing. Midgrass. 60 cm to 1 m (2 to 3 ft) tall. Leaves 15 cm (6 in) long. Root system is well branched and fairly deep.

*Habitat:*
Soil: All soils. Prefers sandy to clay loams. Shallow and calcareous soils. Successful in rocky or gravelly soils.
Elevation: Up to 2,300 m (7,000 ft) reported.
Distribution: Great Plains, central and southern Rocky Mountains, Southern Plateaus.
Precipitation Range: 20 to > 50 cm (8 to > 20 in). Best at > 30 cm (12 in).
Tolerances: Fair to good, drought, poor to fair salt, fair high water table. Tolerant of low fertility.

*Uses:* Native hay, grazing, erosion control and wildlife. Varieties in use are numerous.

## SLENDER WHEATGRASS
(*Agropyron trachycaulum* (Link) Malte)

*Propagation/Reproduction:*
Natural: Season of growth from September through June. Seed matures in July and August.
Artificial Establishment: Easy to establish. Propagated by seed. Seeds germinate quickly, are vigorous and fast growing. Some reports indicate transplanting success is good. Suggested for seed mixtures rather than as single species planting.
Colonizing Ability: Stand density decreases rapidly after 4th year. Short-lived. Fair persistence. Bunches enlarge by tillering.
Habit: Cool season, bunchgrass. Midgrass. Up to 1 m (3 ft). Leaves 9 to 32 cm (3 to 13 in) long.

*Habitat:*
Soil: All textures, prefers loamy to clayey textures.
Distribution: Northern and central Great Plains and Rocky Mountains. Columbia Basin Cascades and Sierra Nevadas, northern and central Intermountain Basins.
Precipitation Range: 32 to > 50 cm (13 to > 20 in).
Tolerances: Fair to good drought, fair to good salt, poor to fair high water table. Not tolerant to close grazing.

*Uses:* Native hay, grazing, produces quick cover for erosion control.

## SMOOTH BROME
(*Bromus inermis* Leyss)

*Propagation/Reproduction:*
Natural: Season of growth begins in early spring. Matures in June or July. Vigorous growth in May and June. Good regrowth in early summer.
Artificial Establishment: Easily established from seed. Can transplant easily. Good growth rate. Strong seedling vigor.
Colonizing Ability: Moderate to long-lived. Spreads by rhizomes and seed. Good persistence.
Habit: Cool season, sod former. Culms 60 to 130 cm (2 to 4 ft) tall. Leafy base with brown, scaley rhizomes. Broad, smooth leaf blades. Dense, fibrous, surface roots and rhizomes. Moderately deep, extensive roots.

*Habitat:*
Soil: All textures. Prefers loamy. Weakly acid to weakly alkaline. Well drained.
Elevation: 1,500 to 3,300 m (5,000 to 11,000 ft); changes with latitude.
Distribution: All Western States.
Precipitation Range: 35 to > 50 cm (14 to > 20 in).
Tolerances: Fair drought, fair salt, fair to good high water table and flooding.

*Uses:* Pasture, irrigated hay, erosion control, wildlife plantings. Many varieties. Northern and southern type strains. Numerous species in this genus (both native and introduced) suitable for reclamation. Check with local agencies for adapted species and variety.

## STREAMBANK WHEATGRASS
(*Agropyron riparium* Scribn. & Smith)

*Propagation/Reproduction:*
Natural: Season of growth and seed maturity similar to that for thickspike wheatgrass (*A. dasystachyum*).
Artificial Establishment: Easy to establish from seed. Quick germination, moderate seedling vigor.
Colonizing Ability: Good longevity. Rhizomatous.
Habit: Cool season, sod former. Midgrass. Similar in appearance to thickspike wheatgrass (*A. dasystachyum*).

*Habitat:*
Soil: All soil textures. Best on loamy textures. Sodic conditions.
Elevation: Reported at 1,070 m (3,500 ft) and up.
Distribution: Northern Great Plains and Rocky Mountains, Snake River Plain and Columbia Basin, Great Basin Intermontane, Cascades-Sierra Nevadas, Northern and central Intermountain Basins.
Precipitation Range: 12 to 40 cm (5 to 18 in).
Tolerances: Good drought, fair salt, fair high water table, moderate grazing.

*Uses:* Erosion control, wildlife. Airfield surfaces. Adapted to subalpine and droughty conditions. Often overlooked for droughty conditions because of name. Variety: Sodar.

## SWITCHGRASS
(*Panicum virgatum* L.)

*Propagation/Reproduction:*
Natural: Season of growth is April through October. Seed matures in September or October.
Artificial Establishment: Average ease of establishment. Rhizomatous. Spread assumed to be good. Germination improved by storing for one year.
Colonizing Ability: Long-lived. Seedling growth is aggressive. Persistence not determined. High yields of seed.
Habit: Warm season, sod forming. 1 to 1.7 m (3 to 5 ft) tall. Leaves 15 to 45 cm (6 to 18 in) long. Heavy, vigorous roots and underground stems. Short, vigorous rhizomes.

*Habitat:*
Soil: Sandy to clayey textures. Best in loamy.
Distribution: Great Plains, Southern Plateaus.
Precipitation Range: > 40 cm (16 in).
Tolerances: Fair drought, fair salt, good high water table. Tolerates acid and low-fertility soils.

*Uses:* Important forage and pasture grass. Erosion control. Native hay. Typically found with bluestems. Many ecotypes for variety of conditions.

## TALL FESCUE
(*Festuca arundinacea* Schreber)

*Propagation/Reproduction:*
Natural: Good early summer and late fall regrowth. Growth season and maturity ranges with latitude.
Artificial Establishment: Easily established from seed. Can be transplanted. High seedling vigor.
Colonizing Ability: Long-lived. Good rate of spread. Good persistence.
Habit: Cool season, bunchgrass. Mid to tall grass. 30 to > 100 cm (1 to 3 ft) tall. Densely tufted. Leaf blades stiff and flat. Large volume of deep, coarsely fibrous roots.

*Habitat:*
Soil: Sandy loam to clay textures. Wide range of pH. Needs summer moisture.
Distribution: All Western States except Dakotas.
Precipitation Range: > 45 cm (> 18 in).
Tolerances: Poor to fair drought, fair to good salt, good high water. Good grazing. Moderate shade.

*Uses:* Erosion control, grazing, and wildlife. Numerous species in this genus suitable for reclamation purposes. Check with local agencies for other adapted species. Both native and introduced.

## TALL WHEATGRASS
(*Agropyron elongatum* (Host) Beauv.)

*Propagation/Reproduction:*
Natural: Season of growth begins in April or early May. Matures in late August or September. Regrowth good in summer and fall depending on moisture.
Artificial Establishment: Easily established from seed. Good growth rate. Prechilling hastens germination. Stands establish in 2 to 3 seasons. May require fertilization to maintain production.
Colonizing Ability: Medium longevity. Good seed production. Moderate to high seedling vigor.
Habit: Coarse, cool season, bunchgrass. Large tufted—up to 160 cm (5 ft) tall. Leaves 20 to 40 cm (8 to 16 in) long. Deep, productive root system.

*Habitat:*
Soil: Sandy to clayey textures. Best in loamy textures. Up to pH of 10.
Elevation: 150 to 2,600 m (500 to 7,500 ft).
Distribution: Dakotas, west to eastern Washington, western Colorado to Nevada, northern Arizona and New Mexico.
Precipitation Range: 32 to > 50 cm (13 to > 20 in).
Tolerances: Fair drought, very good salt, good high water table. Intolerant of heavy grazing. Fair shade.

*Uses:* Grazing, hay, silage. Upland birds. Soil stabilization. Standing winter feed. Varieties: Alkar, Jose, Largo, Orbit.

## THICKSPIKE WHEATGRASS
(*Agropyron dasystachyum* (Hook) Scribn.)

*Propagation/Reproduction:*
Natural: Season of growth begins in spring. Seed usually matures in July. Good fall and fair summer regrowth.
Artificial Establishment: Fair ease of establishment from seed. Prechilling seed improves germination. Light irrigation on droughty sites.
Colonizing Ability: Long-lived. Fair seedling vigor. Spreads aggressively after fires remove shrubs. Slow spread otherwise.
Habit: Cool season, sod former. Single stem to small tufted. Up to 1 m (3 ft) tall. Widely spreading rhizomes. Dense, fibrous root systems.

*Habitat:*
Soil: Loamy sand to clay loam textures. Best on medium to coarse. Well drained.
Elevation: Sea level to 3,300 m (0 to 10,000 ft).
Distribution: From northern Arizona and New Mexico to eastern Washington. East through Dakotas, Wyoming, and Colorado.
Precipitation Range: 15 to > 50 cm (6 to > 20 in).
Tolerances: Good drought, fair salt, moderate of early spring flooding. Moderate shade and grazing.

*Uses:* Erosion control, soil stabilization, upland bird cover. Varieties: Critana.

## TIMOTHY
(*Phleum pratense* L.)

*Propagation/Reproduction:*
Natural: Growth begins in early to late spring. Matures in early to late summer.
Artificial Establishment: Easily established from seed. High seedling vigor, good growth rate.
Colonizing Ability: Short to medium longevity, good rate of natural spread. Fair persistence.
Habit: Small tufted, cool season. Erect culms 60 to 115 cm (2 to 3.5 ft) tall. Leaf blades soft, flat, rough edged up to 30 cm (1 ft) long. Moderately shallow, fibrous root system.

*Habitat:*
Soil: All textures. Prefers finer textures.
Elevation: Sea level to subalpine. Dependent on moisture.
Distribution: Western United States (requires moisture).
Precipitation Range: > 37 cm (> 15 in)
Tolerances: Poor drought, fair salt, fair to good high water table. Not tolerant of heavy grazing.

*Uses:* Hay, pasture, erosion control. Similar native species is Alpine timothy (*P. alpinum*).

## WESTERN WHEATGRASS
(*Agropyron smithii* Rydb.)

*Propagation/Reproduction:*
Natural: Season of growth is September through June. Seed matures July through August.
Artificial Establishment: Average ease of establishment. Slow germination. Rhizomatous. Seed germination improved by 6 months to 1 year of dry storage. Can be transplanted.
Colonizing Ability: Spreads rapidly. Very competitive. Very good persistence. Very hardy.
Habit: Cool season, sod former. Midgrass. 60 to 100 cm (2 to 3 ft) tall. Leaves 20 to 30 cm (8 to 12 in) long. Leaf blades stiff and erect. Entire plant usually covered with a grayish bloom. Root systems profuse and dense.

*Habitat:*
Soil: Prefers loamy to clayey textures. Grows in sandy soils.
Elevation: Assumed to be wide.
Distribution: Western United States (southern Great Plains excluded).
Precipitation Range: 12 to > 50 cm (5 to > 20 in).
Tolerances: Good drought, very good salt, good high water table. Tolerant of siltation. Moderately tolerant of close grazing.

*Uses:* Grazing (excellent winter forage) native hay. Erosion control, wildlife. Excellent for variety of conditions. Many varieties, e.g., Arriba, Barton, Rosana.

*Comments:* Generally adapted to short and midgrass prairies, aspen, sagebrush foothill, Juniper-pinyon, and saline alkaline bottomlands.

## ALFALFA
(*Medicago sativa L.*)

*Propagation/Reproduction:*
Natural: Growth season begins in early spring and continues to fall. Flowers from early to late summer.
Artificial Establishment: Easily established from seed. Inoculate seed. Can transplant.
Colonizing Ability: Good seedling vigor. May be outcompeted by weeds until established. Some rhizomatous varieties available.
Habit: Cool and warm season, legume. Numerous erect stems 60 cm to 1 m (2 to 3 ft) tall. Small leaves. Stout, deep-rooted plants. Taproots may be up to 10 m (30 ft) long.

*Habitat:*
Soil: Sandy to loamy textures. Well drained. Neutral to slightly alkaline calcareous.
Elevation: Below sea level to 2,400 m (8,000 ft).
Distribution: All Western States.
Precipitation Range: 30 to > 50 cm (12 to 20 in).
Tolerances: Fair drought, fair salt, poor high water table.

*Uses:* Grazing in mixed pastures, hay, wildlife, erosion control. Can cause bloat. Many varieties available for different conditions. Highly palatable. Considerable variation in winter hardiness.

## AMERICAN VETCH
(*Vicia americana* Muhl. ex Willd.)

*Propagation/Reproduction:*
Natural: Season of growth begins in early spring. Flowers from May to August. Seeds mature 1 month later.
Artificial Establishment: Fair ease of establishment from seed. Fair growth rate. Good transplanting capabilities.
Colonizing Ability: Weak seedling vigor and rate of spread. Persistence is good once established and if managed correctly.
Habit: Cool season, legume. Stems angled, ascending or climbing 15 to 75 cm (0.5 to 2.5 ft) tall. Leaves pinnate 8 to 12 leaflets. Purplish flowers. Seed pods 2.5 to 3.7 cm (1 to 1.5 in) long. Moderately deep roots. Branched taproots and spreading rhizomes.

*Habitat:*
Soil: Loamy sand to clay loam textures. Prefers deep loams. Slightly acid to moderately alkaline and saline.
Distribution: All Western States. Southwest deserts excluded.
Precipitation Range: 35 to 50 cm (14 to > 20 in).
Tolerances: Good drought, good salt, good shade. Depends on ecotype. Decreaser.

*Uses:* Grazing, wildlife, erosion control. Palatable. Use adapted seed source. Polymorphic species with many ecotypes.

## ARROWLEAF BALSAMROOT
(*Balsamorhiza sagittata* (Pursh) Nutt.)

*Propagation/Reproduction:*
Natural: Season of growth in early spring to early summer. Seed matures in late June to early August. Little summer and fall regrowth depending on moisture.
Artificial Establishment: Fair ease of establishment. Slow growth rate. Seeds germinate over 8-week period. Moist, prechilling at 0° to 5°C for 12 weeks improves germination.
Colonizing Ability: Good persistence once established. Spreads by seed. Good competitiveness once established.
Habit: Cool season, herbaceous. 30 to 60 cm (1 to 2 ft) tall. Leaves mostly basal, long stalks, 30 cm (1 ft) long or longer. Silvery-grey to white wooly pubescent. Yellow flowers 2.5 to 5 cm (1 to 2 in) long. Achene type seeds. Thick, moderately deep taproot.

