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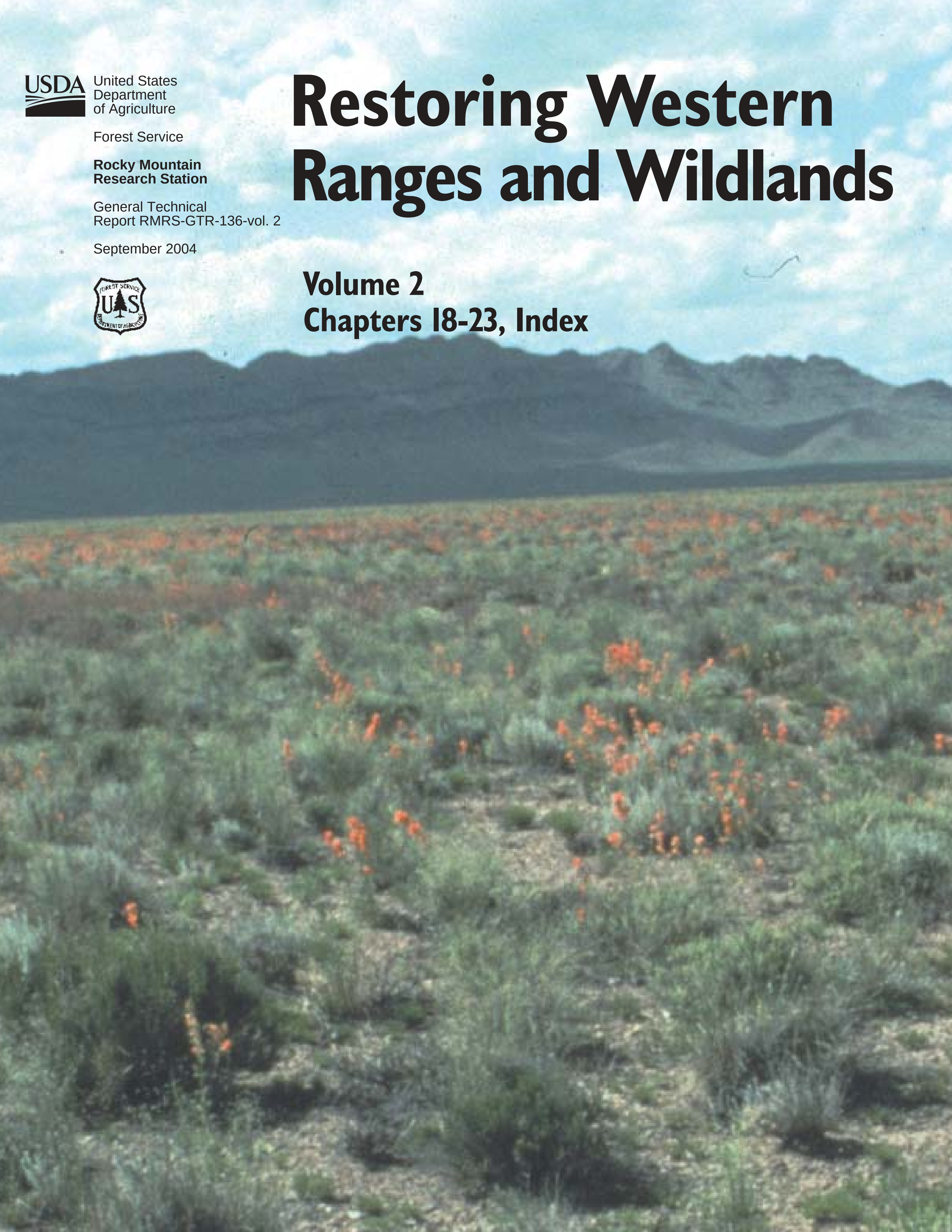
Restoring Western Ranges and Wildlands

Volume 2
Chapters 18-23, Index



Abstract

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This work, in three volumes, provides background on philosophy, processes, plant materials selection, site preparation, and seed and seeding equipment for revegetating disturbed rangelands, emphasizing use of native species. The 29 chapters include guidelines for planning, conducting, and managing, and contain a compilation of rangeland revegetation research conducted over the last several decades to aid practitioners in reestablishing healthy communities and curbing the spread of invasive species. Volume 2 contains chapters 18-23 plus the index.

Keywords: rehabilitation, revegetation, plant ecology, seed, plant communities, wildlife habitat, invasive species, equipment, plant materials, native plants

A

B

A—Curlleaf mountain mahogany.

B—Arrowleaf balsamroot.

C—Bluebunch wheatgrass seed production field.

D—Antelope bitterbrush achene.

E—Squirreltail.

Restoring Western Ranges and Wildlands

Compilers

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Richard Stevens
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Volume 2
Chapters 18–23, index

C

D

E

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Contents

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Chapter 18

Grasses

Grasses are adapted to a wide range of edaphic and climatic conditions and are found in nearly all plant communities. In the Western United States, grasses are seeded on disturbances to provide forage (Hull and Holmgren 1964; Vallentine 1989), wildlife habitat (Plummer and others 1968), and watershed stability (Cornelius 1946; Hafenrichter and others 1949; Piper 1934; Stewart and Young 1939). A number of introduced grass species proved well-suited to Western rangelands and received extensive use in early reseeding efforts (Barnes and others 1995; Hafenrichter and others 1968; Moser and others 1996). Use of these and other introductions continued over time, but by the late 1900s, greater emphasis was being placed on the use of native grasses (Roundy and others 1997).

Selection of introduced and native grasses for Western rangelands began in the late nineteenth century. Excessive livestock grazing across the West followed early European settlement, resulting in widespread disturbances, weed invasions, and a need for revegetation species to stabilize watersheds and produce forage. A few species and accessions were introduced in the West before 1900 (Hanson 1959). Some arrived by chance (Weintraub

Chapter Contents by Species

1953); others were selected for specific uses and areas (Dillman 1946). Field testing and seeding trials for high-elevation disturbances were initiated at this time. Based on results of these trials, Williams (1898) described the values and uses of introduced forage grasses for the Eastern Rocky Mountains.

Seeding trials conducted by the Bureau of Plant Industry were initiated in 1902 (Cotton 1908). Forest Service reseeding research utilizing forage species began in 1907 in cooperation with this agency (Sampson 1913). Ecological studies of grasses native to the National Forests were initiated in about 1911 (USDA Forest Service 1914). Efforts to evaluate grasses for range and wildlife uses were expanded by Forest Service researchers and their cooperators by about 1930 (Stewart and others 1939). Cool-season grasses received special attention for use on Western rangelands (Koonce 1946; Piper 1934).

Breeding and selection programs were organized within the USDA Soil Conservation Service, now the USDA Natural Resources Conservation Service, in the 1930s (Hafenrichter and others 1968). The need to stabilize abandoned farmlands during the 1930's further stimulated the demand for conservation species (Dillman 1946). Weintraub (1953) published a review of publications on testing and field planting studies conducted between 1920 and 1950.

The Soil Conservation Service (now the USDA Natural Resources Conservation Service) and their cooperators began releasing grass varieties in the mid 1940s (Alderson and Sharp 1994; Hanson 1959). Some introduced range and pasture varieties obtained immediate success. Introductions from areas of Europe and Asia with environmental conditions similar to those encountered in Western North America proved useful over wide areas. Testing of drought-tolerant grasses adapted to arid and semiarid rangelands received increasing emphasis during recent decades (Barnes and others 1952; Bridges 1942; Christ 1934; Forsling and Dayton 1931; Koonce 1946; Piper 1934; Price 1938; Stoddart 1946a). Some of the most important grass varieties developed for use on Western range, wildland, and conservation plantings are listed in table 1.

Following is a discussion of introduced and native grasses that have proven most useful for seeding Western wildlands. The range of adaptability, uses, and characteristics of important grasses are summarized in table 2. In the past, productive accessions that were palatable and responded well to grazing were emphasized in plant selection programs for rangelands. Characteristics such as good seed production, ease of seed cleaning and seeding, and good seedling establishment also received priority in the selection process (Frischknecht 1951; Hanson and Carnahan 1956; Plummer and others 1943). Although important, these emphases often discouraged the use of less productive species and accessions that might, nonetheless, be adapted to specific situations. With increased efforts to reestablish native plant communities, it became essential to more fully utilize the array of species and populations adapted to the wide array of environments encountered on Western rangelands. Many native species have not been brought into seed production, but should be seeded in appropriate areas and maintained through proper management. Research is being conducted to develop seed transfer guidelines for native grasses of the Intermountain region to permit increase of adapted seed supplies for revegetation that will conserve the genetic diversity of native populations. Thus, at the present and into the future, greater consideration will be given to native grasses, forbs, and shrubs.

Grass taxonomy has evolved continuously since Linnaeus published the first descriptions in 1753. Extensive revisions, particularly within the Triticeae, have been made over the last few decades as our understanding of origins and genetic relationships increased (Arnow 1987; Barkworth and others 1983). Löve (1982, 1984) reorganized genera within the Triticeae based on genomic relationships. Dewey (1982, 1983a, 1984) concurred with this revision as it provided a clearer picture of phylogenetic and biological closeness. New taxonomic keys, however, continue to utilize conventional morphological features to separate taxa. We subscribe to the recent changes, but we have elected to use the more traditional nomenclature because most land managers, seed dealers, and growers are better acquainted with it. Traditional and current nomenclatures are presented in table 3.