*Habitat:*
Soil: Silty and loamy textures. Well drained. Slightly acid to moderately alkaline. Slightly saline.
Elevation: 300 to 2,700 m (1,000 to 9,000 ft).
Distribution: Intermountain West. Western Coastal States.
Precipitation Range: 25 to > 50 cm (10 to > 20 in).
Tolerances: Good drought, fair salt. Poor high water table. Good grazing and fair shade.

*Uses:* Restoring big game range, grazing, revegetation. Use local seed source. Flowers add color and are esthetically pleasing.

**BIRDSFOOT TREFOIL** (Birdsfoot deervetch)
(*Lotus corniculatus* L.)

*Propagation/Reproduction:*
Natural: Not determined
Artificial Establishment: Fair ease of establishment from seed. Transplanting ease not determined. Inoculate seed.
Colonizing Ability: Seems to spread well from seed.
Habit: Warm season, legume. 50 to 100 cm (20 to 40 in) tall. Upright spreading stems. Alternate leaves in groups of three with two broad leaflets at the base of each leaf branch. Flowers are yellow to deep orange, tinged with red, in clusters of 4 to 8. Slender seed pods 2.5 cm (1 in) long. Deep rooted, branching laterals.

*Habitat:*
Soil: Sandy loam to clay loam textures. Acid tolerant. Wet or poorly drained.
Distribution: Northern and Central Great Plains, Rocky Mountains, Great Basin Intermontane, Columbia Basin, Snake River Plain, Southern Plateaus.
Precipitation Range: 40 to > 50 cm (16 to > 20 in).
Tolerances: Poor drought, fair salt, fair high water table. Low shade.

*Uses:* Grazing, wildlife. Hay. Erosion control. Nutritious and palatable. Many varieties. Use adapted varieties. Does not cause bloat.

**CICER MILKVETCH** (Chick-pea)
(*Astragalus cicer* L.)

*Propagation/Reproduction:*
Natural: Season of growth late spring to early fall. Regrowth in fall with moisture. Seeds mature from August to October.
Artificial Establishment: Fair to difficult ease of establishment. Direct seeding on favorable sites. Transplant is more successful on difficult sites. Seeds require scarification. Slow rate of establishment. Varying results in revegetation trials.
Colonizing Ability: Vigorous creeping rhizomes. Long-lived. Fair persistence. Produces large quantities of seed.
Habit: Legume, medium height. Yellow flowers. Usually > 1 m (3 ft) tall. Leaves 10 to 20 cm (4 to 8 in) long. Odd pinnate, with 21 to 27 light green leaflets about 2.5 to 5 cm (1 to 2 in) long. Short tap root. Spreads up to 10 ft. Black pods at maturity.

*Habitat:*
Soil: Survives on all soil textures. Prefers loamy or clayey textures. Weakly acid to moderately alkaline.
Elevation: 610 to 2,135 m (2,000 to 7,000 ft).
Distribution: All Western States.
Precipitation Range: 35 to > 50 cm (14 to > 20 in) optimum, 46 to 90 cm (18 to 35 in).
Tolerances: Fair drought, fair salt, fair high water.

*Uses:* Grazing, mixed hay, wildlife. Nitrogen-fixing. Erosion control. Varieties: Cicar, Lutana, Monarch. Good cover from spring through fall. Poor in winter. Other species in this genus may be used in reclamation. Check with local agencies for adapted varieties.

## CROWNVETCH
(*Coronilla varia* L.)

*Propagation/Reproduction:*

Natural: Season of growth early spring to early fall. Flowers from June to August.

Artificial Establishment: Good ease of establishment from seed. Transplants well. Fair seedling vigor. Inoculate with specific bacteria.

Colonizing Ability: Rhizomatous. Moderately fast germination. Very competitive once established. May form monoculture. Grazing or mowing thins stands. Good persistence. Spreads slowly.

Habit: Cool season, leguminous. 30 to 130 cm (1 to 4 ft) tall. Creeping stems 60 cm to 2 m (2 to 6 ft) long. Alternate leaves. 9 to 25 leaflets. Deep tap root; heavy, branched root crown. Pinkish-lavender to white flowers.

*Habitat:*

Soil: Loamy textures. Calcareous. Well drained. pH > 5.0.

Distribution: Northern Great Plains, Central Rocky Mountains, Great Basin Intermontane

Precipitation Range: 35 to > 50 cm (14 to > 20 in) optimum, above 45 cm (18 in).

Tolerances: Weakly moderate drought, poor to fair salt, very poor to high water table, moderate shade, moderate to grazing.

*Uses:* Ground cover, erosion control. Temporary grazing. Value as forage questionable. Reports vary for palatability. Use adapted varieties. Requires adequate moisture.

## GOOSEBERRY GLOBEMALLOW
(*Sphaeralcea grossulariaefola* (H.& A.) Rydb.)

*Propagation/Reproduction:*

Natural: Season of growth begins in early spring. Flowers in May or July. Seed matures in June to August. Greens-up again in fall.

Artificial Establishment: Fair ease of establishment. Seeds germinate moderately rapid. Scarification of seed improves germination. Protect from grazing until established.

Colonizing Ability: Good seedling vigor. Spreads by seed, especially in disturbed areas. Weakly moderate in competitiveness.

Habit: Cool season, erect. 30 to 75 cm (1 to 2 ½ ft) tall. Grows in loose tufts. Leaves egg shaped in outline, palmately three-lobed. Flowers on short branches. Red petals, central staminal tube. Branched taproot with several surface roots.

*Habitat:*

Soil: Sandy to clay loam textures. Shallow and gravelly conditions.

Distribution: Great Basin. New Mexico, Arizona north to Washington.

Precipitation Range: Prefers 20 cm to 30 cm (8 to 12 in).

Tolerances: Good drought, moderately saline, poor sodic. Good shade. Winter-hardy but may not survive dry, snow-free winters of Great Plains. Moderately tolerant of grazing.

*Uses:* Erosion control, grazing, range and mine revegetation.

**ILLINOIS BUNDLEFLOWER** (pickle weed)
(*Desmanthus illinoensis* (Michx.) MacM.)

*Propagation/Reproduction:*
Natural: Season of growth is late spring to fall. Flowers from late June through September. Seed matures about 1 month later.
Artificial Establishment: Easily established from seed. Transplants well. Scarification improves germination. Inoculate with specific Rhizobia.
Colonizing Ability: Spreads from seed. Seems to be competitive. Seedling vigor is very good. May produce seed in first season.
Habit: Warm season, leguminous. 60 cm to 120 cm (2 to 4 ft) tall. Alternate leaves 10 cm (4 in) long. 6 to 15 pairs of pinnal, each with 20 to 30 pairs of small leaflets. White flowers. Deep, woody roots. Flat scythe shaped seed pods 2.5 to 4 cm (1 to 1.5 in) long.

*Habitat:*
Soil: Sandy loam to light clay textures. Moderately acid to slightly alkaline.
Distribution: Northern and Central Great Plains
Precipitation Range: 38 to > 50 cm (15 to > 20 in).
Tolerances: Good drought, salt tolerance may be fair, good for high water table or flooding. Not tolerant of close grazing. Winter-hardy.

*Uses:* Grazing and wildlife. Erosion control. Decreases under heavy use. Use adapted species. Usually found in moist depressions but fairly common in open communities without full competition.

**LEWIS FLAX** (Blue flax)
(*Linum lewisii* Pursh)

*Propagation/Reproduction:*
Natural: Growth begins in spring. Flowers between May and September. Matures 4 to 6 weeks after flowering.
Artificial Establishment: Easily established from seed. Easily transplanted. Fair growth rate. Good seedling vigor for forb.
Colonizing Ability: Excellent natural spread by seed. Good persistence.
Habit: Cool season, herbaceous, forb. Stems slender, erect or drooping. Up to 1 m (3 ft) tall. Several showy flowers with five blue petals up to 2.5 cm (1 in) long. Deep, woody taproot.

*Habitat:*
Soil: Coarse textures. Well drained.
Elevation: Prairie to alpine.
Distribution: All Western States.
Precipitation Range: 25 to > 50 cm (10 to > 20 in).
Tolerances: Good drought, fair salt, poor high water table. Moderate grazing and shade.

*Uses:* Wildlife, grazing. Good palatability for big game. Esthetics.

**MAXIMILLIAN SUNFLOWER**
(*Helianthus maximiliani* Schrad.)

*Propagation/Reproduction:*
Natural: Season of growth is April through October, depending on moisture. Flowers from July to October.
Artificial Establishment: Easy to establish from seed. Transplant in early spring. Cuttings root in greenhouse. Seeds may be dormant.
Colonizing Ability: Good seedling vigor. Bunches from short rhizomes. Aggressive spread and good persistence under light use.
Habit: Warm season, bunching. 1 to 2 m (3 to 6 ft) tall. Leaves 10 to 15 cm (4 to 6 in) long. Typical sunflower shaped heads. Bright yellow. Short rhizomes.

*Habitat:*
Soil: Fine sands to light clays. Prefers loam textures. Slightly acid to slightly alkaline.
Elevation: Up to 2,000 meters (6,000 ft).
Distribution: Great Plains.
Precipitation Range: 35 to > 50 cm (14 to > 20 in).
Tolerances: Fair drought, fair saline, moderate high water table. Fair shade.

*Uses:* Grazing, wildlife, revegetation. Species decreases under heavy grazing. Use adapted varieties. Noted varieties: prairie gold, Aztec. Numerous species in this genus. Check with local agencies for adapted species.

**NORTHERN SWEETVETCH**
(*Hedysarum boreale* Nutt.)

*Propagation/Reproduction:*
Natural: Season of growth begins in early or midspring. Flowers in May and June. Seed matures in July and August.
Artificial Establishment: Easily established from seed. Easily transplanted. Germination improved by damp prechilling or scarification.
Colonizing Ability: Propagates by seed and sometimes rhizomatous. Moderate competitiveness for a forb. Good persistence once established and under reduced competition.
Habit: Cool season, legume. Single to several stems from woody crown. 30 to 60 cm (1 to 2 ft) tall. Alternate leaves with 11 to 31 elliptic leaflets. White, pink, or purple flowers. Deep taproots and several laterals.

*Habitat:*
Soil: Sandy to clayey textures. Prefers loamy, well-drained soils. Slightly acid to neutral soils.
Elevation: 1,200 to 2,600 m (4,000 to 8,000 ft).
Distribution: Intermountain Region. Western edge of the Great Plains.
Precipitation Range: 25 to > 50 cm (10 to > 20 in). Prefers > 37 cm (15 in).
Tolerances: Good drought, poor salt, poor high water table. Fair to moderate grazing.

*Uses:* Grazing, wildlife. Improves soil fertility.

## PURPLE PRAIRIE CLOVER
(*Petalostemon purpureum* (Vent.) Rydb.)

*Propagation/Reproduction:*

Natural: Season of growth begins mid to late spring. Flowers from late May to July or later. Seeds mature July and August or later (elevation differences).

Artificial Establishment: Fair ease of establishment from seed. Poor transplanting. Dry-chill at 40°C over winter or dry store for 1 year. Scarification also improves germination. Inoculate seed.

Colonizing Ability: Medium competitiveness. Spreads by seed. Seedling vigor medium.

Habit: Warm season, herbaceous legume. Several branched, streaked stems ascending or erect. 30 cm to 1 m (1 to 3 ft) tall. Stalked leaves with 3 to 7 leaflets. Dense, oblong terminal spike, 1.2 to 5 cm (½ to 2 in) long, composed of small rose or purple flowers. Woody taproot and several surficial branches.

*Habitat:*

Soil: Loamy sand to clay loam textures. Well drained. Moderately alkaline, calcareous.

Elevation: Up to 2,100 m (7,000 ft).

Distribution: Great Plains.

Precipitation Range: 30 to > 50 cm (12 to > 20 in).

Tolerances: Moderate drought, fair salt, poor high water table. Moderate grazing.

*Uses:* Range vegetation, erosion control. Some wildlife. Fair palatability to sheep, less for cattle. Use adapted seed source. White prairie clover (*P. candidum*) is similar. Has white flowers, often more decumbent spreading form. 5 to 7 leaflets. Requires less precipitation and tolerant of coarser, drier, and disturbed soils. Distributions of these species overlap.

## ROCKY MOUNTAIN PENSTEMON
(*Penstemon strictus* Benth.)

*Propagation/Reproduction:*

Natural: Season of growth begins in early spring. Flowers from late May through June. Matures in July or later.

Artificial Establishment: Fair ease of establishment from seed. May transplant well. Seed germinates in about 14 days under favorable conditions. May require weed control until established.

Colonizing Ability: Spreads by seed. Decumbent stems grow roots when in contact with moist soil. Seedling vigor good for forb. Persistent once established. May be outcompeted by grasses.

Habit: Cool season, herbaceous. Several smooth, strictly erect stems. 30 to 75 cm (1 to 2.5 ft) tall. Basal leaves from rosette-like tufts. Numerous ascending flowers on one-sided raceme. Flowers deep blue or purple at throat, lighter blue in tube. Few large and many fine, shallow roots.

*Habitat:*

Soil: Sandy loam textures. Rocky. Slightly acidic and alkaline.

Elevation: 1,800 to 3,300 m (6,000 to 11,000 ft).

Distribution: Northeastern Arizona, New Mexico, Western Colorado, Utah, southern Wyoming.

Precipitation Range: 18 to > 50 cm (13 to > 20 in).

Tolerances: Fair drought, salt and high water table not determined.

*Uses:* Forage when mature for wildlife and livestock. Esthetics. Use adapted seed source. Many ecotypes. The Penstemon genus contains numerous species that may be useful in reclamation. Check with local agencies for suitable species and varieties.

## SAINFOIN
(*Onobrychis viciaefolia* Scop.)

*Propagation/Reproduction:*
Natural: Growth begins in spring (before alfalfa) and continues through summer with moisture.
Artificial Establishment: Easily established from seed. Good seeding vigor. Best performance under irrigation. May require fertilization.
Colonizing Ability: Moderately strong competitor. Short-lived (5 years). May be a decreaser on rangelands.
Habit: Cool season, leguminous forb. 30 to 100 cm (1 to 3 ft) tall. Semi-erect stems. Numerous pink to purple pea-like flowers. Deep main taproot with several large and many fine laterals.

*Habitat:*
Soil: Sandy to silty textures. Well drained. Calcareous.
Distribution: East of Sierra Nevada-Cascades to eastern Montana, Wyoming, Utah, Nevada, and Colorado.
Precipitation Range: > 32 cm (> 13 in).
Tolerances: Moderate drought, good salt, poor high water table. Moderate grazing, poor shade.

*Uses:* Pasture, grazing, hay, wildlife, erosion control. Varieties: Eski, Remont, Melrose.

## SCARLET GLOBEMALLOW
(*Sphaeralcea coccinea*)

*Propagation/Reproduction:*
Natural: Season of growth begins in early spring. Flowers from May to July. Seed matures in late July.
Artificial Establishment: Good ease of establishment. Germination is good. Requires little scarification.
Colonizing Ability: Spreads by rhizomes and seed. Commonly found on disturbed soils.
Habit: Cool season, forb. 8 to 25 cm (3.0 to 10 in) tall. 6 to 12 cm (2.5 to 4.8 in) spread. Bright red-orange flowers. Deep, spreading root system.

*Habitat:*
Soil: Sandy to clayey loam textures. Prefers clayey soils.
Elevation: 900 to 2,100 m (3,000 to 7,000 ft).
Distribution: Native to Great Plains
Precipitation Range: No data. Probably similar to gooseberry leaf globemallow.
Tolerances: Good drought, fair salt.

*Uses:* Reclamation, not highly sought after as forage.

## SMALL BURNET
(*Sanguisorba minor* Scop.)

*Propagation/Reproduction:*
Natural: Growth resumes in early spring. Flowers in early summer. Seed matures in late summer.
Artificial Establishment: Easily established from seed. Fairly easy to transplant. Control weeds. Stands develop slowly.
Colonizing Ability: Good propagation by seed. Fair rate of spread. Fair persistence.
Habit: Cool season, herbaceous, evergreen. 15 to 60 cm (0.5 to 2 ft) tall. Tufted with many ascending stems. Flowers unisexual or bisexual borne in dense head or terminal spike. Taproot and short root stock.

*Habitat:*
Soil: Sandy loam to clayey textures. Prefers loamy. Well drained moderately alkaline.
Distribution: Northern New Mexico and Arizona west to Sierra Nevadas. North to Idaho and Montana.
Precipitation Range: > 30 cm (> 12 in).
Tolerances: Good drought, moderate salt, poor high water table. Moderate grazing, fair shade. Winter-hardy.

*Uses:* Revegetating mined lands, rangelands, and big game range. Variety: Delar.

## WESTERN YARROW
(*Achillea millefolium lanulosa* (Nutt.) Piper)

*Propagation/Reproduction:*
Natural: Growth begins in early spring. Flowers in late spring through summer. Matures in summer and fall.
Artificial Establishment: Easily established from seed. Can transplant. Good seedling vigor.
Colonizing Ability: Persists by seed and rhizomes. Strongly competitive when established. Weedy. Invades rapidly.
Habit: Cool season, herbaceous, forb. 30 to 100 cm (1 to 3 ft) tall. May be shorter. Small composite flower heads. White. Shallow, fibrous roots and extensive slender rhizomes.

*Habitat:*
Soil: Loamy textures. Moist.
Elevation: Prairie to alpine
Distribution: Western States.
Precipitation Range: > 45 cm (18 in); also survives at lower ranges.
Tolerances: Poor to fair drought, fair salt, good flooding and high water table. Good grazing and shade.

*Uses:* Mostly wildlife, some grazing. Soil stabilization. Use adapted seed source. Similar species is common yarrow (*A. millefolium*). Introduced. Many authors consider species the same.

## WHITE CLOVER
(*Trifolium repens* L.)

*Propagation/Reproduction:*

Natural: Season of growth from early to mid spring. Flowers in May to July. Seeds mature 3 to 4 weeks later. Abundant regrowth in summer with less in fall.

Artificial Establishment: Fair ease of establishment. Inoculate before seeding. Control weeds and grasses.

Colonizing Ability: Fair in seedling vigor. Good stands need 2 to 3 years to establish. Grasses will outcompete this species. Spreads by seed and stolons.

Habit: Prostrate growing legume. Creeping stems up to 37 cm (15 in) long. Polymorphic species many intermediate types. Shallow rooted. Leaves vary widely in size and shape. Flower heads composed of 20 to 40 or more individual white to pinkish white florets on long stalks.

*Habitat:*

Soil: Clay loam to silt loam textures. Slightly acid to slightly alkaline.

Elevation: Sea level to subalpine.

Distribution: All Western States.

Precipitation Range: 35 to > 50 cm (14 to > 20 in).

Tolerances: Moderate drought, poor salinity, poor high water table.

*Uses:* Pasture, hay, grazing, erosion control, wildlife. Usually seeded in grass mixes. Turf and lawn uses. Several varieties available. Use adapted sources. Numerous species in this genus have similar traits. Check with local agencies for adapted species.

## YELLOW SWEETCLOVER
(*Melilotus officinalis* (L.) Lam.)

*Propagation/Reproduction:*

Natural: Season of growth begins in early spring. Flowers in late spring or early summer. Good regrowth before flowering. None when mature.

Artificial Establishment: Easily established from seed. Fast growth rate. Good germination. Scarify seeds to improve germination. Inoculate. May require phosphorous fertilization.

Colonizing Ability: Very good persistence. Spreads by seed. Very strong competitor as seedling and when mature.

Habit: Cool season, legume. 60 cm to 2 m (2 to 6 ft) tall by 2nd season. Leaves trifoliate, dentate-margined. Small yellow flowers. Small one-seeded pods. Large taproot.

*Habitat:*

Soil: Sandy loam to clay loam textures. Strongly alkaline to slightly acid.

Distribution: Western States.

Precipitation Range: 25 to > 50 cm (10 to > 20 in).

Tolerances: Good drought, fair to good salt, poor to fair high water table. Good grazing, moderate shade.

*Uses:* Grazing, hay, silage, temporary pasture, wildlife. Good quick cover for erosion control. Green manure crop. Noted varieties: Cumino, Goldtop, Madrid. Yukon white sweetclover (*M. alba*) has similar characteristics.

## ANTELOPE BITTERBRUSH
(*Purshia tridentata* (Pursh) DC.)

*Propagation/Reproduction:*

Natural: Flowers in April to June. Seed ripens in July to August.

Artificial Establishment: Good establishment by direct seeding with excellent germination rate and fair initial seedling growth rate. Seed production is excellent and seeds are easily handled. Rates of 0.5 to 3 lb/acre. Seed in late fall or early winter for natural stratification. Easily transplanted.

Colonizing Ability: Persistence is good but natural spread is poor. Good competitive ability. Generally compatible with grass and forbs.

Habit: Evergreen to late deciduous, small- to medium-sized shrub, 0.6 to 3.1 m (2 to 10 ft) tall. Fibrous root system with variable depth. Capable of nitrogen fixation.

*Habitat:*

Soil: Basic or acidic, well-drained, sandy to clayey soils. Does best on coarse soils.

Elevation: Sea level to 2,745 m (9,000 ft).

Distribution: New Mexico to California and north to British Columbia. Prevalent in Intermountain West.

Precipitation Range: 25 to 64 cm (10 to 25 in).

Tolerances: Good drought tolerance and fair salt tolerance. Grazing resistant. Moderately shade tolerant. Intolerant of flooding or high water table. Susceptible to fire except a sprouting ecotype.

*Uses:* Highly palatable browse for livestock and big game. Protection and food for small mammals and birds. Stoloniferous characteristic provides good soil-erosion control.

## APACHE-PLUME
(*Fallugia paradoxa* (D. Don) Endl.)

*Propagation/Reproduction:*

Natural: Flowers in the summer and seed matures in early spring.

Artificial Establishment: Seeds germinate readily without scarification, but only fair establishment. Good seedling growth rate and drought resistance. Seed in fall or spring. Also propagated vegetatively but with difficulty.

Colonizing Ability: Often a pioneer plant on disturbed sites and raw slopes; prefers full sunlight. Weak competitive ability. Compatible with associates. Good ability to spread by seed and vegetatively.

Habit: Cool season, semievergreen, spreading with a range in height from 1 to 2 m (3 to 6 ft) and spread from 1 to 3 m (3 to 10 ft); shallow, spreading, fibrous root system.

*Habitat:*

Soil: Neutral to moderately basic, well drained, medium to coarse-textured soils.

Elevation: 600 to 1,500 m (2,000 to 5,000 ft).

Distribution: West Texas through New Mexico and Arizona. On dry arroyos, alluvial plains, and gravelly or rocky slopes. Common on Juniper-pinyon sites.

Tolerances: Fair salt and drought tolerance.

*Uses:* Good winter browse for sheep and big game; good for erosion control.

## BIG SAGEBRUSH
(*Artemisia tridentata* Nutt.)

*Propagation/Reproduction:*
Natural: Flowers from July to October and seeds mature from October to December.
Artificial Establishment: Good establishment by direct seeding with excellent growth rate. Also may be propagated by stem cutting. Can be transplanted. Usually seeded in the fall but spring seeding possible.
Colonizing Ability: Good competitor with excellent persistence; long-lived. Good compatibility with associates. Good ability to spread naturally.
Habit: Ranges in height from 0.5 to 3 m (1.5 to 9 ft) with a spread ranging from 0.3 to 1.5 m (1 to 5 ft). Root system is deep and extensive. Recognized subspecies are: *A. tridentata vaseyana*, *A. tridentata wyomingensis*, and *A. tridentata tridentata*. Each have variable forms, palatabilities, and stress tolerances.

*Habitat:*
Soil: Well-drained, acidic and basic, medium to clayey soils. Prefers deep, fertile alluvial soils.
Elevation: 500 to 3,000 m (1,650 to 10,000 ft).
Distribution: New Mexico and Arizona to Nebraska and California. Most widespread shrub of Western North America.
Precipitation Range: 20 to 43 cm (7.5 to 17 in).
Tolerances: Good drought and fair salt tolerance. Intolerant of flooding.

*Uses:* Soil stabilizer on disturbed, exposed sites. Winter browse for wildlife and livestock, often of high protein content; aromatic oils may reduce its digestibility. Very important plant for reclamation work.

*Comments:* Less palatable ecotypes can be used for erosion control.

## BLACK GREASEWOOD
(*Sarcobatus vermiculatus* (Hook.) Torr.)

*Propagation/Reproduction:*
Natural: Flowers in midsummer and seeds mature by early fall.
Artificial Establishment: Fair propagation by seed with good rate of germination. Fair seed production and ease of handling. Stem cuttings have not shown good success.
Colonizing Ability: Good persistence but slow rate of natural spread. Will form pure stands on saline areas. Established naturally on disturbed sites in its range.
Habit: Warm season, deciduous, erect or spreading, spiny shrub, 1 to 3 m (3 to 10 ft) tall with an equal spread. Deep taproot and/or shallow root system, depending on soil moisture.

*Habitat:*
Soil: Saline-alkaline clayey soils with high water table or seasonal flooding.
Elevation: 900 to 2,100 m (3,000 to 7,000 ft).
Distribution: West Texas to Arizona and north to Canada.
Precipitation Range: No data.
Tolerances: Excellent salt and good drought tolerance. Tolerant of flooding. Excellent grazing tolerance. Tolerant of sodium sites.

*Uses:* Important winter browse for livestock and wildlife. May be limited due to oxalate content. Good potential on mined soils for control of mass slippage and erosion.

## BLACK SAGEBRUSH
(*Artemisia arbuscula nova* (A. Nels.) Cronq.)

*Propagation/Reproduction:*
- Natural: Flowers in September and seed matures in October.
- Artificial Establishment: Good establishment by seeding with fair seedling growth rate. Seed in late fall or winter. For average site, seed 0.5 to 1.016 lb/acre. Also can be propagated by stem cutting or by transplants.
- Colonizing Ability: Fair competitor but weak shade tolerance. Fair compatibility with most associated species. Excellent rate of natural spread.
- Habit: Semi-evergreen, low 10 to 40 cm (4 to 18 in) spreading 30 to 60 cm (1 to 2 ft) shrub; deep and extensively branched generalized root system.

*Habitat:*
- Soil: Neutral or slightly basic, well drained, shallow, medium-textured soils.
- Elevation: 1,200 to 2,400 m (4,000 to 8,000 ft).
- Distribution: Intermountain West and vicinity. Generally on foothills and rocky ridges and other exposed sites.
- Precipitation Range: 15 to 50 cm (6 to 20 in).
- Tolerances: Good drought tolerance but poor tolerance of salt or wet sites; fire intolerant; poor grazing tolerance.

*Uses:* Winter browse for sheep, deer, and antelope. Good for soil stabilization.

## CATCLAW ACACIA
(*Acacia greggii* A. Gray)

*Propagation/Reproduction:*
- Natural: Flowers in May and June and seed pods mature from July to September.
- Artificial Establishment: Poor establishment by direct seeding; requires seed inoculation on mine tailings. More easily established by transplants.
- Colonizing Ability: Good ability to spread by seed and vegetatively.
- Habit: Warm season, deciduous, much branched, thicket forming, thorny, shrub or small tree.