Agropyron cristatum Fairway Crested Wheatgrass

Description

Fairway crested wheatgrass, also called crested wheatgrass, is an introduced, long-lived, cool-season, generally nonrhizomatous bunchgrass that produces strong tillers and an extensive root system. Stems and leaves are tightly clustered at the base. Plants are generally uniform in stature and growth form. Stem heights within individual plants range from 8 to 20 inches (20 to 50 cm), but may reach 40 inches (1 m). Stems are generally erect, but some may be bent slightly at the lower nodes. Leaves develop from the plant base and stems. Leaf blades are 2 to 8 inches (5 to 20 cm) long and 0.08 to 0.2 inch (2 to 5 mm) wide, appearing flat or loosely bent along the midrib. Blades are rough, heavily grooved with raised nerves, and often have a bluish cast. Hairs are sometimes present on the upper portion of the leaf blade. Auricles are small and clasping. Ligules are membranous

Table 1—Selected grass cultivars and germplasms for range and wildlife projects.

Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Bentgrass, redtop *Agrostis stolonifera*	Streaker	1982	Combined Illinois collections	Jacklin Seed Company, Post Falls, ID	Highly rhizomatous, fine leaves
Bluegrass, alpine *Poa alpina*	Gruening	1986	La Cure, Switzerland	NRCS, Palmer, AK	Low growing, nonrhizomatous, winter hardy, selected for Alaska
Bluegrass, big *Poa ampla*	Sherman	1945	Sherman County, OR	NRCS, Pullman, WA	Early greenup, highly productive
Bluegrass, Canada *Poa compressa*	Foothills Germplasm	2001	Composite of eight accessions	NRCS, Bridger, MT	Good forage and seed production, useful on low-fertility sites of moderate acidity and at high elevations
	Reubens	1976	Reubens, ID	Jacklin Seed Company, Post Falls, ID	Dense, low-maintenance turf for erosion control on infertile sites
Bluegrass, Kentucky *Poa pratensis*	Newport	1958	Lincoln County, OR	NRCS, Pullman, WA	Vigorous, highly productive, broad climatic tolerance
Bluegrass, Sandberg *Poa secunda* (*P. canbyi*)	Canbar	1979	Blue Mountains, WA	NRCS, Pullman, WA	Good drought tolerance and provides early greenup, competitive with annual weeds
	High Plains Germplasm	2000	Composite from Montana and Wyoming	NRCS, Bridger, MT	Tall, productive, used in native seed mixes for wildlife habitat and reestablishment of native plant communities
	Service	1989	Whitehorse, Yukon, Canada	NRCS, Palmer, AK	Erect, vigorous, winter hardy
Brome, California *Bromus carinatus*	Cucamonga	1949	Cucamonga, CA	NRCS, Lockeford, CA	Rapid development, early maturing, selfseeding, cover crop
Brome, meadow *Bromus riparius*	Regar	1966	Zek, Kars Province, Turkey	NRCS, Aberdeen, ID	Excellent establishment and early development, highly productive, tolerant of shade, winter hardy
Brome, mountain *Bromus marginatus*	Bromar	1946	Whitman County, WA	NRCS, Pullman, WA	Rapid development, erect, leafy, late maturing, heavy seed and forage producer
	Garnet	2000	Garnet, MT	UCEPC, Meeker, CO	Good stand longevity and head smut resistance
	Other cultivars are Fleet and Paddock.				

(con.)

Table 1 (Con.)

Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Brome, smooth *Bromus inermis*	Manchar	1943	Manchuria, China	NRCS, Pullman, WA	Most widely planted northern type in the West, moderately spreading type, high yields, good regrowth
Northern types	Polar	1965	Arctic brome hybrids and smooth brome sources	Alaska AES	Winter hardy, high yields, early spring growth
Southern types	Achenbach	1944	Washington County, KS	Kansas AES	Leafy, vigorous, spreads rapidly, competitive
	Lincoln	1942	Hungary	Nebraska AES	Aggressive sodformer, good seedling vigor, drought tolerant
	Numerous other smooth brome cultivars of both the northern and southern types have been developed for regional uses.				
Canarygrass, reed *Phalaris arundinacea*	Ioreed	1946	Composite clones	Iowa AES	Very productive, well-suited to wet sites, useful for hay
	Other less common cultivars include Auburn, Castor, Frontier, Highland, Rise, and Vantage.				
Fescue, Arizona *Festuca arizonica*	Redondo	1973	Los Alamos, NM	NRCS, Los Lunas, NM	High seed yields, excellent seed production
Fescue, hard sheep *Festuca ovina* var. *duriuscula*	Durar	1949	Union, OR, 1934 planting	NRCS, Pullman, WA	Leafy, persistent, moderate forage value, adapted to semiarid sites
Fescue, Idaho *Festuca idahoensis* (*F. ovina* var. *ingrata*)	Joseph	1983	Composite clones	U of Idaho, Moscow, ID	Improved seed size, high fertility, improved germination, large growth form
	Nezpurs	1983	Composite clones	U of Idaho, Moscow, ID	Excellent forage attributes, erect, leafy ecotype
Fescue, sheep *Festuca ovina* var. *ovina*	Covar	1977	Konya, Turkey	NRCS, Pullman, WA	Dwarf, blue green, densely tufted, drought tolerant, persistent, competitive
	MX86	1989	Germany	Jacklin Seed Company, Post Falls, ID	Improved seedling vigor and yields
Fescue, tall *Festuca arundinacea*	Alta	1940	Composite clones	Oregon AES	Remains green throughout the summer, high forage yields, cold tolerant
	Fawn	1964	Named varieties and foreign introductions	Oregon AES	High forage and seed production, widely adapted

(con.)

Table 1 (Con.)

Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Foxtail, creeping (reed) *Alopecurus arundinaceus*	Garrison	1963	Europe	NRCS, Bismarck, ND	Highly productive, excellent quality forage, heavy seed producer, rhizomatous, adapted to mountain meadows
Foxtail, meadow *Alopecurus pratensis*	Dan	1987	Wilno, Poland	AC, Ottawa, Ontario, Canada	Early maturity, good winter hardiness
Galleta *Hilaria jamesii*	Viva	1979	New Kirk, NM	NRCS, Los Lunas, NM	Improved seedling vigor, high seed production
Grama, black *Bouteloua eriopoda*	Nogal	1971	Socorro County, NM	NRCS, Los Lunas, NM	Intermediate growth habit, fine stemmed
Grama, blue *Bouteloua gracilis*	Hachita	1980	Hachita, NM	NRCS, Los Lunas, NM	High seed and herbage production, drought tolerant
	Lovington	1963	Lovington, NM	NRCS, Los Lunas, NM	Excellent seedling vigor, rapid establishment
Grama, sideoates *Bouteloua curtipendula*	Butte	1958	Holt and Platte Counties, NE	Nebraska AES	Good seedling vigor, winter hardy, long lived
	El Reno	1944	El Reno, OK	NRCS, Manhatten, KS	Outstanding leafiness, forage production, vigor
	Haskell	1983	Haskell, TX	NRCS, Knox City, TX	Strong rhizome production
	Killdeer	1960	Dunn and Bowman Counties, TX	NRCS, Bismarck, ND	Outstanding vigor, tolerates cold and dry climates
	Niner	1984	Socorro County, NM	NRCS, Los Lunas, NM	No rhizomes, matures evenly
	Pierre	1960	Pierre, SD	NRCS, Bismarck, ND	Outstanding vigor, leafiness, good seedling vigor
	Premier	1960	Mexico	Texas AES	Upright, leafy type, seedlings develop rapidly
	Trailway	1958	Holt County, NE	Nebraska AES	Winter hardy, long lived, late maturing
	Vaughn	1940	Vaughn, NM	NRCS, Los Lunas, NM	Good seedling vigor, drought tolerant, easily established

(con.)