*Habitat:*
- Soil: Shallow calcareous sites. Dry sandy or gravelly soils.
- Elevation: 305 to 1,370 m (1,000 to 4,500 ft).
- Distribution: West Texas through southern New Mexico and Arizona. Along dry washes and ravines, arid mesas, and canyon slopes.
- Precipitation Range: 18 to 43 cm (7 to 17 in).
- Tolerances: Strongly drought and grazing tolerant.

*Uses:* Low maintenance landscaping. Habitat for wildlife. Often the only browse available. When herbaceous forage is available its palatability is poor. Firewood. Honey plant.

## CHOKECHERRY
(*Prunus virginiana* L.)

*Propagation/Reproduction:*
- Natural: Flowers during April through June and seed matures July through September. Reproduces naturally by seed.
- Artificial Establishment: Direct seeding in fall does not require stratification. Spring seeding. Surface germination. Only fair germination and seedling vigor expected on poor sites.
- Colonizing Ability: Sprouts readily from rhizomatous roots to form thickets. Prefers open sites. Competes well with grasses and forbs.
- Habit: Cool season, deciduous, large shrub or small tree. Height of 1.5 to 9 m (5 to 30 ft). Extensive, shallow, rhizomatous roots.

*Habitat:*
- Soil: Moist but well-drained sites and deep silty to sandy soils of good fertility. Moderately acid to moderately basic soils.
- Elevation: 1,370 to 2,440 m (4,500 to 8,000 ft).
- Distribution: Most of the cooler regions of Western United States. Widely distributed in Northern United States. Hillsides, canyons, and roadsides.
- Precipitation Range: 30 to 75 cm (12 to > 30 in). Mesic, mountain areas.
- Tolerances: Intolerant of dense clay sites with poor drainage. Fair drought tolerance but less vigorous. Tolerant of moderate shade but prefers open sites. Moderately tolerant of grazing.

*Uses:* Erosion control. Toxic to livestock (hydrocyanic or prussic acid), but fair browse for wildlife. Probably best for reestablishing woody draws.

## CREOSOTEBUSH
(*Larrea divaricata* Cav.)

*Propagation/Reproduction:*
- Natural: Flowers and sheds seeds throughout the year if sufficient moisture available.
- Artificial Establishment: Easily propagated by direct seeding; also by container stock.
- Colonizing Ability: Can form pure stands.
- Habit: Evergreen, strong scented, woody shrub

*Habitat:*
- Soil: Deep, well-drained sandy soil.
- Elevation: Sea level to 1,500 m (5,000 ft).
- Distribution: New Mexico, Arizona, and southern Utah Mojave Desert.
- Precipitation Range: 5 to 18 cm (2 to 7 in).
- Tolerances: Good drought tolerance. Poor shade tolerance. Not cold tolerant.

*Uses:* Unpalatable to livestock. Good potential for soil stabilization where herbivores may otherwise limit seeding establishment. Cover for wildlife.

## CUNEATE SALTBUSH
(*Atriplex cuneata* A. Nels.)

*Propagation/Reproduction:*
Natural: Flowers from April to July and seed matures mid-July to September.
Artificial Establishment: Fair ability to be established by seed with a fair initial seedling growth rate and good seedling tolerance of droughty conditions. More easily propagated by transplant.
Colonizing Ability: Good rate of natural spread but rarely forming dense stands.
Habit: Evergreen, well branched, prostrate to slightly erect. Low shrub, 15 to 30 cm (6 to 12 in) tall with spread twice its height. Root system is spreading and deep.

*Habitat:*
Soil: Highly alkaline clayey to coarse textured soils.
Elevation: 1,220 to 2,130 m (4,000 to 7,000 ft).
Distribution: Northern New Mexico, eastern Utah and southwestern Colorado.
Precipitation Range: 15 to 25 cm (6 to 10 in).
Tolerances: Excellent drought and salt tolerance.

*Uses:* Highly palatable browse to livestock and wildlife. Erosion control.

## CURLLEAF MOUNTAIN-MAHOGANY
(*Cercocarpus ledifolius* Nutt.)

*Propagation/Reproduction:*
Natural: Flowers from May to July and seeds dispersed by August and September.
Artificial Establishment: Difficult to establish by direct seeding and seedling growth rate is slow. Germination rates are reported to be good. Sow in the fall or winter, generally within mixtures of other plants to add diversity. Poor success with transplanting.
Colonizing Ability: Persistence is good once established but the rate of natural spread is only fair. May form closed stands.
Habit: Evergreen, bushy shrub or small tree, 1 to 6 m (3 to 20 ft) tall. Often multi-trunked.

*Habitat:*
Soil: Dry, clayey to coarse textured soils on exposed mountainous slopes and rocky ridges.
Elevation: 1,950 to 2,700 m (6,500 to 9,000 ft) in Colorado.
Distribution: Intermountain West, Montana to Arizona.
Precipitation Range: Semi-arid.
Tolerances: Sensitive to drought and frost. Fair tolerance of browsing.

*Uses:* Seeds are food for small mammals and browse is highly preferred by large game. Provides winter shelter for wildlife. Erosion control. Preferred firewood.

## DESERT BITTERBRUSH
(*Purshia glandulosa* Curran.)

*Propagation/Reproduction:*
Natural: Flowers in April to May and seed ripens during June and August.
Artificial Establishment: Successful propagation by direct seeding with excellent germination and fair initial growth rate. Good seedling tolerance of drought. Good seed production and handling. Seed in late fall and winter with stratification. Easily transplanted.
Colonizing Ability: Good persistence but fair rate of spread. Good competitive ability.
Habit: Deciduous, dense shrub, 1 to 2 m (3 to 7 ft) tall with an equal spread. Deep extensive root systems, capable of nitrogen fixation.

*Habitat:*
Soil: Well drained, sandy to clayey soils.
Elevation: Sea level to > 3,000 m (10,000 ft).
Distribution: Northwestern Arizona and southwestern Utah to southeastern Nevada and California.
Precipitation Range: Semi-arid.
Tolerances: Drought tolerant. Good resistance to grazing.

*Uses:* Soil stabilization. Palatable browse.

## DOUGLAS RABBITBRUSH
(*Chrysothamnus viscidiflorus* (Hook.) Nutt.)

*Propagation/Reproduction:*
Natural: Reproduces by seeds and sprouts. Blooms in late summer and fall and seed matures from late summer until winter.
Artificial Establishment: Fair establishment by direct seeding with excellent germination rates and fair growth rates. Best to seed in late fall or early spring. Also by transplanting wildlings or container stock. Poor results with cuttings.
Colonizing Ability: Persistence is good and rate of spread is excellent. May be competitive with grass and forbs due to generalized root system.
Habit: Warm season, deciduous, round-topped, small shrub, 0.3 to 1 m (1 to 3 ft) tall, with spread of equal dimension. Deep, widely spreading, generalized root system.

*Habitat:*
Soil: Basic, well-drained, clayey to coarse-textured deep soils. Broad range of adaptability. Will grow in weakly acid soils.
Elevation: 1,500 to 7,000 m (5,000 to 10,000 ft).
Distribution: New Mexico and Arizona north to Montana. Prevalent in Intermountain Region.
Precipitation Range: 15 to 50 cm (6 to 20 in).
Tolerances: Fair salt, good drought tolerance. Fair shade tolerance. Sprouting ability affords it good fire and grazing tolerance.

*Uses:* Fair to poorly utilized browse. Provides cover for birds and small mammals. Good for slippage and erosion control.

## FOUR-WING SALTBUSH
(*Atriplex canescens* (Pursh)(Nutt.)

*Propagation/Reproduction:*
Natural: Flowers from May to August, depending on zone. Seeds mature 14 to 16 weeks after blooming.
Artificial Establishment: Propagated fairly easily by direct seeding with rapid seedling growth. Rate of sowing 0.56 kg /ha (0.5 lb/ac); also by stem cuttings or by transplants. Short stratification period allows it to be seeded with grass and forbs.
Colonizing Ability: Good persistence and average rate of natural spread.
Habit: Evergreen, brittle, erect, branching from base, 0.6 to 2 m 〉 2 to 6 ft) tall. Deep and extensive root system. Capable of nitrogen fixation (endotropic mycorrhizae). Has broad genetic entities.

*Habitat:*
Soil: Alkaline, well-drained, sandy to clayey soils. Best on calcareous soils.
Elevation: Sea level to 2,440 m (8,000 ft).
Distribution: From Canada to Mexico and Great Plains to Pacific Coast. One of the most widespread and adaptable shrubs in western United States.
Precipitation Range: 〉 15 to 38 cm (〉 6 to 15 in).
Tolerances: Good drought and salt tolerance. Poor grazing tolerance.

*Uses:* Good species for surface stabilization and slippage control. Highly nutritious and palatable for livestock and wildlife.

## FRINGED SAGEBRUSH
(*Artemisia frigida* Willd.)

*Propagation/Reproduction:*
Natural: Flowers in late summer or fall and seed matures in September and October.
Artificial Establishment: Fair establishment by seed but poor seedling growth rate and good seedling drought resistance; late fall or early spring.
Colonizing Ability: Fair competitor and fair shade tolerance but prefers open areas. Good rate of natural spread.
Habit: Cool season, erect, branching from woody decumbent base; height of 10 to 35 cm (4 to 14 in) and spread of 15 to 30 cm (6 to 12 in); moderately deep, fibrous root systems.

*Habitat:*
Soil: Neutral to slightly basic, well-drained, medium-texture soils; mostly on foothills and rocky or gravely sites; prefers open, disturbed sites.
Distribution: From west Texas through most of the coal region of Western U.S.
Precipitation Range: 20 to 50 cm (8 to 20 in).
Tolerances: Good drought tolerance and fair salt tolerance; good grazing tolerance.

*Uses:* Good browse for sheep and goats and winter feed for elk and deer; surface stabilization.

## GAMBEL OAK
(*Quercus gambelii* Nutt.)

*Propagation/Reproduction:*
Natural: Fruit ripening and seed dispensal occur in fall.
Artificial Establishment: Only fair to poor establishment by direct seeding. Not transplanted easily.
Colonizing Ability: Persistence is good once established but natural spread is slow. Fair compatibility with other plants.
Habit: Cool season, deciduous, commonly thicket-forming shrub or small tree to 5 m (16 ft) tall, but can be to 16 m (50 ft).

*Habitat:*
Soil: Sandy and gravelly loams on foothills, canyons, and lower mountain slopes.
Elevation: 1,200 to 2,440 m (4,000 to 8,000 ft).
Distribution: West Texas to Arizona north through Utah and Colorado to southern Wyoming.
Precipitation Range: 40 to 50 cm (16 to 20 in).
Tolerances: Good grazing tolerance.

*Uses:* Fairly palatable browse for livestock and big game. Acorns also food for wildlife and livestock. High tannic acid in young shoots can be toxic to livestock. Good cover for wildlife. Good soil builder. Good soil stabilizer.

## GARDNER SALTBUSH
(*Atriplex gardneri*)(moq. Standl.)

*Propagation/Reproduction:*
Natural: Flowers in late spring and seed matures beginning in August.
Artificial Establishment: Poor initial establishment with fair germination and good growth rates. Seed production is fair. Transplanted easily or propagated by stem cuttings.
Colonizing Ability: Fair persistence and rate of spread. Fairly compatible with other plants and good competitive ability.
Habit: Evergreen, woody-based, well-branched, creeping small shrub, 20 to 50 cm (8 to 20 in) tall. Well-branched, deep root system.

*Habitat:*
Soil: Basic, clayey soils.
Elevation: 1,200 to 2,100 m (4,000 to 6,000 ft).
Distribution: Intermountain Region on dry slopes and ridges.
Precipitation Range: 13 to 30 cm (5 to 12 in).
Tolerances: Grazing tolerant. Good drought tolerance. Excellent salt tolerance.

*Uses:* Winter browse for sheep and cattle. Good soil stabilizer due to spreading habit.

## GOLDEN CURRANT
(*Ribes aureum* Pursh.)

*Propagation/Reproduction:*
Natural: Flowers in spring and seed matures in summer (June and July).
Artificial Establishment: Established easily by seed with good seedling growth rate. Requires cold stratification in the spring. Fall is preferred time to seed. Also propagated by stem and root cuttings, or container stock.
Colonizing Ability: Good persistence and natural spread. Tolerant of moderate shade. Good compatibility with associates and good competitive ability. Spreads by rhizomes.
Habit: Deciduous clumped shrub ranging in height from 1 to 2 m (3.3 to 6.5 ft) and in width from 1 to 1.5 m (3.3 to 5 ft). Rhizomatous spreading root system.

*Habitat:*
Soil: Slightly acidic (pH 6.0) to weakly basic, well-drained, loamy soils. Also adaptable to coarse-textured soils. Prefers fertile soil.
Elevation: 760 to 2,000 m (2,533 to 8,000 ft).
Distribution: Most of Western Coal Region of the United States, including the Texas panhandle. Generally on mesic sites.
Precipitation Range: 30 to 50 cm (12 to 20 in).
Tolerances: Good grazing tolerance. Tolerant of moist sites but only fair tolerance of drought. Fair fire tolerance. Poor salt tolerance.

*Uses:* Soil stabilization. Excellent big game browse. Avoid planting with five-needled pines because this is an alternate host of white pine blister rust.

## GRAY MOLLY SUMMER CYPRESS
(*Kochia americana* var. *Vestita* S. Watts)

*Propagation/Reproduction:*
Natural: Flowers from June to August.
Artificial Establishment: Good seed germination rates. Also by stem cuttings.
Colonizing Ability:
Habit: Warm season, suffrutescent shrub, 10 to 50 cm (4 to 20 in) tall.

*Habitat:*
Soil: Alkaline or saline clay soils.
Elevation: 1,370 to 1,830 m (4,500 to 6,000 ft).
Distribution: New Mexico and Arizona, north to Montana and Idaho.
Precipitation Range: 15 to 25 cm (6 to 10 in).
Tolerances: Excellent drought and good salt tolerance.

*Uses:* Winter browse for sheep. Surface stabilization potential on saline mine sites.

## GREEN EPHEDRA
(*Ephedra viridis* Coville.)

*Propagation/Reproduction:*
Natural: Flowers in spring and seed matures in May to July.
Artificial Establishment: Good establishment by direct seeding but needs cold stratification; plant before the growing season when soil moisture available. Stem cutting unreliable. Poor rate of natural spread.
Colonizing Ability: Spreads by roots; fair competitive ability.
Habit: Erect broom-like branches; range in height from 0.6 to 1.2 m (2 to 4 ft); spread of 0.6 to 1 m (2 to 3 ft). Deep, spreading root system.

*Habitat:*
Soil: Well-drained, alkaline, coarse textured. Adapted to dry shallow soils on slopes.
Elevation: 900 to 2,287 m (3,000 to 7,500 ft).
Distribution: Utah and northern Arizona to eastern California.
Precipitation Range: 20 to 35 cm (8 to 14 in).
Tolerances: Good salt tolerance and excellent drought resistance. Intolerant of high water table.

*Uses:* Winter browse for deer and livestock; less palatable in the summer. Good potential for erosion control. Sand dune stabilization as it withstands soil encroachment.

## LEADPLANT AMORPHA
(*Amorpha canescens* Pursh.)

*Propagation/Reproduction:*
Natural: Flowers in June and July and seed matures in August and September.
Artificial Establishment: Established easily by direct seeding with an excellent seedling growth rate and good seedling tolerance of droughty conditions. Untreated seed in late fall and scarified seed in spring. Also by cuttings of green stem in early summer and hard stem cuttings in fall. Suckers also can be used.
Colonizing Ability: Good persistence and compatibility with grasses and seeded plants.
Habit: Warm season, gray-canescens, low shrub, 30 to 100 cm (12 to 40 in). Leguminous plant capable of nitrogen fixation.

*Habitat:*
Soil: Slightly acidic to moderately basic, silty to sandy-textured soils.
Elevation: 1,050 to 1,350 m (3,500 to 4,500 ft) in Colorado.
Distribution: Great Plains from North Dakota to central Texas. Plains and hills.
Precipitation Range: 37 to 50 cm (15 to 20 in).
Tolerances: Good drought and shade tolerance. Resistant to fire. Intolerant of close grazing.

*Uses:* Palatable and nutritious browse. Watershed cover.

## LONGLEAF SNOWBERRY
(*Symphoricarpos longiflorus* Gray)

*Propagation/Reproduction:*
Natural: Flowers from early to late summer and seed matures from late summer to fall.
Artificial Establishment: Fair establishment by seeding with poor seedling growth rate and fair seedling drought tolerance. Also by stem cuttings.
Colonizing Ability: Good persistence and compatible with associates. Good natural spread.
Habit: Deciduous, low, spreading shrub 50 to 100 cm (20 to 40 in) tall. Fibrous taproot.

*Habitat:*
Soil: Basic and acid, well-drained, dry soils.
Elevation: 1,220 to 1,830 m (4,000 to 6,000 ft).
Distribution: Oregon south to Texas and California.
Precipitation Range: Mesic sites.
Tolerances: Excellent tolerance to grazing. Fair drought tolerance and poor salt tolerance.

*Uses:* Soil stabilization. Poorly palatable browse. Good for plantings of woody draws on mesic foothills.

## MAT SALTBUSH
(*Atriplex corrugata*)

*Propagation/Reproduction:*
Natural: Flowers April to June and seeds ripen in July and August.
Artificial Establishment: Difficult to germinate and establish by seed. Can be propagated by stem cuttings and is transplanted easily.
Colonizing Ability: Good competitive ability. Apparently slow rate of natural spread.
Habit: Evergreen, dense, prostrate shrub, 5 to 10 cm (2 to 4 in) high; spreads of 30 to 60 cm (1 to 2 ft). Deep, spreading root system. Branches produce adventitious roots with soil contact.

*Habitat:*
Soil: Alkaline clay (from mancus shale formation).
Elevation: 1,220 to 2,130 m (4,000 to 7,000 ft).
Distribution: Eastern Utah, western Colorado, and northwestern New Mexico. On dry ridges and slopes.
Precipitation Range: 10 to 25 mm (4 to 10 in).
Tolerances: Excellent salt and drought tolerance.

*Uses:* Browse for sheep in the summer and fall. Good potential for soil stabilization on harsh saline. Alkaline sites, but stands generally sparse.

## MARTIN CEANOTHUS
(*Ceanothus martinii* M. E. Jones)

*Propagation/Reproduction:*
Natural: Flowers in May and June and seeds mature in late summer.
Artificial Establishment: Good establishment by direct seeding with fair rate of germination and initial growth rate. Fire helps seed germination. Transplanted easily. Difficult seed production and handling.
Colonizing Ability: Excellent persistence and fair rate of spread. Compatible with associated plants.
Habit: Deciduous, small or large shrub, 30 to 120 cm (1 to 4 ft) tall. Generalized root system, capable of root sprouting and layering. A nitrogen fixer.

*Habitat:*
Soil: Slightly acid to weakly basic, well-drained, medium-textured soils. Adaptable to rocky and shallow soils.
Elevation: About 2,250 m (7,500 ft).
Distribution: Utah and vicinity. Narrow range.
Precipitation Range: 40 to 50 cm (16 to 20 in).
Tolerances: Good grazing tolerance. Poor salt tolerance. Moderate shade tolerance. Fair drought tolerance. Root sprouting provides fire resistance.

*Uses:* Highly palatable browse for sheep and cattle and wildlife; provides cover for birds and small mammals. Excellent for soil stabilization. Generally an optional species in game range seeding.

## MEXICAN CLIFFROSE
(*Cowania mexicana* Don.)

*Propagation/Reproduction:*
Natural: Flowers in early spring; seeds mature in July and August or later.
Artificial Establishment: By direct seeding with fair germination. Can be seeded with forbs and grasses because of the short stratification. Seed in late fall or early winter. Transplant of container stock also possible.
Colonizing Ability: Slow rate of stand establishment.
Habit: Evergreen shrub to small tree reaching height of 0.9 to 6 m (3 to 20 ft). Stiff and erect stems. Capable of nitrogen fixation.

*Habitat:*
Soil: Mostly on limestone areas but adaptable to most soils. Has performed well on harsh and shallow soils.
Elevation: 1,220 to 2,440 m (4,000 to 8,000 ft).
Distribution: Most of Western United States.
Precipitation Range: 30 to 50 cm (12 to 20 in).
Tolerances: Fair seedling drought and shade tolerance. Strongly drought tolerant once established. Frost sensitivity. Intolerant to fire. Grazing tolerant.

*Uses:* Browse for livestock and deer. Soil stabilization.

## NUTTALL SALTBUSH
(*Atriplex nuttallii* Wats.)

*Propagation/Reproduction:*
Natural: Flowers from May to June and seed matures from August until November.
Artificial Establishment: Excellent results with direct seeding; good seedling vigor but slow growth rate. Seed in spring or fall when moisture is sufficient. On difficult sites by transplant stock.
Colonizing Ability: Poor competitive ability due to low stature and slow growth. Best to sow separately. Other plants may outcompete Nuttall saltbush on harsh saline sites.
Habit: Warm season, suffruticose, small shrub, 15 to 90 cm (0.5 to 3 ft) tall. Well-branched, shallow to moderately deep root system.

*Habitat:*
Soil: Basic, clay soils.
Elevation: 1,220 to 2,287 m (4,000 to 7,500 ft).
Distribution: Intermountain West and vicinity.
Precipitation Range: 13 to 30 cm (5 to 12 in).
Tolerances: Salt tolerant. Cold tolerant. Resistance to fire due to root sprouting. Susceptible to grazing.

*Uses:* Palatable browse for livestock and big game, especially in winter. Soil stabilization on disturbed sites. Good potential for mined soils.

## PROSTRATE KOCHIA OR PROSTRATE SUMMER-CYPRESS
(*Kochia prostrata* L.(Schrad.))

*Propagation/Reproduction:*
Natural: Flowers from July to September.
Artificial Establishment: Excellent propagation by direct seeding with vigorous seedling growth rate and seedling tolerance of droughty conditions. Variable field germination. Very short seed viability (1 yr). Also can be transplanted.
Colonizing Ability: Good competitive ability and good rate of natural spread once established. May outcompete other desirable species. Long-lived.
Habit: Cool and warm season, perennial, half-shrub. Erect annual branching from decumbent woody base; reaches height of 30 to 90 cm (1 to 3 ft). Extensively branched root system.

*Habitat:*
Soil: Basic, coarse-textured soils; sandy to stony to sodic soils, depending on ecotype.
Distribution: Introduced from arid and semi-arid regions of Eurasia. Well adapted to Intermountain Region.
Precipitation Range: 20 to 45 cm (8 to 18 in).
Tolerances: Excellent tolerance to drought and salinity. Exceptionally well suited for mined soils of low fertility. Poor grazing resistance.

*Uses:* Good browse for livestock and big game. Palatability variable.

## RUBBER RABBITBRUSH
(*Chrysothamnus nauseosus* (Pall.)(Britt.))

*Propagation/Reproduction:*
Natural: Seeds ripen over long period from late summer to late fall.
Artificial Establishment: Established easily by direct seeding and vigorous seedling growth. Can be transplanted (in spring). Vegetative propagation is poor.
Colonizing Ability: Spreads aggressively from seed. Can compete with seeded grass. Good persistence.
Habit: Height ranges from 0.3 to 2.4 m (1 to 8 ft) with a spread ranging from 0.6 to 1 m (0.2 to 3.3 ft). Dense, multi-branched deciduous shrub with deep root system.

*Habitat:*
Soil: Basic, sandy to clayey deep soils. Generally prefers less stressful sites.
Elevation: 610 to 2,440 m (2,000 to 8,000 ft).
Distribution: Western Texas north to British Columbia. Prevalent in Great Basin.
Precipitation Range: 20 to 40 cm (8 to 16 in).
Tolerances: Tolerant of both drought and high water. Moderately salt tolerant.

*Uses:* Wildlife browse but can be toxic, especially to cattle. Soil stabilization plantings.

*Comments:* Less palatable subspecies can be used to discourage grazing for soil stabilization plantings.

## SASKATOON SERVICEBERRY
(*Amelanchier alnifolia* Nutt.)

*Propagation/Reproduction:*
Natural: Flowers from May to June and fruit matures from July to September.
Artificial Establishment: Fair establishment by direct seeding or by root cuttings. Can be transplanted from nursery stock. Fair seedling growth rate, seeding in late fall and spring. Transplanted in the spring.
Colonizing Ability: Good persistence but fair natural spread. Good compatibility.
Habit: Warm-season species. Reaches height of 0.9 to 4.5 m (3 to 15 ft).
Numerous and branching stems. Deep and superficial roots.

*Habitat:*
Soil: Medium to clayey textures. Prefers well-drained, deep, medium-textured soil. Occurs on weakly acid to weakly basic soils.
Elevation: Sea level to 2,700 m (9,000 ft).
Distribution: Western Texas and New Mexico north to Montana and extending to West Coast.
Precipitation Range: 35 to 50 cm (14 to 20 in).
Tolerances: Good grazing tolerance. Fair drought tolerance but poor tolerance to salt and flooding. Good fire tolerance.

*Uses:* Soil stabilization and erosion control. Preferred winter browse for big game; fair to good for livestock.

## SHADSCALE
(*Atriplex confertifolia* (Torr. & Frem.) S. Wats.)

*Propagation/Reproduction:*
Natural: Flowers from late March to June and utricles mature about 15 weeks after blooming.
Artificial Establishment: Poor establishment by direct seeding. Better propagation by stem cuttings from late winter. Establishes well by transplanting in early spring.
Colonizing Ability: Good natural rate of spread after well established.
Habit: Compact, spinescent, decumbent, reaching maximum heights of about 0.8 m (2.6 ft); generally 15 to 90 cm (6 to 36 in) tall; deep and spreading root system; cool season.

*Habitat:*
Soil: Alkaline, fine-textured to gravelly soils.
Elevation: 460 to 2,135 m (1,500 to 7,000 ft).
Distribution: New Mexico to Canada and west to eastern California, Oregon, and Washington. Prevalent in Great Basin and Colorado Plateau.
Precipitation Range: 10 to 20 cm (4 to 8 in).
Tolerances: Excellent salt and drought tolerance. Spines provide grazing resistance.

*Uses:* Palatable despite the spines; good winter browse for livestock; erosion and soil slippage control, especially on saline sites.

## SIBERIAN PEA SHRUB
(*Caragana arborescens* Lam.)

*Propagation/Reproduction:*
Natural: Flowers from April to June and seed matures from June to August.
Artificial Establishment: Fairly easy to establish by direct seeding with an excellent germination rate and fair seedling growth rate. Seedling is tolerant of droughty conditions. Seed in late summer or spring, generally in mixtures, using 1 lb/ac or less. Also by stem or root cuttings. Transplanting ability is excellent.
Colonizing Ability: Persistence and rate of spread once established is fair. Good competitor and only fair compatibility with forbs and grasses. A long-lived plant.
Habit: Deciduous, upright shrub or small tree, 1.5 to 4.5 m (5 to > 15 ft). Extensive and branched moderately deep root system.

*Habitat:*
Soil: Strongly basic (pH 10 to 11) and strongly acid (pH 4.0), well-drained soils of moist textural classes. Adaptable to infertile, shallow, and rocky soils.
Distribution: Northern Great Plains through central Utah and Colorado. Introduced from Siberia and Manchuria.
Precipitation Range: 30 to 50 cm (12 to 20 in).
Tolerances: Resistant to grazing. Intolerant of wet soils. Moderately salt tolerant. Excellent drought tolerance. Fair shade tolerance. Winter-hardy.