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Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Hairgrass, tufted *Deschampsia caespitosa*	Norcoast	1981	Alaska	Alaska AES	High forage production, adapted to semiwet and acid soils
	Nortran	1986	Composite collection, Alaska and Iceland	Alaska AES	Low-maintenance ground cover
	Peru Creek	1995	Summit County, CO	NRCS, Meeker, CO	Adapted to high elevations and acidic soils
Muhly, spike *Muhlenbergia wrighti*	El Vado	1973	Park View, NM	NRCS, Los Lunas, NM	Upright growth form, leafy, free of galls
Needlegrass, green *Stipa viridula*	Lodorm	1970	Bismarck, ND	ARS, Mandan, ND	High palatability, good regrowth
Orchardgrass *Dactylis glomerata*	Latar	1957	U.S.S.R.	NRCS, Pullman, WA	Late maturing, abundant leaves, highly productive
	Paiute	1983	Ankara, Turkey	NRCS, Aberdeen, ID	Drought hardy, easily established, moderately productive
	Potomac	1954	Combined collections	Washington Crop Improvement Association	Highly productive, persistent, leafy type
	Numerous other pasture cultivars are available				
Reedgrass, bluejoint *Calamagrostis canadensis*	Sourdough	1976	Alaska	NRCS, Palmer, AK	Winter-hardy, robust, cool-season perennial developed for Alaska
Ricegrass, Indian *Oryzopsis hymenoides*	Nezpar	1978	Whitebird, ID	NRCS, Aberdeen, ID	Excellent seedling vigor, low-percentage hard seeds
	Paloma	1974	Pueblo, CO	NRCS, Los Lunas, NM	Soil stabilization, drought tolerant, highly palatable
	Rimrock	1996	Billings, MT	NRCS, Bridger, MT	Good seed retention, low shattering, large stature
Sacaton, alkali *Sporobolus airoides*	Salado	1982	Claunch, NM	NRCS, Los Lunas, NM	Good seedling vigor and forage production
	Saltalk	1981	Erick, OK	NRCS, Knox City, TX	Highly palatable, good germination
Squirreltail, bottlebrush *Sitanion hystrix*	Sand Hollow	1996	Gem County, ID		Self-pollinating, grows at low temperatures

(con.)

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Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Timothy *Phleum pratense*	Climax	1947	Combined progeny	AC, Ottawa, Ontario, Canada	Highly productive, very leafy, establishes quickly
	Drummond	1940	Northern Europe	McGill University, Montreal,Quebec, Canada	Shade tolerant, provides late-season forage
	Numerous pasture cultivars are available.				
Wheatgrass, beardless *Agropyron spicatum* ssp. *inerme* (*Pseudoroegneria spicata* ssp. *inermis*)	Whitmar	1946	Whitman County, WA	NRCS, Pullman, WA	Long-lived, highly productive, drought resistant
Wheatgrass, bluebunch *Agropyron spicatum, Pseudoroegneria spicata*	Anatone	2003	Asotin County, WA	Breeder, seed maintenance	USDA FS, Ricky Mountain Research Station, Provo, UT; NRCS , Aberdeen, ID Good seedling vigor, recommended for semiarid sites
	Goldar	1989	Asotin County, WA	NRCS, Aberdeen, ID	Good seedling vigor, adapted to semiarid sites
	P-7	2001	Multiple origin polycross of 25 populations	ARS, Logan, UT	Recommended for mesic to semiarid sites
Wheatgrass, fairway crested *Agropyron cristatum*	Douglas	1994	U.S.S.R./Iran/Turkey	NRCS, Aberdeen, ID	Excellent seedling vigor and summer greenness
	Ephraim	1983	Ankara, Turkey	NRCS, Aberdeen, ID	Low growing, slightly rhizomatous, drought tolerant
	Fairway	1927	U.S.S.R.	AC, Saskatoon, Saskatchewan, Canada	Productive, leafy types
	Parkway	1969	Fairway germplasm	AC, Saskatoon, Saskatchewan, Canada	High seed and forage yields, leafiness, increased vigor
	Ruff	1974	Commercial lots and Nebraska AES	Nebraska AES	Early, cool season, adapted to low rainfall areas
Wheatgrass, hybrid *Agropyron repens* x *A. spicatum* (*Elytrigia repens* x *Pseudoroegneria spicata*)	NewHy	1989	Quackgrass and bluebunch wheatgrass hybrid	ARS, Logan, UT	Vigorous, highly productive, high salinity tolerance

(con.)

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Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Wheatgrass, hybrid *Agropyron spicatum* x *A. dasystachyum*	SL1	1991	Hybrid	ARS, Logan, UT	Large culms, productive, improved seedling vigor
Wheatgrass, hybrid crested *Agropyron cristatum* x *A. desertorum*	CDII	1996	10-clone synthetic derived from Hycrest	ARS, Logan, UT	Leafy, highly productive, adapted to arid sites
	Hycrest	1984	Central Asia	ARS, Logan, UT	Excellent seedling vigor and early maturity, highly competitive with annuals
	Kirk	1987	Tetraploid selection	AC, Saskatoon, Saskatchewan, Canada	Improved vigor, fertility, seed development, reduced awns
Wheatgrass, intermediate *Agropyron intermedium* (*Thinopyrum intermedium*)	Amur	1952	Manchuria, China	NRCS, Los Lunas, NM	Excellent forage traits, good establishment attributes
	Chief	1961	U.S.S.R. and selection from Ree	AC, Saskatoon, Saskatchewan, Canada	Improved forage and seed yields
	Clarke	1980	20-clone synthetic	AC, Swift Current, Saskatchewan, Canada	Drought tolerant, winter hardy, high seed yields
	Greenar	1945	U.S.S.R.	NRCS, Pullman, WA	Vigorous, highly productive, late maturing, good regrowth
	Oahe	1961	Selection from Ree	South Dakota AES	Vigorous, rhizomatous, drought tolerant
	Reliant	1991	6-clone synthetic	ARS, Mandan, ND	Late maturation, high forage production
	Rush	1995	Germany	NRCS, Aberdeen, ID	Excellent seedling vigor, highly productive, good ground cover
	Slate	1969	Blend of Amur and Nebraska 50	Nebraska AES	Erect culms, strongly spreading
	Tegmar	1968	Turkey	NRCS, Aberdeen, ID	Drought tolerant, dwarf strain, late maturing, sodforming

(con.)

Table 1 (Con.)

Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Wheatgrass, pubescent *Agropyron intermedium* (*Thinopyrum intermedium, A. trichophorum*)	Greenleaf	1966	Commercial seed lots	AC, Lethbridge, Alberta, Canada	Sod forming, high seedling vigor and forage production, winter hardy
	Luna	1963	U.S.S.R.	NRCS, Los Lunas, NM	Adapted to warm temperatures and dry sites, excellent seedling vigor, highly productive
	Topar	1953	U.S.S.R.	NRCS, Aberdeen, ID	Vigorous, drought tolerant, sodformer
Wheatgrass, Siberian *Agropyron sibiricum* (*A. fragile*)	P27	1953	U.S.S.R.	NRCS, Aberdeen, ID	Drought resistant, good seedling vigor, persistent
	Vavilov	1994	U.S.S.R.	NRCS, Aberdeen, ID	Excellent seedling vigor, highly productive
Wheatgrass, slender *Agropyron trachycaulum* (*Elymus trachycaulus*)	Adanac	1990	Climax, Saskatchewan, Canada	AC, Saskatoon, Saskatchewan, Canada	Highly productive, adapted to saline soils
	Primar	1946	Beebe, MT	NRCS, Pullman, WA	Vigorous, early growing, long-lived, high yield, alkali tolerant
	Pryor	1988	South-central MT	NRCS, Bridger, MT	Tolerant of drought and salinity, vigorous seedlings
	Revenue	1970	Revenue, Saskatchewan, Canada	AC, Saskatoon, Saskatchewan, Canada	Excellent establishment, high seed and forage yields
	San Luis	1984	Rio Grande County, CO	NRCS, Meeker, CO	Excellent establishment and longevity, adapted to high elevations
Wheatgrass, Snake River *Elymus wawawaiensis* (*Agropyron spicatum, E. lanceolatus* spp. *wawawai*)	Secar	1980	Lewiston, ID	NRCS, Pullman, WA	Dryland ecotype, drought tolerant, tufted bunchgrass
Wheatgrass, standard crested	Nordan	1953	Central Asia	ARS, Mandan, ND	Good seedling vigor, large seeds, high yields, cold hardy
Agropyron desertorum	Summit	1953	U.S.S.R.	AC, Saskatoon, Saskatchewan, Canada	Excellent forage traits, high seed yields

(con.)

Table 1 (Con.)

Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Wheatgrass, tall *Agropyron elongatum* (*Thinopyrum ponticum*)	Alkar	1951	U.S.S.R.	NRCS, Pullman, WA	Tall, robust type, tolerant of wet and saline soils
	Jose	1965	Australia	NRCS, Los Lunas, NM	Drought and salt tolerant, early maturing, fine leaves
	Largo	1961	Turkey	NRCS, Los Lunas, NM	Highly productive, large bunch type
	Orbit	1966	PI 98526 and local strain	AC, Swift Current, Saskatchewan, Canada	Winter hardy, withstands flooding, good seed and forage yield
	Platte	1972	Nebraska 98526	Nebraska AES	Winter hardy bunchgrass with short, spreading rhizomes, tolerant of alkali soils
Wheatgrass, thickspike Agropyron dasystachyum (*Elymus lanceolatus* var. *lanceolatus*, *A. riparium*)	Bannock	1995	Composite	NRCS, Aberdeen, ID	Rhizomatous, highly productive, drought tolerant
	Critana	1971	Havre, MT	NRCS, Bridger, MT	Excellent seedling vigor, strongly rhizomatous
	Schwendimar	1994	The Dalles, OR	NRCS, Pullman, WA	Weakly rhizomatous, adapted to dry sites
	Sodar	1954	Grant County, MT	NRCS, Aberdeen, ID	Drought resistant, strongly rhizomatous, excellent ground cover
	Thickspike	1994	The Dalles, OR	NRCS, Aberdeen, ID	Vigorous sodformer and controls weeds
Wheatgrass, western *Agropyron smithii* (*Elytrigia smithi*, *Pascopyrum smithii*)	Arriba	1973	Flagler, CO	NRCS, Los Lunas, NM	Rapid germination, excellent establishment, good seed and forage yields
	Barton	1970	Heizer, KS	NRCS, Manhattan, KS	Strongly rhizomatous, leafy, highly productive
	Flintlock	1975	Nebraska and Kansas	AES, Lincoln, NE	Spreading type, early spring growth, drought tolerant
	Rodan	1983	Mandan, ND	ARS, Mandan, ND	Highly productive, excellent pasture type, vigorous
	Rosana	1972	Forsyth, MT	NRCS, Bridger, MT	Excellent seedling vigor, close sod, leafy
	Walsh	1982	Alberta and Saskatchewan	AC, Lethbridge, Alberta, Canada	Drought tolerant, dense sodformer, high yields, tolerant of flooding and salinity

(con.)