*Uses:* Mined-land soil stabilization. Windbreak planting. Fair browse in spring and summer, but generally poorly palatable to livestock. Nesting site and food for birds.

## SILVER BUFFALOBERRY
(Shepherdia Argentea (Pursh) Greene.)

*Propagation/Reproduction:*

Natural: Flowers in spring and early summer and seed matures in late summer through fall.

Artificial Establishment: Difficult to establish by direct seeding with fair germination rate and seedling growth rate. In the fall or spring if stratified. Also propagated by root sprouts or wildlings or container stock.

Colonizing Ability: Good persistence once established with fair natural rate of spread. Strong competitive ability so often incompatible with other less competitive plants. Spreads by root sprouting.

Habit: Deciduous, thorny, thicket-forming large shrub. May reach height of 7 m (23 ft). Extensive and well-branched, shallow root system, capable of nitrogen fixation. Rhizomatous.

*Habitat:*

Soil: Basic, well-drained, medium coarse soils. Common on seasonally wet sites.

Elevation: 1,350 to 2,250 m (4,500 to 7,500 ft) in Colorado.

Distribution: From eastern California to central New Mexico and Kansas, north to Montana. Generally in valleys along streams or in low meadows and other wet sites.

Precipitation Range: 30 to 50 cm (12 to 20 in).

Tolerances: Good tolerance of grazing. Salt tolerant. Poorly tolerant of shade. Good drought tolerance. Fair fire tolerance. Shade intolerant.

*Uses:* Soil stabilization. Excellent browse for wildlife, but poorly palatable to cattle. Windbreak plantings. Live fencing.

## SILVER SAGEBRUSH
(*Artemisia cana* Pursh.)

*Propagation/Reproduction:*

Natural: Flowers in late summer and fruit matures in fall.

Artificial Establishment: Fair establishment by seeding at any time of year when moisture is available; seed about 0.4 to 0.8 kg/ha (0.5 to 1.0 lb/ac).

Colonizing Ability: Compatible with herbaceous associates but poor shade tolerance. Forms extensive colonies by rhizomes. Good rate of natural spread both by seed and vegetatively.

Habit: Warm season, evergreen, woody-based small shrub 1 to 1.5 m (3 to 5 ft) tall. Generally well-branched rhizomatous root system. Aromatic.

*Habitat:*

Soil: Weakly acidic to moderately basic, well-drained, medium-textured soils; generally on valley terraces and uplands.

Elevation: 1,500 to 3,000 m (5,000 to 10,000 ft) in Canada.

Distribution: Northern New Mexico to Montana and west to central California, Oregon and Washington; prevalent in the Intermountain West.

Precipitation Range: 25 to 36 cm (10 to 14 in).

Tolerances: Intolerant of wet sites; good drought tolerance; poor shade tolerance; good tolerance to grazing.

*Uses:* Browse for sheep and big game in winter; soil stabilization.

## SKUNKBUSH SUMAC
(*Rhus trilobata* Nutt.)

*Propagation/Reproduction:*

Natural: Flowers when leafless in early spring and seed matures in late summer to fall. Also spreads by root sprouting.

Artificial Establishment: Established fairly easily by direct seeding, with good seedling competitive ability and drought tolerance. Poor seed germination. Hard seed coat; requires scarification. Propagated readily by stem or root cuttings.

Colonizing Ability: Rhizomatous roots; forms thickets. Excellent persistence once established but slow to spread. Only fairly compatible with grass and forbs.

Habit: Cool season, deciduous, multi-branched and dense shrub. Reaches height of 0.6 to 3 m (2 to 10 ft) and equal to greater spreads. Rhizomatous spreading roots and extremely branched deeper roots.

*Habitat:*

Soil: Slightly basic, well-drained soils of most textural classes.

Elevation: 1,260 to 3,300 m (4,200 to 11,000 ft).

Distribution: Most of the Western Coal Region of United States. Generally found on shallow and dry rocky foothills.

Precipitation Range: 25 to 50 cm (10 to 20 in).

Tolerances: Excellent tolerance of grazing. Fair drought tolerance and poor salt tolerance. Intolerant of flooding. Poor tolerance of shade. Fire tolerant.

*Uses:* Good browse for big game but poorly palatable to livestock. Soil stabilization and windbreaks.

## SPINELESS HOPSAGE
(*Grayia brandegei*)

*Propagation/Reproduction:*

Natural: Flowers from June to August and the seed matures from September to October.

Artificial Establishment: Fair propagation by seed with excellent germination rate and good initial seedling growth rate. Needs cold stratification and protection from rodents and rabbits.

Colonizing Ability: Good persistence and fair rate of natural spread once established. Fair compatibility with other plants.

Habit: Deciduous small shrub, 0.5 to 1 m (1.7 to 3.3 ft) tall with a spread of 0.3 to 1.2 m (1 to 4 ft). Spreading root system. Drops leaves early in summer with stress.

*Habitat:*

Soil: Basic, silty clay loam soil derived from shale formations.

Elevation: 900 to 2,100 m (3,000 to 7,000 ft).

Distribution: Upper Colorado River drainage.

Precipitation Range: 25 to 40 cm (10 to 16 in).

Tolerances: Excellent tolerance to grazing and good drought tolerance. Fair salt tolerance.

*Uses:* Good potential for soil stabilization. Good spring, summer, and winter browse for livestock and wildlife. May contain toxic levels of selenium on soils containing selenium.

## SPINY HOPSAGE
(*Grayia spinosa* (Hook.) Moq.)

*Propagation/Reproduction:*
Natural: Flowers from April to June and seed matures from June to August.
Artificial Establishment: Fair establishment by direct seeding with only a poor seedling growth rate. Generally seeded in mixtures as an option species. Seed in early fall or spring. Also by root or stem cuttings.
Colonizing Ability: Good competitor when established but seedlings have poor competitive ability and drought resistance. Performs best in full sunlight but also grows in open woodlands. Fair to poor ability to spread.
Habit: Warm season, deciduous, spinescent, much branched and spreading shrub that reaches height of 0.3 to 1.2 m (1 to 4 ft) and about equal width. Shallow to moderately deep spreading root system. Begin growth in late winter and early spring. Often evergreen in southern habitat. Generally dormant in summer. Loses leaves in summer.

*Habitat:*
Soil: Alkaline to near neutral, shallow sandy to clayey soils. Calcareous sites.
Elevation: 900 to 2,100 m (3,000 to 7,000 ft).
Distribution: Intermountain West and vicinity on plains and foothills.
Precipitation Range: 25 to 40 cm (10 to 16 in).
Tolerances: Excellent drought tolerance. Fair salt tolerance. Fair grazing tolerance.

*Uses:* Fall winter and spring browse for deer, goats, and sheep. Good for surface stabilization.

## SPINY SAGEBRUSH OR BUD SAGE
(*Artemisia spinescens* (DC.) Eat.)

*Propagation/Reproduction:*
Natural: Flowers from March to June and sheds seeds in June and July.
Artificial Establishment: Can be established by seed, though germination rate is slow and production and handling of seed is difficult. Also by stem cuttings. Fair establishment by transplant.
Colonizing Ability: Good persistence and rate of spread once established. Generally compatible with associates.
Habit: Cool season, well-branched, rigid, spinescent, evergreen, small shrub, 20 to 25 cm (4 to 10 in) tall with about an equal spread. Shallow and fibrous root system.

*Habitat:*
Soil: Basic, well-drained, shallow loamy soils.
Elevation: 1,200 to 1,620 m (4,000 to 5,400 ft).
Distribution: Central New Mexico to California and north to central Washington and Montana. Prevalent in Great Basin.
Precipitation Range: 20 to 35 cm (8 to 14 in).
Tolerances: Resistant to browsing; however, can be eliminated by heavy spring grazing. Excellent drought tolerance and fair salt tolerance.

*Uses:* Good browse for sheep and wildlife in winter and early spring. Surface stabilization.

## TRUE MOUNTAIN MAHOGANY
(*Cercocarpus montanus* Raf.)

*Propagation/Reproduction:*
Natural: Flowers from May to June and seed matures by August.
Artificial Establishment: Poor propagation by direct seeding; seedlings susceptible to drought and frost action. Plant unstratified seed in the fall. Also by stem cutting or by transplanting.
Colonizing Ability: Good persistence and fair rate of natural spread. Can form pure stands.
Habit: Cool season, one-half evergreen, shrub or small tree, 1 to 6 m (3.3 to 20 ft) tall. Deep and wide spreading root system, capable of nitrogen fixation.

*Habitat:*
Soil: Well drained, slightly acid to basic, medium to clay textures on south- or west-facing slopes.
Elevation: 1,220 to 2,440 m (4,066 to 8,133 ft).
Distribution: South Dakota to Texas and west to Oregon and California
Precipitation Range: 14 to 50 cm (5 to 20 in).
Tolerances: Good to fair drought tolerance but poor salt tolerance. Good tolerance of lime. Intolerant of flooding and high water table. Tolerant of grazing.

*Uses:* Excellent browse for livestock and wildlife.

## UTAH SERVICEBERRY
(*Amelanchier utahensis* Koehne)

*Propagation/Reproduction:*
Natural: Flowers in late spring and early summer and seed matures in late summer.
Artificial Establishment: Fair establishment by seed with good seed germination but relatively poor early seedling growth rate and fair seedling tolerance of drought. Good final establishment. Seed requires cold stratification. Also can be propagated by root cuttings.
Colonizing Ability: Good persistence once established and fair rate of spread. Generally compatible with other plants.
Habit: Cool season, deciduous, extensively branched erect shrub, 1 to 4 m tall (3 to 12 ft). Spread of 0.6 to 4.5 m (2 to 15 ft). Deep and spreading root system that is capable of suckering.

*Habitat:*
Soil: Slightly basic, well-drained, medium- to coarse-textured soils.
Elevation: 1,200 to 2,500 m (4,000 to 8,000 ft).
Distribution: Great Basin and vicinity. Generally on dry ridges and slopes.
Precipitation Range: 35 to 50 cm (14 to 20 in).
Tolerances: Good grazing resistance. Fair drought tolerance but poor tolerance of saline soils.

*Uses:* Soil erosion and slippage control. Good browse for livestock and used by deer during winter months.

## WAR CURRANT OR SQUAW CURRANT
(*Ribes cereum* Dougl.)

*Propagation/Reproduction:*
Natural: Flowers from April to June and seed matures by August.
Artificial Establishment: Poor establishment by direct seeding. Somewhat better by transplant.
Colonizing Ability: Poor rate or natural spread but good persistence.
Habit: Cool season, much-branched, thornless shrub, 0.6 to 1.2 m (2 to 4 ft) tall.

*Habitat:*
Soil: Acid to basic soils; dry rocky open slopes and ridges.
Elevation: 1,200 to 3,300 m (4,000 to 11,000 ft) in Colorado.
Distribution: Montana to New Mexico.
Tolerances: Good grazing tolerance.

*Uses:* Poorly palatable to livestock and poor browse for wildlife. Soil stability.

## WESTERN SNOWBERRY
(*Symphoricarpos occidentalis* Hook.)

*Propagation/Reproduction:*
Natural: Flowers in late spring and early summer and seed matures from summer to fall.
Artificial Establishment: Fair establishment by direct seeding in fall (warm-stratified) or in spring (moist-prechilled). Also by cuttings or transplanting wildlings.
Colonizing Ability: Strongly competitive and forms dense colonies. Generally excludes grass and forbs. Spreads by rhizomes. Prefers disturbed, open sites. Good to excellent ability to spread naturally.
Habit: Deciduous, dense colony forming short shrub, generally 0.5 to 1.5 m (20 to 60 in) tall. Superficial, well-branched road system with intermittent rhizomes.

*Habitat:*
Soil: Weakly basic and slightly acidic soils of most textural classes.
Elevation: 1,050 to 2,550 m (3,500 to 8,500 ft) in Colorado.
Distribution: Great Plains and Rocky Mountains. Hillsides, valleys, along streams, draws, and similar wet areas.
Precipitation Range: 30 to 50 cm (12 to > 20 in). Mesic areas.
Tolerances: Tolerant of flooding but not of permanently high water table. Excellent drought tolerance. Tolerant of grazing and fire. Tolerant of partial shade.

*Uses:* Good browse for deer, but poorly palatable for livestock. Soil stabilization. Good for plantings of woody draws on mesic sites.

## WESTERN VIRGINSBOWER
(*Clematis Ligusticifolia* Nutt.)

*Propagation/Reproduction:*
Natural: Flowers from June to August and seed matures in fall and winter.
Artificial Establishment: Fair establishment by direct seeding with slow rates of germination and initial growth. Collection and handling difficulties. Limits propagation by seeds. Established more easily by transplant.
Colonizing Ability: Tends to invade disturbed sites and has fair to good rate of natural spread.
Habit: Woody-based climbing vine, 3 to > 6 m long. Fibrous, shallow root system.

*Habitat:*
Soil: Weakly acid to moderate alkaline, well-drained, coarse textured soils.
Elevation: 1,500 to 2,550 (5,000 to 8,500 ft) in Colorado.
Distribution: Most of the Western Coal Region of United States. Often on disturbed sites, with some form of support (e.g. trees, slopes, banks).
Precipitation Range: 30 to 50 cm (12 to 20 in).
Tolerances: Fair drought resistance; moderate shade tolerance. Not frost sensitive.

*Uses:* Soil stabilization on mined soils. Browse for deer. Poorly palatable for livestock.

## WINTERFAT
(*Ceratoides lanata* (L.) C.A. Mey.)

*Propagation/Reproduction:*
Natural: Flowers in March to July and seeds mature from September to November.
Artificial Establishment: Direct seeding with rapid germination and fair establishment rates. Short stratification allows mixed seeding. Frost sensitive in early seedling stage. Transplanted easily.
Colonizing Ability: Good persistence but poor shade tolerance; fair competition with grass; long-lived and adaptable to most sites. Good rate of natural spread.
Habit: Cool season, erect or spreading, reaching heights of 30 to 60 cm (12 to 24 in) and spread of 15 to 45 cm (6 to 18 in); deep and fibrous root system.