Table 1 (Con.)

Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Wildrye, Altai *Elymus angustus* (*Leymus angustus*)	Eejay	1989	U.S.S.R.	AC, Indian Head, Saskatchewan, Canada	Highly productive, good-quality late-season herbage, good seedling vigor
	Pearl	1989	U.S.S.R.	AC, Swift Current, Saskatchewan, Canada	Highly productive, good production in late summer, good seedling vigor, drought tolerant
	Prairieland	1976	U.S.S.R.	AC, Swift Current, Saskatchewan, Canada	Excellent producer, good-quality late-season herbage, free of leaf spot
Wildrye, beardless *Elymus triticoides* (*Leymus triticoides*)	Rio	1991	Stratford, CA	NRCS, Lockford, CA	Excellent seed viability, vigorous spreader or creeper
	Shoshone	1980	Riverton, WY	NRCS, Bridger, MT	Leafy, fine stemmed, highly productive, rhizomatous
Wildrye, blue *Elymus glaucus*	Arlington	1995	Arlington, WA	NRCS, Corvallis, OR	Vigorous, disease-free, high-quality seed
Wildrye, Canada *Elymus canadensis*	Mandan	1946	Mandan, ND	ARS, Mandan, ND	Easily established, short stature, high seed and forage production, leafy, persistent
Wildrye, Dahurian *Elymus dahuricus*	Arthur	1989	China	AC, Swift Current, Saskatchewan, Canada	Short lived, highly productive first 13 years of stand establishment, erect, green foliage
	James	1989	China	AC, Indian Head, Saskatchewan, Canada	Highly productive, good stand establishment
Wildrye, Great Basin *Elymus cinereus* (*Leymus cinereus*)	Magnar	1979	Saskatchewan, Canada	NRCS, Aberdeen, ID	Large, robust, extremely productive, excellent ground cover, good seed quality
	Trailhead	1991	Roundup, MT	NRCS, Bridger, MT	Vigorous, drought tolerant, early spring forage
Wildrye, mammoth *Elymus giganteus* (*Leymus racemosus*)	Volga	1949	U.S.S.R.	NRCS, Meeker, CO	Tall, persistent, useful for dune stabilization

(con.)

Table 1 (Con.)

Common and scientific names	Cultivar or germplasm	Release date	Origin	Breeder seed maintenance[a]	Attributes
Wildrye, Russian *Elymus junceus* (*Psathyrostachys juncea*)	Bozoisky-Select	1984	U.S.S.R.	ARS, Logan, UT	Improved seedling vigor, highly productive
	Cabree	1976	Six clones from Manyberries, Alberta, Canada seeding	AC, Lethbridge, Alberta, Canada	Improved seed retention, seedling vigor, and forage and seed yield
	Mankota	1991	Six clone synthetic, U.S.S.R. and Mandan, ND	Mandan, ND	Excellent fall and winter grazing, seedling establishment, and forage production
	Mayak	1971	Twenty-clone synthetic	AC, Swift Current, Saskatchewan, Canada	Productive, good late-summer herbage, resistant to leaf spot disease
	Swift	1978	Twenty-six clone synthetic	AC, Swift Current, Saskatchewan, Canada	Improved seedling vigor, highly productive, good seed quality and yield
	Tetracan	1988	Colchicine induced tetraploids	AC, Swift Current, Saskatchewan, Canada	Large seeds, improved seedling vigor
	Vinall	1960	Five clone synthetic	ARS, Mandan, ND	Provides early greenup and fall grazing, high seed production

[a] NRCS = USDA Natural Resource Conservation Service, formerly USDA Soil Conservation Service; AES = Agricultural Experiment Station; AC = Agriculture Canada; ARS = USDA Agricultural Research Service; UCEPC = Upper Colorado Environmental Plant Center.

Table 2—Characteristics of selected grasses.

Species	Seed production	Ease of seed harvesting	Ease of seed cleaning	Ease of seeding	Germination	Seedling vigor	Growth rate	Final establishment	Method of spread	Spring growth	Summer growth	Fall growth	Compatibility with other species	Longevity	Forage production	Spring palatability	Summer palatability	Grazing tolerance	Soil stabilization	Shade tolerance	Flood tolerance	Ecotypic variability	Vegetative types[a]
	- - - - - - - - - - - *ratings*[b] - - - - - - - - - - -																						
Barley, bulbous	4	4	3	4	5	5	4	2	S	5	2	2	3	4	3	5	5	5	3	2	2	4	WM,JP,BS
Barley, meadow	3	4	3	4	4	5	4	3	V	5	4	3	4	3	3	5	4	3	3	4	4	2	SA,A,WM
Bluegrass, big	3	5	5	4	5	5	4	4	S	4	3	4	4	4	3	4	4	4	4	4	3	3	A,MB,JP,PP,MS,R
Bluegrass, Canada	3	5	5	4	4	5	4	4	V	5	3	4	4	4	3	4	4	4	4	4	2	3	SA,A,MB,PP
Bluegrass, Kentucky	3	5	5	4	4	5	4	5	V	5	4	4	2	5	2	4	4	5	5	4	4	5	SA,A,WM,MB,PP, JP,MS,R
Bluegrass, mutton	2	3	5	4	4	5	3	5	S	5	5	4	4	4	4	4	4	3	3	3	3	3	MB,PP,JP,MS
Bluegrass, Sandberg	3	5	5	4	4	4	4	5	S	5	2	3	4	5	2	5	2	4	4	2	2	5	MB,PP,JP,MS, BS,WS,SS,C,AW
Brome, mountain	4	5	5	4	5	5	5	4	S	3	4	4	5	3	4	4	4	4	4	4	4	3	SA,A,MB,PP,MS
Brome, nodding	4	5	5	4	5	5	5	4	S	4	4	4	5	3	4	4	4	4	4	5	4	3	SA,A,MB,PP,MS
Brome, smooth northern	5	5	5	4	5	5	4	5	V	4	4	4	1	5	5	4	4	5	5	5	4	4	SA,A,WM,MB, PP,MS,R
Brome, smooth southern	5	5	5	4	5	5	5	5	V	4	4	3	1	5	4	4	3	5	5	3	4	4	SA,A,WM,MB, PP,JP,MS,BS,R
Brome, subalpine	3	5	5	4	5	4	3	4	S	4	4	4	4	4	4	4	4	3	4	5	4	3	SA,A,WM,MS
Canarygrass, reed	5	3	4	4	3	2	5	5	V	3	5	3	1	5	5	3	3	5	5	2	5	2	SA,A,WM,IS,R
Dropseed, sand	3	3	4	4	3	2	4	4	S	5	3	2	4	4	3	3	2	4	4	2	3	3	MB,PP,JP,BS, WS,SS,BB,C,AW
Fescue, hard sheep	4	5	5	5	5	4	4	5	S	4	3	2	1	5	2	2	2	5	4	2	2	4	A,MB,PP,JP,MS,BS
Fescue, Idaho	3	5	5	5	5	4	3	3	S	5	3	2	4	4	3	5	4	4	4	2	2	3	MB,PP,MS
Fescue, meadow	3	5	5	5	5	4	4	5	S	4	4	3	2	4	4	5	4	5	5	3	4	2	SA,A,WM,JP,BG,IS
Fescue, sheep	3	5	5	5	5	4	4	4	S	5	3	2	3	4	3	3	2	4	4	2	2	5	SA,A,MB,PP,MS
Fescue, spike	2	4	4	4	3	3	4	3	V	4	3	2	4	4	4	3	3	4	3	3	3	2	MB,PP,JP,MS
Fescue, reed	5	3	3	3	5	4	4	5	S	4	4	3	2	2	4	5	4	4	5	3	5	2	SA,A,WM,JP,BG,IS
Fescue, Thurber	2	3	4	4	4	4	3	3	S	5	2	2	4	5	3	4	3	4	3	2	2	4	SA,A,MB,MS
Foxtail, meadow	5	2	2	2	4	2	4	5	V	4	4	4	2	5	5	5	5	5	5	3	5	2	SA,A,WM,MB,IS
Foxtail, creeping	5	2	2	2	4	2	4	5	V	4	4	4	2	5	5	5	5	5	5	3	5	2	SA,A,WM,MB,IS
Galleta	3	3	3	3	3	4	3	3	V	3	4	2	4	4	3	4	4	3	4	2	1	5	JP,BS,WS,SS,BB
Grama, sideoats	3	4	4	5	4	4	3	3	S	3	4	2	4	4	3	4	2	3	4	2	1	3	JP,BS,WS,SS,BB
Grama, blue	2	4	4	5	4	4	3	4	V	3	4	2	3	5	2	4	2	5	5	3	1	3	JP,BS,WS,SS,BB
Grama, black	2	4	4	5	4	4	3	4	V	3	4	2	3	5	2	4	2	5	5	3	1	3	JP,BS,WS,SS,BB
Hair grass, tufted	3	4	4	4	4	4	4	4	S	3	4	2	4	4	2	2	2	4	3	2	2	3	SA,A,WM,MB,PP,IS
Junegrass, prairie	2	4	5	4	3	4	4	3	S	5	3	3	5	4	2	5	3	4	3	3	2	3	MB,PP,JP,MS, JP,WS,BB
Needle-and-thread	3	2	2	3	3	4	3	5	S	5	4	3	3	5	3	4	2	4	4	2	2	3	MB,PP,JP,BS, WS,C,AW
Needlegrass, green	4	3	2	3	4	4	4	4	S	5	4	3	4	4	4	4	3	4	4	3	3	3	A,MB,PP,MS
Needlegrass, Letterman	3	3	2	3	3	3	3	4	S	3	5	2	4	5	2	2	2	4	4	3	3	2	SA,A,MB,MS
Needlegrass, subalpine	2	2	2	3	3	3	3	3	S	3	5	3	4	5	2	4	3	4	4	4	3	2	SA,A,MS
Needlegrass, Thurber	3	2	2	3	2	3	3	5	S	5	4	3	3	5	4	4	4	4	4	3	2	3	MS,BS,WS,C,AW
Oatgrass, tall	4	3	3	4	5	4	4	4	S	5	4	3	4	3	4	5	4	3	4	5	3	2	SA,A,MB,PP,MS
Oniongrass	2	5	5	5	5	4	5	3	V	4	3	3	4	2	3	4	4	3	3	5	3	2	A,MB,PP,MS
Orchardgrass	5	5	5	5	5	5	5	4	S	5	4	4	3	4	5	5	4	4	5	5	4	5	SA,A,WM,MB, PP,MS
Redtop	3	3	4	4	3	3	3	5	V	3	4	2	3	4	2	3	2	4	3	3	4	3	A,WM,BS,BG,IS
Ricegrass, Indian	4	3	3	4	2	4	3	4	S	5	2	2	4	5	3	4	3	4	4	2	5	4	MB,PP,PJ,MS,BS, WS,SS,BG,BB,C,AW

(con.)

Table 2 (Con.)

Species	Seed production	Ease of seed harvesting	Ease of seed cleaning	Ease of seeding	Germination	Seedling vigor	Growth rate	Final establishment	Method of spread	Spring growth	Summer growth	Fall growth	Compatibility with other species	Longevity	Forage production	Spring palatability	Summer palatability	Grazing tolerance	Soil stabilization	Shade tolerance	Flood tolerance	Ecotypic variability	Vegetative types[a]
	ratings[b]																						
Rye, mountain	5	4	4	5	5	5	5	4	S	5	2	5	3	2	5	5	4	4	4	3	2	3	MB,PP,JP,MS,BS,WS,SS, BB,C,AW
Sacaton, alkali	3	3	4	4	1	2	2	4	V	3	3	3	1	5	2	2	2	5	5	2	4	3	WM,BS,WS,SS,BG, BB,IS,R
Squirreltail, bottlebrush	4	2	2	3	4	4	4	4	S	5	2	2	4	4	3	4	2	4	4	2	5	5	MB,PP,JP,BS,WS,SS,BG, BB,C,AW
Three-awn, purple	2	2	2	3	3	4	3	4	S	5	2	2	3	5	3	1	1	5	4	2	3	4	MB,PP,JP,MB,BS, WS,SS,C,AW
Timothy, mountain	4	4	4	4	5	4	5	4	S	3	4	3	4	3	3	5	5	5	4	4	5	3	SA,A,WM
Timothy	5	4	4	4	5	5	5	5	S	4	4	4	4	3	5	5	5	4	3	4	4	3	SA,A,WM,MB,PP,JP,MS
Trisetum, spike	2	2	4	3	4	3	4	3	S	5	4	3	4	3	2	3	3	3	3	3	2	3	MB,JP,MS,BS,WS
Wheatgrass, bluebunch	5	5	5	4	5	4	4	4	S	5	3	4	4	5	5	5	4	4	4	3	5	5	MB,PP,JP,MS,BS, WS,C,AW
Wheatgrass, fairway crested	5	5	5	5	5	5	5	5	S	5	3	3	1	5	4	5	3	5	5	3	4	3	MB,PP,JP,MS,BS,WS,SS, BG,BB,C,AW
Wheatgrass, intermediate	5	5	5	5	5	5	5	5	V	5	4	3	1	5	5	5	4	5	5	4	4	5	A,MB,PP,JP,MS,BS,WS, SS,R,C,AW
Wheatgrass, pubescent	5	5	5	5	5	5	5	5	V	4	3	5	1	5	5	5	3	5	5	2	2	5	MB,PP,JP,MS,BS,WS, SS,BB,R,C,AW
Wheatgrass, Siberian crested	3	5	5	5	5	4	4	4	S	5	2	2	2	5	3	5	3	5	4	2	2	4	BS,WS,SS,BG,BB, IS,C,AW
Wheatgrass, slender	4	5	5	5	4	5	4	4	S	4	4	3	4	3	4	5	4	4	4	4	3	5	SA,A,MB,PP,JP,MS
Wheatgrass, Snake River	5	5	5	5	5	5	4	4	S	5	3	4	4	5	5	5	4	4	4	2	2	5	MB,PP,JP,MS,BS, WS,C,AW
Wheatgrass, standard crested	5	5	5	5	5	5	5	5	S	5	2	3	1	5	4	5	3	5	5	3	2	4	MB,PP,JP,MS,BS,WS, SS,BG,BB,C,AW
Wheatgrass, tall	5	5	5	5	5	5	5	4	S	4	3	3	2	4	5	3	2	4	4	3	5	4	MB,PP,JP,MS,BS,WS, BG,IS,R,C,AW
Wheatgrass, thickspike	4	5	5	5	4	4	4	3	V	5	3	3	2	5	3	4	2	5	5	4	3	5	MB,PP,JP,MS,BS
Wheatgrass, western	3	5	5	5	3	3	3	5	V	5	3	3	3	5	3	4	3	5	5	4	3	5	MP,PP,JP,MS,BS,WS, SS,BG,R,C,AW
Wildrye, Altai	5	5	5	4	2	2	3	5	V	4	4	3	3	4	5	4	3	5	5	4	4	3	MB,PP,JP,BG,IS,R
Wildrye, blue	4	5	5	4	5	5	4	3	S	4	4	3	3	4	5	4	4	2	4	3	3	2	A,MB
Wildrye, Canada	4	3	2	4	4	3	4	4	S	4	4	3	4	4	4	4	4	3	4	4	3	2	A,MB,WM,IS,R
Wildrye, alkali	3	4	5	4	4	4	4	4	V	4	4	2	3	4	4	4	3	4	5	2	3	2	WM,JP,BS,WS,SS,BG,IS
Wildrye, Great Basin	5	4	5	4	4	3	3	3	S	5	4	2	4	5	5	4	3	2	4	2	4	5	WM,MB,MS,BG,IS, R,C,AW
Wildrye, mammoth	1	3	5	4	3	3	3	2	V	4	4	2	4	5	5	2	2	4	4	2	4	4	MB,JP,MS,BS
Wildrye, Russian	4	4	5	5	4	3	3	5	S	5	4	4	4	5	4	5	5	5	4	2	2	4	MS,JP,MS,BS,WS,SS, BG,BB,IS,C,AW
Wildrye, Salina	2	4	5	4	1	2	2	4	V	4	3	2	2	5	2	1	1	5	5	2	3	2	MB,PP,JP,MS,BS,WS, SS,BG,IS,C,AW

[a]Vegetative types to which the species is adapted: A = Aspen-conifer; AW = Annual weeds; BB = Blackbrush; BG = Black greasewood; BS = Basin big sagebrush; C = Cheatgrass; IS = Inland saltgrass; JP = Juniper-pinyon; MB = Mountain brush; MS = Mountain big sagebrush; PP = Ponderosa pine; R = Riparian; SA = Subalpine; SS = Shadscale saltbush; WM = Wet and semiwet meadows; WS = Wyoming big sagebrush.

[b] Key to ratings: 1 = Poor – difficult; 2 = Fair; 3 = Medium; 4= Good; 5 = Excellent – easy; A = Annual - reproduction from seed; S = Reproduction from seed; V = Reproduction vegetative and from seed .

Table 3—Scientific names, synonyms, and common names of grass species. ND = Species not described in reference.