*Habitat:*
Soil: Basic, rocky to clayey soils.
Elevation: Sea level to more than 3,048 m (10,000 ft).
Distribution: Most of Western United States and very prevalent in the Intermountain Salt Desert Range. Mostly on valley floors.
Precipitation Range: 12.5 to 50 cm (5 to 20 in).
Tolerances: Excellent drought tolerance and good salt resistance. Intolerant to high water table and acid soils. Poor grazing resistance.

*Uses:* Soil stabilization. Highly palatable and nutritious browse to wildlife and livestock.

## WOODS ROSE
(*Rosa woodsii* Lindl.)

*Propagation/Reproduction:*
Natural: Flowers in summer and seed matures from midsummer until fall. Reproduces by seed.
Artificial Establishment: Established fairly easily by seed with good seedling growth rate. Only poor germination. Seed in spring and fall. Propagated readily by root cuttings or by transplanted seedlings.
Colonizing Ability: Excellent persistence once established with fair ability to spread. Aggressive pioneer on open, disturbed site. Fairly compatible with grass and forbs and only moderately competitive.
Habit: Cool season, deciduous, spiny, thicket-forming shrub, reaching height of 0.6 to 3.6 m (2 to 6 ft). Extensively branched, shallow root system. Often rhizomatous. Renew growth in spring.

*Habitat:*
Soil: Moderately acid to slightly basic, well-drained, loamy to sandy soils. Prefers nonsaline sites.
Elevation: 1,300 to 2,250 m (4,500 to 7,500 ft) in Colorado.
Distribution: Intermountain West and Great Plains to western Texas and eastern Arizona. Most common on dry slopes, plateaus, and plains.
Precipitation Range: 30 to 50 cm (12 to 20 in).
Tolerances: Good grazing tolerance. Intolerant of flooding. Moderate drought tolerance. Moderately shade tolerance. Good tolerance of fire.

*Uses:* Good browse for big game but only fair for livestock. Excellent for erosion control. Because of thorns this species is better suited for mixed planting.

## ARIZONA CYPRESS
(*Cupressus Arizonica* Greene)

*Propagation/Reproduction:*
Natural: Pollination occurs in late fall through spring and seeds mature 15 to 18 months later.
Artificial Establishment: Good establishment by direct seeding. Seed production, handling, and germination is fair. Seeds need to be stratified and protected from damping-off fungi. Can be transplanted as 1- or 2-year-old seedlings.
Colonizing Ability: Persistence is good once established but only fair rate of natural spread. Seedling is poorly competitive with other plants.
Habit: Evergreen tree, 9.2 to 27 m (30 to 90 ft) tall. Seedling has taproot and lateral roots.

*Habitat:*
Soil: Gravelly northern slopes or cuts.
Elevation: 915 to 2,440 m (3,000 to 8,000 ft).
Distribution: Arizona, New Mexico, and southern Texas.
Precipitation Range: 40 to 50 cm (16 to 20 in).
Tolerances: Grazing tolerant. Seedling poorly tolerant of droughty conditions. Tolerant of high temperatures.

*Uses:* Watershed, erosion control and windbreak plantings. Habitat for wildlife. Timber products.

## BIGTOOTH MAPLE
(*Acer grandidentatum* Nutt.)

*Propagation/Reproduction:*
Natural: Flowers from April to May and fruit ripens from August to September.
Artificial Establishment: Good establishment by direct seeding, but slow rate of seedling growth. Transplanted easily.
Colonizing Ability: Moderate rate of natural spread.
Habit: Deciduous shrub to tree, to 12 m (40 ft) tall.

*Habitat:*
Soil: Similar to Rocky Mountain Maple (*A. glabrum*). Moderately acid to slightly basic, well-drained, porous sandy or gravelly loams. Also on cliffs and rocky canyon sides.
Distribution: Utah and western Wyoming, south to southeastern Arizona and New Mexico.

*Uses:* Watershed and habitat plantings. Beautiful fall colors.

## BUR OAK
(*Quercus macrocarpa* Michx.)

*Propagation/Reproduction:*
Natural: Flowers from April to June and acorns ripen from August to November.
Artificial Establishment: By direct seeding or by planting container stock. Plant acorns in the fall at rate of about 1,000 per acre. Container stock planted on the more difficult sites; in late winter or early spring.
Colonizing Ability: Establishment required reducing competition from other plants and controlling livestock and small mammal activity.
Habit: Deciduous, spreading, medium-size tree; to 30 m (100 ft) tall.

*Habitat:*
Soil: Wide range of soils. Acid (pH 4.0) to moderately basic, medium- to coarse-textured soils.
Distribution: The Dakotas and northeast Wyoming and the Midwest south to Texas.
Precipitation Range: 38 to 100 cm (15 to 40 in).
Tolerances: Drought resistant. Intolerant of flooding. Winter-hardy.

*Uses:* Habitat for wildlife, environmental forestry, watershed protection, and timber products.

## DESERT WILLOW
(*Chilopsis linearis* (Cav.) Sweet)

*Propagation/Reproduction:*
Natural: Flowers from April to August and seed matures from late summer to fall.
Artificial Establishment: By seeding in the spring immediately after the soil warms. Also by cuttings.
Colonizing Ability: Requires protection from other plant competition and grazing to become established. Naturally invades eroded drainages.
Habit: Deciduous, short-lived tree, 3 to 7.5 m (10 to 25 ft) tall. No information on rooting characteristics. Leaf out in spring.

*Habitat:*
Soil: Neutral to basic, well-drained, sandy to gravelly alluvium.
Elevation: 450 to 1,500 m (1,500 to 5,000 ft).
Distribution: Southern Arizona to southwestern Texas. Generally along streams and dry washes in the desert.
Precipitation Range: Arid zones of Southwest.

*Uses:* Wildlife cover and soil stabilization. Poorly palatable to livestock.

## DOUGLAS-FIR
(*Pseudotsuga menziesii* Franco.)

*Propagation/Reproduction:*
Natural: Flowers from April to June and seeds mature from July to September.
Artificial Establishment: By direct seeding only under ideal conditions. Generally by container stock in winter and early spring. Also by stem cuttings.
Colonizing Ability: Competitive only after seedling stage. Establishment requires a reduction in competition from other plants and grazing animals.
Habit: Evergreen, medium-size tree, to 39 m (130 ft) tall.

*Habitat:*
Soil: Moderately acid to neutral, well-drained but moist, medium- to coarse-textured soils.
Elevation: 570 to 3,300 m (1,900 to 11,000 ft). Generally on the north-facing slope at lower elevations.
Distribution: Western Texas to Arizona and north to Montana and Washington.
Precipitation Range: 40 to 127 cm (16 to 50 in).
Tolerances: Fair drought tolerance and shade tolerance. Poor fire tolerance. Poor tolerance of heavy, repeated grazing.

*Uses:* Watershed and environmental planting. Habitat for wildlife. Timber. Windbreaks.

## GREEN ASH
(*Fraxinus pennsylvanica* Marsh.)

*Propagation/Reproduction:*
Natural: Flowers from March to May and seed matures by September to October.
Artificial Establishment: By unstratified seed in the fall and stratified seed in the spring. Generally established by transplanting seedlings.
Colonizing Ability: Slow and often poor growth on mined lands. Requires protection from competition from other plants for establishment.
Habit: Deciduous, small to medium-size tree, 18 m (60 ft) tall. Shallow and extensive root system. Coppice often being cut.

*Habitat:*
Soil: Medium- to coarse-textured soils. Generally found on alluvial soils. Moderately basic to strongly acid (pH of 4.0).
Distribution: Central Montana and Wyoming through the Dakotas and most of Eastern United States.
Precipitation Range: 37 to 114 cm (15 to 45 in).
Tolerances: Tolerant of periodic flooding and acid conditions. Good drought tolerance.

*Uses:* Environmental forestry, shelterbelts, timber production, and shelter and food for wildlife. Poorly palatable to livestock. Good shade tree.

## NEW MEXICO LOCUST
(*Robinia neomexicana* A. Gray)

*Propagation/Reproduction:*
Natural: Flowers from May to June and fruit ripens by September. Also reproduces by suckers.
Artificial Establishment: Fair rate of establishment by direct seeding with fair seedling growth rate. Seedling moderately drought resistant. Also by nursery-stock transplants.
Colonizing Ability: Competitive ability is fair. Established readily on harsh sites. Good rates of natural spread by seed and vegetatively.
Habit: Thicket-forming, spiny shrub or small tree; 1.8 to 7.6 m (6 to 25 ft) tall. Root sprouter.

*Habitat:*
Soil: Moist soils. On canyon bottoms and north slopes at lower elevations and on rocky slopes and dry ridge tops at higher elevations.
Elevation: 1,220 to 2,590 m (4,000 to 8,500 ft).
Distribution: West Texas to Arizona north through Utah and Colorado.
Tolerances: Resistant to grazing.

*Uses:* Browse for goats and mule deer. Habitat for wildlife. Shelterbelt and watershed plantings. Shade. Erosion control.

## PINYON
(*Pinus edulis* Engelm.)

*Propagation/Reproduction:*
Natural: Flowers in June (Arizona) and seed ripens in September.
Artificial Establishment: Fair establishment with direct seeding but seedling growth is slow (5 cm in 2 years). Can be transplanted; best results with 2-year-old nursery stock.
Colonizing Ability: Can become a pest. Very long-lived. Root competition for soil moisture maintains widely spaced stands. Highly competitive with herbaceous vegetation. Good rates of natural spread.
Habit: Evergreen, much branched, 4.6 to 14 m (15 to 47 ft) tall. Extensive shallow lateral roots and deep taproots.

*Habitat:*
Soil: Alkaline, sandy to silty shallow soils. Adapted to calcareous caliche soils.
Elevation: 1,525 to 2,287 m (5,000 to 7,500 ft). May reach altitude of 2,700 m (9,000 ft).
Distribution: Semiarid areas of New Mexico, Arizona, Utah, and Colorado. On very harsh eroded sites.
Precipitation Range: 30 to 46 cm (12 to 18 in).
Tolerances: Drought tolerant. Heat tolerant. May be frost sensitive. Intolerant of shade.

*Uses:* Habitat for wildlife. Seeds important wildlife food. Landscaping. Timber products.

## PONDEROSA PINE
(*Pinus ponderosa* Laws.)

*Propagation/Reproduction:*

Natural: Flowers from April to June and seed is dispersed from August to September.

Artificial Establishment: By untreated seed in the fall and stratified seed in the spring. But establishment by direct seeding is not reliable. Better success with container stock. Older stock best for mined soils. Competitive vegetation must be removed.

Colonizing Ability: Poor when competing with grass, but generally good rate of natural spread.

Habit: Evergreen, straight trunk, tall, 30 to 60 m (100 to 200 ft). Deep root system.

*Habitat:*

Soil: Acid to basic (4.5 to 9 pH), well-drained, clay loams to loamy sands. Prefers deep soils but also found on shallow soils.

Elevation: 1,220 to 2,440 m (4,000 to 8,000 ft).

Distribution: Widely distributed through Western Coal Region, from western Dakotas to Montana and south to Arizona and western Texas.

Precipitation Range: 38 to 63 cm (15 to 25 in). Can survive on 18 cm (7 in) of rainfall.

Tolerances: Good drought tolerance. Poor tolerance of saline and sodic soils. Not tolerant of shade. Good fire tolerance.

*Uses:* Environmental forestry, timber, shelterbelt. Browsed by mule deer, mountain sheep, and white-tailed deer. Some birds and small mammals eat the seeds.

## QUAKING ASPEN
(*Populus tremuloides* Michx.)

*Propagation/Reproduction:*

Natural: Flowers from March to May and seeds mature from May to June.

Artificial Establishment: By container stock or root cuttings. Not propagated by seed.

Colonizing Ability: Spreads by underground runners to form dense colonies.

Habit: Deciduous, short-lived, 6 to 12 m (20 to 40 ft) tall. Extensive and shallow root system. Sprouts from roots.

*Habitat:*

Soil: Moderately basic to slightly acid, well-drained soils of moist textural classes. Performs best on deep sandy to silty loams.

Elevation: Sea level to upper timberline. At higher elevations on south-facing slopes and lower elevations on north-facing slopes.

Distribution: Most of Western Coal Region.

Precipitation Range: 37 to 75 cm (15 to 30 in) in Rocky Mountains.

Tolerances: Winter-hardy. Shade intolerant. Fire tolerant. Fair browsing tolerance.

*Uses:* Palatable browse to livestock and wildlife. Seeds eaten by various birds. Provides good cover for watershed protection and soil stabilization at high altitudes. Wood products also are used.

## ROCKY MOUNTAIN JUNIPER
(*Juniperus scopulorum* Sarg.)

*Propagation/Reproduction:*

Natural: Flowers from mid-April to mid-June and fruit mature from mid-September to mid-December.

Artificial Establishment: Direct seeding is difficult and slow. Transplant of bare root stock also difficult.

Colonizing Ability: Long-lived and persistent; natural spread is good. Very slow growing.

Habit: Bushy shrub to a tree with irregular crown and average mature height of about 4.2 m (14 ft).

*Habitat:*

Soil: Alkaline (pH to 8.0), calcareous eroded soils. Found on shallow limestone, sandstone, lava, adobe, and other soils. On southern exposed rugged sites.

Elevation: 1,525 to 2,745 m (5,000 to 9,000 ft).

Distribution: Scattered throughout Western Coal Region, including west Texas and the Dakotas.

Precipitation Range: 30 to 65 cm (12 to 26 in).

Tolerances: Drought tolerant. Tolerant of very harsh sites where other vegetation does not survive. Grazing tolerant. Resistant to damping-off. Poor tolerance of shade.

*Uses:* Windbreaks. Wildlife habitat. Timber products.