Scientific name				Common name	
Hitchcock (1951)	**Barkworth and Dewey (1985), Dewey (1984)**	**Arnow (1987)**	**USDA NRCS (2002)**	**Plummer and others (1977)**	**USDA NRCS (2002)**
Agropyron cristatum	*Agropyron cristatum*	*Agropyron cristatum*	*Agropyron cristatum*	Wheatgrass, fairway crested	Wheatgrass, crested
Agropyron dasystachyum	*Elymus lanceolatus*	*Elymus lanceolatus*	*Elymus lanceolatus*	Wheatgrass, thickspike	Wheatgrass, streambank
Agropyron desertorum	*Agropyron desertorum*	*Agropyron desertorum*	*Agropyron desertorum*	Wheatgrass, standard crested (desert)	Wheatgrass, desert
Agropyron elongatum	*Thinopyrum elongatum*	*Elymus elongatus*	*Thinopyrum ponticum*	Wheatgrass, tall	Wheatgrass, rush
Agropyron inerme	*Pseudoroegneria spicata*	*Elymus spicatus*	*Pseudoroegreria spicata* ssp. *inermis*	Wheatgrass, beardless bluebunch	Wheatgrass, beardless
Agropyron intermedium	*Thinopyrum intermedium*	*Elymus hispidus*	*Thinopyrum intermedium*	Wheatgrass, intermediate	Wheatgrass, intermediate
Agropyron junceum	*Thinopyrum junceiforme*	ND	*Thinopyrum junceiforme*	Wheatgrass, rushleaf	Wheatgrass, Russian
Agropyron repens	*Elytrigia repens*	*Elymus repens*	*Elymus repens*	Quackgrass	Quackgrass
Agropyron riparium	*Elymus lanceolatus*	*Elymus lanceolatus*	*Elymus lanceolatus* ssp. *lanceolatus*	Wheatgrass, steambank	Wheatgrass, steambank
Agropyron scribneri	*Elymus scribneri*	*Elymus scribneri*	*Elymus scribneri*	Wheatgrass, Scribner	Wheatgrass, spreading
Agropyron sibiricum	*Agropyron fragile*	*Agropyron cristatum*	*Agropyron fragile*	Wheatgrass, Siberian	Wheatgrass, Siberian
Agropyron smithii	*Pascopyrum smithii*	*Elymus smithii*	*Pascopyrum smithii*	Wheatgrass, western	Wheatgrass, western
Agropyron spicatum	*Pseudoroegneria spicata*	*Elymus spicatus*	*Pseudoroegneria spicata* ssp. *spicata*	Wheatgrass, bluebunch	Wheatgrass, bluebunch
Agropyron subsecundum	*Elymus trachycaulus*	*Elymus trachycaulus*	*Elymus trachycaulus* ssp. *subsecundus*	Wheatgrass, bearded	Wheatgrass, slender
Agropyron trachycaulum	*Elymus trachycaulus*	*Elymus trachycaulus*	*Elymus trachycaulus* ssp. *trachycaulus*	Wheatgrass, slender	Wheatgrass, slender
Agropyron trichophorum	*Thinopyrum intermedium*	*Elymus hispidus*	*Thinopyrum intermedium*	Wheatgrass, pubescent	Wheatgrass, intermediate
Agrostis alba	ND	*Agrostis stolonifera*	*Agrostis gigantea*	Bentgrass, redtop	Redtop
Agrostis stolonifera	ND	*Agrostis stolonifera*	*Agrostis stolonifera*	Bentgrass, carpet	Bentgrass, creeping
Alopecurus arundinaceus	ND	ND	*Alopecurus arundinaceus*	Foxtail, reed	Foxtail, creeping meadow
Alopecurus pratensis	ND	*Alopecurus pratensis*	*Alopecurus pratensis*	Foxtail, meadow	Foxtail, meadow
Aristida longiseta	ND	*Aristida purpurea*	*Aristida purpurea* var. *longiseta*	Threeawn, red	Threeawn, fendler
Arrhenatherum elatius	ND	*Arrhenatherum elatius*	*Arrhenatherum elatius*	Oatgrass, tall	Oatgrass, tall
Bouteloua curtipendula	ND	*Bouteloua curtipendula*	*Bouteloua curtipendula*	Grama, sideoats	Grama, sideoats
Bouteloua gracilis	ND	*Bouteloua gracilis*	*Bouteloua gracilis*	Grama, blue	Grama, blue
Bromus anomalus	ND	*Bromus anomalus*	*Bromus anomalus*	Brome, nodding	Brome, nodding
Bromus biebersteinii	ND	*Bromus biebersteinii*	*Bromus biebersteinii*	Brome, Regar (meadow)	Brome, meadow
Bromus carinatus	ND	*Bromus carinatus*	*Bromus carinatus*	Brome, mountain	Brome, California
Bromus erectus	ND	ND	*Bromus erectus*	Brome, meadow	Brome, erect
Bromus inermis	ND	*Bromus inermis*	*Bromus inermis*	Brome, smooth	Brome, smooth
Bromus marginatus	ND	*Bromus carinatus*	*Bromus marginatus*	Brome, big mountain	Brome, mountain
Bromus pumpellianus	ND	*Bromus inermis*	*Bromus inermis* ssp. *pumpellianus*	Brome, Pumpelly	Brome, Pumpelly
Bromus rubens	ND	*Bromus rubens*	*Bromus rubens*	Brome, foxtail	Brome, red
Bromus tectorum	ND	*Bromus tectorum*	*Bromus tectorum*	Brome, cheatgrass	Cheatgrass
Calamagrostis canadensis	ND	*Calamagrostis canadensis*	*Calamagrostis canadensis*	Reedgrass, bluejoint	Bluejoint
Calamagrostis epigeios	ND	ND	*Calamagrostis epigeios*	Reedgrass, chee	Reedgrass, chee
Dactylis glomerata	ND	*Dactylis glomerata*	*Dactylis glomerata*	Orchardgrass	Orchardgrass
Deschampsia caespitosa	ND	*Deschampsia cespitosa*	*Deschampsia caespitosa*	Hair-grass, tufted	Hairgrass, tufted
Distichlis spicata	ND	*Distichlis spicata*	*Distichlis spicata*	Saltgrass, inland	Saltgrass, inland
Elymus angustus	*Leymus angustus*	ND	*Leymus angustus x*	Wildrye, Altai	Wildrye, Altai
Elymus aristatus	ND	ND	*Elyleymus aristatus* (*Elymus elymoides* x *Leymus triticoides*)	Wildrye, purple	Wildrye, purple
Elymus canadensis	*Elymus canadensis*	*Elymus canadensis*	*Elymus canadensis*	Wildrye, Canada	Wildrye, Canada
Elymus cinereus	*Leymus cinereus*	*Elymus cinereus*	*Leymus cinereus*	Wildrye, Great Basin	Wildrye, basin
Elymus flavescens	*Leymus flavescens*	ND	*Leymus flavescens*	Wildrye, yellow	Wildrye, yellow
Elymus giganteus	*Leymus racemosus*	ND	*Leymus racemosus*	Wildrye, mammoth	Wildrye, mammoth
Elymus glaucus	*Leymus glaucus*	*Elymus glaucus*	*Elymus glaucus*	Wildrye, blue	Wildrye, blue
Elymus junceus	*Psathyrostachys juncea*	*Elymus junceus*	*Psathyrostachys juncea*	Wildrye, Russian	Wildrye, Russian
Elymus sabulosus	ND	ND	*Leymus racemosus* ssp. *sabulosa*	Wildrye, sabulosa	Wildrye, mammoth
Elymus salinus	*Leymus salinus*	*Elymus salinus*	*Leymus salinus* ssp. *salinus*	Wildrye, salina	Wildrye, saline

(con.)

Table 3 (Con.)

Scientific name				Common name	
Hitchcock (1951)	Barkworth and Dewey (1985), Dewey (1984)	Arnow (1987)	USDA NRCS (2002)	Plummer and others (1977)	USDA NRCS (2002)
Elymus simplex	*Leymus simplex*	*Elymus simplex*	*Leymus simplex*	Wildrye, low creeping	Wildrye, alkali
Elymus triticoides	*Leymus triticoides*	*Elymus triticoides*	*Leymus triticoides*	Wildrye, creeping	Wildrye, beardless
Festuca arizonica	ND	*Festuca ovina* var. *arizonica*	*Festuca arizonica*	Fescue, Arizona	Fescue, Arizona
Festuca arundinacea	ND	*Festuca arundinacea*	*Lolium arundinaceum*	Fescue, reed (Alta, tall)	Fescue, tall
Festuca elatior	ND	*Festuca pratensis*	*Lolium pratense*	Fescue, meadow	Ryegrass, meadow
Festuca idahoensis	ND	*Festuca ovina* var. *ingrata*	*Festuca idahoensis*	Fescue, Idaho	Fescue, Idaho
Festuca ovina var. *duriuscula*	ND	*Festuca ovina* var. *duriuscula*	*Festuca trachyphylla*	Fescue, hard sheep	Fescue, hard
Festuca ovina var. *ovina*	ND	*Festuca ovina* var. *ovina*	*Festuca ovina*	Fescue, sheep	Fescue, sheep
Festuca thurberi	ND	*Festuca thurberi*	*Festuca thurberi*	Fescue, Thurber	Fescue, Thurber
Hesperochloa kingii	ND	*Leucopoa kingii*	*Leucopoa kingii*	Fescue, spike	Fescue, spike
Hilaria jamesii	ND	*Hilaria jamesii*	*Pleuraphis jamesii*	Galleta	Galleta, James
Hordeum brachyantherum	*Hordeum brachyantherum*	*Hordeum brachyantherum*	*Hordeum brachyantherum*	Barley, meadow	Barley, meadow
Hordeum bulbosum	ND	ND	*Hordeum bulbosum*	Barley, bulbous	Barley, bulbous
Hordeum jubatum	*Hordeum jubatum*	*Horedum jubatum*	*Hordeum jubatum*	Barley, foxtail	Barley, foxtail
Hordeum vulgare	ND	*Horedum vulgare*	*Hordeum vulgare*	Barley, beardless	Barley, common
Koeleria cristata	ND	*Koeleria macrantha*	*Koeleria macrantha*	Junegrass, prarie	Junegrass, prarie
Lolium multiflorum	ND	*Lolium perenne*	*Lolium perenne* ssp. *multiflorum*	Ryegrass, Italian	Ryegrass, Italian
Lolium perenne	ND	*Lolium perenne*	*Lolium perenne*	Ryegrass, perennial	Ryegrass, perennial
Melica bulbosa	ND	*Melica bulbosa*	*Melica bulbosa*	Oniongrass	Oniongrass
Oryzopsis hymenoides	ND	*Stipa hymenoides*	*Achnatherum hymenoides*	Ricegrass, Indian	Ricegrass, Indian
Phalaris arundinacea	ND	*Phalaris arundinacea*	*Phalaris arundinacea*	Canarygrass, reed	Canarygrass, reed
Phleum alpinum	ND	*Phleum alpinum*	*Phleum alpinum*	Timothy, alpine	Timothy, alpine
Phleum pratense	ND	*Phleum pratense*	*Phleum pratense*	Timothy	Timothy
Poa ampla	ND	*Poa secunda*	*Poa secunda*	Bluegrass, big	Bluegrass, Sandberg
Poa bulbosa	ND	*Poa bulbosa*	*Poa bulbosa*	Bluegrass, bulbous	Bluegrass, bulbous
Poa canbyi	ND	*Poa secunda*	*Poa secunda*	Bluegrass, Canby	Bluegrass, Sandberg
Poa compressa	ND	*Poa compressa*	*Poa compressa*	Bluegrass, Canada	Bluegrass, Canada
Poa cusickii	ND	*Poa fendleriana*	*Poa cusickii*	Bluegrass, Cusick	Bluegrass, Cusick
Poa fendleriana	ND	*Poa fendleriana*	*Poa fendleriana*	Bluegrass, mutton	Muttongrass
Poa longiligula	ND	*Poa fendleriana*	*Poa fendleriana* ssp. *longiligula*	Bluegrass, longtongue	Muttongrass
Poa nevadensis	ND	*Poa secunda*	*Poa secunda*	Bluegrass, Nevada	Bluegrass, Sandberg
Poa pratensis	ND	*Poa pratensis*	*Poa pratensis*	Bluegrass, Kentucky	Bluegrass, Kentucky
Poa reflexa	ND	*Poa reflexa*	*Poa reflexa*	Bluegrass, nodding	Bluebrass, nodding
Poa scabrella	ND	*Poa secunda*	*Poa secunda*	Bluegrass, pine	Bluegrass, Sandberg
Poa secunda	ND	*Poa secunda*	*Poa secunda*	Bluegrass, Sandberg	Bluegrass, Sandberg
Secale montanum	ND	*Secale montanum*	ND	Rye, mountain	ND
Sitanion hystrix	*Elymus elymoides*	*Elymus elymoides*	*Elymus elymoides*	Squirreltail, bottlebrush	Squirreltail
Sporobolus airoides	ND	*Sporobolus airoides*	*Sporobolus airoides*	Sacaton, alkali	Sacaton, alkali
Sporobolus cryptandrus	ND	*Sporobolus cryptandrus*	*Sporobolus cryptandrus*	Dropseed, sand	Dropseed, sand
Stipa columbiana	ND	*Stipa nelsonii*	*Achnatherum nelsonii*	Needlegrass, subalpine	Needlegrass, Columbia
Stipa comata	ND	*Stipa comata*	*Hesperostipa comata*	Needle-and-thread	Needle-and-thread
Stipa lettermanii	ND	*Stipa lettermanii*	*Achnatherum lettermanii*	Needlegrass, Letterman	Needlegrass, Letterman
Stipa thurberiana	ND	*Stipa thurberiana*	*Achnatherum thurberianum*	Needlegrass, Thurber	Needlegrass, Thurber
Stipa viridula	ND	*Stipa viridula*	*Nassela viridula*	Needlegrass, green	Neddlegrass, green
Trisetum spicatum	ND	*Trisetum spicatum*	*Trisetum spicatum*	Trisetum, spike	Tristetum, spike

and about 0.04 inch (l mm) long. The spike is 0.8 to 4 inches (2 to 10 cm) long and 0.2 to 0.9 inch (5 to 23 mm) wide. Spikelets are several times longer than the internodes. Each produces 3 to 10 florets, but the upper florets are sterile. Glumes and lemmas are tapered to a short awn about 0.12 inch (3 mm) long. Arnow (1987), Brown (1979), Cronquist and others (1977), Hitchcock and others (1969), Gould (l951), Looman (1982), and Powell (1994) provide detailed descriptions of the species.

Although fairway crested wheatgrass resembles standard crested wheatgrass and Siberian wheatgrass, some differences can usually be observed (fig. 1). The major taxonomic feature used to differentiate the three grasses is the spike shape. Fairway crested wheatgrass spikes are shorter, wider at the base, and more distinctly tapered at the tip than those of standard crested wheatgrass. Spikes of Siberian wheatgrass are relatively long and narrow compared to those of the other two wheatgrasses. Fairway crested wheatgrass spikelets and awns are divergent and arranged in a "comblike" manner, while those of standard crested wheatgrass and Siberian wheatgrass grow at a strong upward angle. Compared to fairway crested wheatgrass, the stems of standard crested wheatgrass are more erect and more or less uniform in height, its leaves are mostly basal, and the upper leaf blades are generally without hairs.

Figure 1—Spikelets of fairway crested wheatgrass (center) are divergent and comblike, while those of standard crested wheatgrass (left) and Siberian crested wheatgrass (right) grow upward (RMRS photo).

Ecological Relationships and Distribution

Problems relative to the proper identification and use of the crested wheatgrasses arose, in part, from the failure of earlier workers to identify them correctly and to recognize their differing ecological requirements. In addition, although the name "crested wheatgrass" refers to the comblike spike of fairway crested wheatgrass, this common name has been applied to all three taxa. Dillman (1946) suggested that some of the confusion resulted from a 1910 report he prepared in which both fairway crested wheatgrass and standard crested wheatgrass were referred to as *A. cristatum* (Dillman 1910). This was compounded in 1935 when Hitchcock (1935) used a drawing of A. *desertorum* to illustrate *A. cristatum* in the "Manual of the Grasses of the United States."

To address these problems, Weintraub (1953) applied the following common names: crested wheatgrass = *A. cristatum*; desert wheatgrass = *A. desertorum*; and Siberian wheatgrass = *A. sibiricum*. Beetle (1961) recommended acceptance of this usage, but the confusion continued. Dewey (1986) later suggested that the most appropriate names for the three groups in North America are fairway crested wheatgrass (*A. cristatum*), standard or desert crested wheatgrass (*A. desertorum*), and Siberian crested wheatgrass (*A. sibiricum*) (fig. 1). Differences between Eurasian and North American taxonomic treatments further compound this situation and have yet to be resolved.

The crested wheatgrasses constitute a polyploid complex (Dewey 1986; Taylor and McCoy 1973). Diploid (2n = 14) fairway crested wheatgrass is native to the Steppe region of Eastern Russia and Southwestern Siberia (Asay 1995a,b; Dewey 1966, 1969, 1973; Dewey and Asay 1982; Konstantinov 1920). Dewey and Asay (1982) identified different morphological growth forms of diploid introductions, but found that they hybridized readily. Tetraploids (2n = 28) include standard and Siberian wheatgrass and are widely distributed from central Europe to the Middle East, Siberia, Mongolia, and China (Asay and Dewey 1979; Dewey 1986; Knowles 1955; Tsvelev 1976). The hexaploids (2n = 42) are less common and more scattered, occurring in Turkey, Iran, and Kazakhstan (Asay and others 1990; Dewey and Asay 1975). All possible crosses have been made among the three ploidy levels (Asay and Dewey 1979; Asay and Knowles 1985a,b; Dewey 1971, 1974), but breeding has generally been confined to selections within ploidy levels, particularly the diploid and tetraploid levels (Asay 1986).