## ROCKY MOUNTAIN MAPLE
(*Acer glabrum* Torr.)

*Propagation/Reproduction:*
Natural: Flowers from April to June and seeds mature from August to October.
Artificial Establishment: Good rates of establishment by direct seeding. Stratification required for spring sowing but not for fall seeding. Transplanting success is fair. Recommend using older nursery stock.
Colonizing Ability: Persistence generally poor and rate of neutral spread only fair. Poorly competitive with grass and forbs; establishment requires a reduction in competition.
Habit: Deciduous, dense, low bushy shrub or tree, 1.5 to 9 m (5 to 30 ft) tall, with short trunk. Extensive root system of variable depth.

*Habitat:*
Soil: Moderately acid to slightly basic, well drained, porous sandy or gravelly loams. Also on cliffs and rocky canyon sides.
Elevation: Foothills to 3,000 m (10,000 ft).
Distribution: New Mexico and Arizona, north to Montana and Washington.
Precipitation Range: 30 to > 63 cm (12 to > 25 in).
Tolerances: Tolerant of seasonally flooding. Winter-hardy. Fair to poor drought tolerance and fair shade tolerance. Fire resistant.

*Uses:* Watershed plantings and wildlife habitat. Fair browse for goats and sheep and good for big game.

## RUSSIAN OLIVE
(*Elaeagnus angustifolia* L.)

*Propagation/Reproduction*
Natural:
Artificial Establishment: Fair results with direct seeding. Propagated more easily by transplanting. Nursery stock or wildlings. Good growth rate.
Colonizing Ability: Long-lived and persistent. Reproduces rapidly on wet sites. Good compatibility with other plants. Good rate of natural spread. Can spread into meadows and become a pest.
Habit: Late deciduous, shrub to tree, 1 to 12 m (3 to 40 ft).

*Habitat:*
Soil: Alkaline harsh sites of wide range of soil textures.
Elevation: Montane foothills to about 2,440 m (8,000 ft).
Distribution: Introduced from southern Europe, western Asia, and western Himalayas and well adapted to Intermountain West and Northern and Central Great Plains.
Precipitation Range: 25 to 50 cm (10 to 20 in).
Tolerances: High tolerance of alkalinity and salt. Good drought tolerance. Good tolerance to grazing. Winter-hardy. Intolerant of shade. Salt tolerant.

*Uses:* Shade, live fencing, and windbreaks. Browse for livestock and big game in late fall. Berries are food for birds.

## UTAH JUNIPER
(*Juniperus osteosperma* (Torr.) Little)

*Propagation/Reproduction:*
Natural: Flowers from March to April and seed ripens by September the 2nd year.
Artificial Establishment: Poor establishment by direct seeding. Propagated by transplanting bare root stock possible but not with high rate of success.
Colonizing Ability: Excellent persistence and fair rate of natural spread once established. Poorly compatible with other plants.
Habit: Evergreen, 4.6 to 9.2 m (15 to 30 ft) tall.

*Habitat:*
Soil: Dry, well-drained, rocky or sandy slopes. Calcareous soils.
Elevation: 915 to 2,700 m (3,000 to 9,000 ft).
Distribution: Intermountain West and vicinity.
Precipitation Range: 27.5 to 45 cm (11 to 18 in).
Tolerances: Drought tolerant. Excellent tolerance of grazing as it is poorly palatable.

*Uses:* Habitat for wildlife, shelterbelt, and possibly soil stabilization.

## Suggested Species Mixtures

Species mixtures provide several advantages over single species (monocultures) and, except for cropland purposes, usually are better suited to fulfilling reclamation goals in the Western Coal Region. A most important goal is long-term stability. Ideally, in a mixture, each species is adapted to one or more of the different environmental conditions and stresses that may occur on the reclaimed area. Thus, with nearly any environmental situation, some of the species in the mixture will remain productive or, at least, persist. Mixtures also are less susceptible than monocultures to decimation by a species-selective pathogen or herbivore. Species mixtures enhance wildlife values by providing a diversity or variety of forages and habitats. Increased productivity, too, may be achieved where plants with different life forms are used in mixtures (Rumbaugh et al. 1981). Once the revegetation objectives are defined, criteria can be set for choosing species and developing mixtures. Because domestic livestock grazing (range) and wildlife habitat are primary land uses in the Western Coal Region, the goal of revegetation often is to establish stands of native species similar to predisturbance stands. Normally, the number and types of species included in reclamation mixtures are less than found in native stands. Usually, 10 or fewer species are planted (Oaks 1982). Even so, these mixtures may offer some of the advantages of native vegetational communities such as more stable cover and productivity, and greater habitat diversity for wildlife.

Mixtures most likely to attain these advantages include species with differing life forms, phenology, physiology, and morphology. Selecting from species that thrive in nearby native communities may be a guide to formulating mixtures of species for reclamation. A mixture that includes different life forms such as grasses, forbs, and shrubs may lead to more efficient use of aboveground growing space and light. Below ground, a mixture of deep-rooted shrubs and shallow-rooted grasses and forbs may access more completely the moisture and nutrients in soil than a monoculture with uniform rooting depth and habit.

Where the climate is appropriate for both warm- and cool-season species, mixtures of the two types may provide forage for a longer period of time than either type alone. Inclusion of nitrogen-fixing species, such as legumes and actinorrhizal plants, will increase and prolong productivity of the stand. In some planting situations, species that can survive extended droughts and those that can survive in wet, poorly drained soils both may be needed. Species tolerant of alkaline or sodic soils or those tolerant of acidic soils may need to be included in some mixtures. Minesoils can vary greatly within a given area in moisture availability, nutrients, and toxic materials; thus, mixtures containing species capable of establishing on all soil types are most likely to provide long-term stability and productivity.

The plant community needs to survive through fluctuations in weather and climate. Some species, usually the most productive ones, will dominate in wet years, but will produce little forage in drought years. A drought-tolerant species may not produce large yields of forage at any time but will provide more consistent, though lower, forage production during dry years.

Species with relatively large seeds may produce seedlings that are more aggressive than small-seeded species. Thus, seeding rates of the large seed may need to be reduced, and small seeds should be sown closer to the surface. The seeding density should be adjusted for the different life forms and growth characteristics. For example, a dense stand of cool-season grasses planted in early spring might prevent the establishment of warm-season grasses that germinate later in the spring. High seeding densities frequently result in establishment of seedlings with low vigor (DePuit et al. 1980). Introduced species often are successful because they have been selected and bred for rapid and aggressive seedling establishment. It is preferable to calculate seeding densities on the basis of number of seeds per unit area rather than on weight of seeds. In this way, the density of each species can be controlled to overcome some of the problems that are related to seedling density.

Fertilization and irrigation often are used to improve the establishment of seeded mixtures, but may affect the success of each species differently (DePuit and Coenenberg 1979). Those species most responsive to fertilization or irrigation tend to dominate the stand and reduce the establishment of less-responsive species. Introduced species often respond to these amendments more than native species. Where a stand of native species is desired, it often is recommended that introduced species be used sparingly or not at all.

Specific mixtures are not described here because none are appropriate for all of the Western Coal Region. In general, an attempt should be made to include the different life forms found locally, such as mixtures of shrubs, grasses, and forbs. Where certain life forms are not available commercially, such as some native legumes, introduced species can be substituted, but care should be taken to avoid those that may outcompete the native species component. Recommendations for mixtures that are used locally can be obtained from State and Federal agencies which are involved with reclamation and range improvement, including State Experiment Stations and Extension Services, the USDI Fish and Wildlife Service and the Bureau of Land Management, the USDA Soil Conservation Service and the Forest Service, and State regulatory agencies which oversee coal-mine reclamation.

## Agricultural Situation

Agricultural land in the western United States is land that has been converted from native range and forests to pasture or cropland. Cropland exists in those areas where irrigation water is available or rainfall is sufficient for the land to be economically cropped, and other factors such as high salt content or inadequate drainage do not seriously limit productivity. Land constraints such as steep slopes and rocky soil also limit management for cropland.

Because precipitation and other factors severely limit the amount of land where crops can be grown, pasture is the dominant form of reclaimed agricultural land in the West. Reclaiming agricultural land to pasture is particularly im-

portant on steep slopes where continuous cover is required to prevent erosion. Land is reclaimed to pasture where the primary intended use is livestock grazing.

**Pasture**

Pasture land is defined as "land used primarily for the production of domesticated forage plants, to be grazed by livestock or occasionally cut and cured for livestock feed." Reclaiming mined land to pasture in the West has to be done with the conscious decision that the primary intended use of the land will be grazing by livestock. Other uses, such as recreation and wildlife habitat, are not precluded, but necessarily play a secondary role. This contrasts with the large acreages of natural grasslands in the West known as rangelands. Rangeland is defined as "land on which the natural plant cover is primarily native grasses, forbs, and shrubs valuable for forage." These lands provide recreation and wildlife habitat and function as watersheds in addition to providing forage for livestock. Restoration to rangeland implies that the land will be used for these multiple purposes. The decision on whether land should be reclaimed as rangeland or pasture should be based on the desired land use goal.

Pasture can be established and managed successfully under most climatic conditions encountered in the West. However, the annual precipitation will determine how difficult it is to establish the pasture, what species should be used, and the degree of management needed for maintenance. Pastures in the West can be divided into two major zones based on annual precipitation—arid and semiarid. An arid zone typically has less than 8 inches of precipitation annually while a semiarid zone generally receives 8 to 24 inches of precipitation annually (Packer and Aldon 1978).

Thornburg and Fuchs (1978) have broken the arid and semiarid West into nine major plant-growth regions. Of these, part or all of the Intermountain Desertic Basins, California Valleys, and the Desert Southwest are arid. There is potential for development of pastures on arid soils, including reclaimed mine soils, though few such pastures presently exist. There is a need for forage production for livestock in arid zones as well as a need for erosion control. Improved pastures are well suited to provide both.

Establishment of the desired species in arid zones often is difficult, especially when the limited precipitation is variable and unpredictable. Maintaining repeated success in establishing pasture usually requires the addition of some supplemental water. Ries and Day (1978) reviewed much of the information currently available on irrigation for plant establishment on reclaimed land.

Careful management of arid-zone pastures is essential. Overgrazing alone on an arid-zone pasture can be sufficient to destroy its integrity. These pastures also must be grazed at the proper time of the year, and other management practices such as fertilization, burning, and mowing must be done with care. Improved forage for livestock can be produced on properly managed arid-land pastures.

Semiarid climatic zones make up most of the remaining land in the Western Coal Region with the exception of some mountainous areas and the northern Pacific Coast. The higher rainfall of semiarid zones, especially where annual precipitation is greater than 12 inches, makes establishment and management of pastures somewhat easier than in arid zones. Current research shows that the establishment, management, and use of reestablished grasslands is similar to the establishment, management, and use of nonmined grasslands.

As in the arid regions, pasture species must be selected that will accomplish the land use designated for the reclaimed land. These species must be adapted to the climate of the region and to the soil and other environmental factors of the site. These factors include the degree of salinity and sodicity of a site, the texture of the soil, and the steepness of the slope. Once the species selection has been made, the seeds can be drilled or broadcast at the appropriate season of the year—early spring or fall for cool-season grasses and late spring for the warm-season grasses. Even during the optimum season for seeding, plant establishment can fail due to inadequate moisture.

Although big advances have been made in the last 15 years in our understanding of the establishment and management of reclaimed pastures in the west, new information will continue to refine our present ideas and introduce new ideas. Since current reclamation practices require the replacement of topsoil and, in some cases, subsoil over spoil, pasture management problems are similar to those on nonmined land and much of the research on nonmined land should be applicable to mined land.

**Cropland**

The use of land reclaimed after mining for cropland is limited in the West primarily because of climatic conditions. Climatic and topographic conditions favorable for cropland are found almost exclusively in the Northern Great Plains. Cropland does exist in other western states, but often is irrigated and isolated from any of the present mining. In the Northern Great Plains, the majority of the cropland that occurs at mining sites is located in North Dakota and to a lesser extent in Montana. The crops grown are mainly small grains with some corn and sunflowers in western North Dakota.

Land reclaimed as cropland has been shown to be similar to unmined cropland. A reconstructed soil that contains the topsoil and possibly the subsoil of the original soil has essentially the same physical and chemical properties as the original soil. Nevertheless, much of the structure has been lost and some research data indicate that these reconstructed soils initially are more susceptible to erosion. A good practice is to seed newly reclaimed land into pasture for several years until some initial development of soil structure has occurred.

Proper planning for reclamation is necessary where the intended use of reclaimed land is cropland. Slopes that are too steep to safely operate farm machinery or where erosion is likely to quickly reduce the productivity of the reclaimed soil should not be considered for cropland. Reclamation can increase the overall suitability of an area for cropland by reducing slopes and adding topsoil to the higher areas of a landscape that formerly were knobs and eroded hilltops.

Some of the cropland in North Dakota has been designated as prime farmland. These areas of prime farmland

are located in small tracts of 40 acres or less in well-drained toeslopes and swale positions of the landscape where they receive runon water. The greater depth of topsoil and subsoil on these prime soils was derived in part from the deposition of topsoil eroded from the surrounding hilltops and hillsides. Prime soils in North Dakota are commonly derived from the same material as adjacent nonprime land and are differentiated from the nonprime soils mainly by depth of topsoil and related parameters such as depth to carbonates. The higher productivity of prime soils results primarily from thicker topsoil and subsoil and additional runon water. Results of recent research suggests that the thickness of topsoil and subsoil available on these prime soils often exceeds that necessary for maximum crop production on these soils.

Currently, prime topsoils and subsoils are stripped, stockpiled, and replaced separately from nonprime topsoils and subsoils. Limited research on prime land in North Dakota suggests that overall productivity of the landscape could be improved and the productivity of the prime soils maintained by distributing the available topsoil and subsoil more uniformly throughout the landscape.

Reclamation of mined land can improve productivity over that of premine cropland and create productive cropland from land that what formerly was suitable only for rangeland or pasture. These possibilities exist where they are well planned as part of postmining land use goals.

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