Crested wheatgrass was first introduced in the United States by the U.S. Department of Agriculture in 1889 (Dillman 1946; Reitz and others 1936). Materials were obtained from the Valuiki Experiment Station, Samara Government, on the Volga River, some 150 miles (240 km) north of St. Petersburg, Russia.

Additional seed was obtained from the Valuiki Station in 1906. This shipment included six seed lots of 4 to 5 pounds (1.8 to 2.3 kg) each. One lot, S.P.I. 19536, was labeled *A. cristatum* and five lots, S.P.I. 19537 to19541, *A. desertorum*. Plantings and research with crested wheatgrass began in 1908 at the Belle Fourche Station, Newell, SD, and in 1915 at the Northern Great Plains Field Station in Mandan, ND (Dillman 1946).

Studies initiated in Canada greatly advanced the development and use of crested wheatgrass (Kirk 1928). Kirk and others (1934) reported that seed obtained from the U.S. Department of Agriculture was planted in University of Saskatchewan experimental plots. Additional introductions were obtained from Russia, Siberia, and Mandan, ND. In 1927, seed obtained from Montana was planted at Manyberries, Alberta. The University of Saskatchewan developed two strains. One, identified as 'Fairway' (S-10), ultimately gained widespread use (Kirk and others 1934). Fairway was initially distributed by the Field Husbandry Department, University of Saskatchewan, in 1927, and licensed in 1932 as a variety (Kirk 1932; Knowles 1956). Dillman (1946) concluded that the Fairway variety originated from the same accession S.P.I. 19536, *A. cristatum*.

Scientists working in Montana recognized that the erect bunch-type growth forms of *A. desertorum* differed from fairway-type crested wheatgrass. The Montana Station was the first to apply the name "standard crested wheatgrass" for certified seed increased from S.P.I. 19537, an *A. desertorum* accession (Dillman 1946). The selection was used as a standard of comparison for assessment of other selections (Dewey 1986). The name "standard crested wheatgrass" slowly evolved to distinguish any nonfairway-type crested wheatgrass. Standard is not a specific cultivar, but is now used to identify all standard-type *A. desertorum*. Seed of standard wheatgrass was first produced commercially by a grower in Montana shortly after 1920, and was first listed in 1927 by a dealer in North Dakota (Westover and others 1932).

Plant Culture

Good seed crops of fairway crested wheatgrass are regularly produced on irrigated farmlands in Western Canada, the Pacific Northwest, the Intermountain area, and the Great Plains (Hafenrichter and others 1949; Knowles 1956; Reitz and others 1936; Westover and Rogler 1947; Westover and others 1932). In these areas, dryland farms, pastures, and rangeland plantings are also managed for seed production. Seed is harvested from these plantings only during years with adequate moisture, but large quantities of seed may be harvested in good precipitation years. Yields from irrigated fields average 300 to 600 pounds per acre (325 to 675 kg per ha), while yields from dryland stands produce 250 to 300 pounds per acre (275 to 325 kg per ha) (Westover and others 1932). Less than 100 pounds per acre (110 kg per ha) are normally harvested from rangeland stands in the Intermountain area. Row spacings of 36 to 42 inches (91 to 107 cm) are recommended for cultivated fields. This equates to 5 to 8 pounds of seed per acre (5.5 to 9.5 kg per ha). Planting at 3 to 4 pounds per acre (3.4 to 4.5 kg per ha) provides satisfactory, but slower developing, stands (Westover and Rogler 1947). Direct combining provides seed lots with purities of 50 to 80 percent; this may be increased to 95 percent purity by screening and fanning. Germination is often near 90 percent. Seed can usually be stored in a warehouse for several years without loss of viability.

Fairway crested wheatgrass is one of the most reliable plants to establish from drill seedings on adapted range and wildland sites. It generally develops fairly uniform stands, even on highly variable sites. Maynard and Gates (1963) reported that establishment success of crested wheatgrass could be attributed to the tolerance of the seeds to extreme fluctuations in soil moisture. Wetting and drying cycles can increase germination. Plummer (1943) reported that the success of crested wheatgrass stems from its ability to produce a greater total root length in the seedling stage than other grass species.

Drill seeding rangeland sites with 2 to 16 pounds of fairway crested wheatgrass seed per acre (2.2 to 17.6 kg per ha) was initially advised for sites receiving more than 12 inches (310 mm) of precipitation, and 5 to 6 pounds per acre (5.5 to 6.6 kg per ha) for sites receiving less than 12 inches (310 mm) of moisture (Thomas and others 1945). More recently, seeding recommendations have been reduced to 2 to 4 pounds per acre (2.2 to 4.4 kg per ha) for either drilling or broadcast seeding. When fairway crested wheatgrass is seeded alone in areas invaded by weeds, the rate should be increased 2 to 3 times. Seeding in dense annual weeds, however, is not advisable. Springfield (1965) reported that crested wheatgrass stands will reach an equilibrium within 5 to 8 years, regardless of the amount of seed sown or the drill row spacing used. He found similar herbage yields on sites seeded at 2, 4, and 6 pounds seed per acre (2.2, 4.4, and 6.6 kg per ha) at 5-, 12-, and 18-inch (13-, 30-, 46-cm) row spacings in the fifth, sixth, and eighth years after seeding.

Fairway crested wheatgrass seed should be drilled or otherwise planted at depths of 0.5 to 1.0 inch (1.3 to 2.5 cm). Planting at greater depths in heavy-textured soils is not advised. Compared with many other rangeland grasses, fairway crested wheatgrass establishes better with limited seedbed preparation. McGinnies (1962), however, found that packing to create a firm seedbed improved planting success. Cultipacking before seeding provides a firm seedbed, permitting furrow openers to function more effectively. Broadcast seeding without some means of seed coverage is not recommended. Direct drilling or broadcast seeding and covering the seed following burning or removal of competition is generally successful. Stevens (1987b) reported that fairway crested wheatgrass plants establish extremely well following aerial seeding and chaining on pinyon-juniper and big sagebrush disturbances.

Fall seedings are recommended, but spring plantings on prepared seedbeds may be successful if adequate spring precipitation is received. Frischknecht (1951) found that the total emergence from crested wheatgrass and other grass seedings was greater from early fall than from late fall or spring plantings, and that cold temperatures accounted for most grass seedling mortality. Buman and Abernethy (1988) found that mountain rye, crested wheatgrass, and cheatgrass have similar germination temperature requirements, which accounts for the ability of fairway crested wheatgrass seedlings to compete favorably with cheatgrass. Asay and Johnson (1983) found that genetic differences among populations of crested wheatgrass accounted for over 50 percent of the total phenotypic variation in traits affecting seeding establishment. Seed weight was closely correlated to seeding establishment.

Established stands of fairway crested wheatgrass may produce seed crops annually, depending on precipitation, but plants do not spread rapidly to adjacent areas. Seedlings of this species quickly occupy openings created in fairway crested wheatgrass stands. When seeded in mixtures with other grasses, fairway crested wheatgrass often increases in density at the expense of the other species. Walker and others (1995), reporting on long-term studies of seedings in pinyon-juniper sites in central Utah, found that fairway crested wheatgrass density increased at a higher rate than native bunchgrasses during periods of normal precipitation, but native bunchgrasses increased in density and ground cover at a greater rate during years of low precipitation. They found that over a 23-year period, native grasses were not able to compete with introduced species including fairway crested wheatgrass. Broadcast seeding fairway crested wheatgrass at low rates of 1 to 2 pounds per acre (1.1 to 2.2 kg per ha) in pinyon-juniper and big sagebrush disturbances has been employed to encourage the recovery of native species. Although native herbs and shrubs increase initially in some situations, slow but persistent increase of fairway crested wheatgrass followed, and within 25 to 40 years it gained dominance.

Uses and Management

Fairway crested wheatgrass has been extensively used in pasture and rangeland plantings in the United States and Canada. In Western Canada, it is used far more than standard crested wheatgrass (Westover and Rogler 1947). In the United States, the Civilian Conservation Corps used both fairway and standard crested wheatgrass extensively for conservation plantings in the 1930s. Use increased in 1945 following a special Congressional Appropriation for research to improve rangelands (Reynolds and Springfield 1953).

Fairway crested wheatgrass is well adapted to the Northern and Central Great Plains and the drier communities of the Intermountain region. Fairway and standard crested wheatgrass are seeded to stabilize marginal farmlands and deteriorated rangelands in the Western United States. Fairway crested wheatgrass has been used in mixtures with other grasses and alfalfa for hay production. It has also been planted alone in lawns, yards, and on roadways where supplemental irrigation cannot be provided (Knowles 1956).

Fairway crested wheatgrass cultivars are best adapted to ponderosa pine, mountain brush, pinyon-juniper, and benchland sites occupied by big sagebrush. They are also adapted to open, exposed slopes with intermixed aspen and spruce-fir communities. Reitz and others (1936) reported that fairway crested wheatgrass persists on dry, open areas at elevations up to 6,800 ft (2,070 m). Plantings in central Utah have established well on open slopes at elevations near 8,000 ft (2,440 m).

On adapted sites, fairway crested wheatgrass becomes dormant during dry periods, but it will resume growth in fall or spring when adequate moisture becomes available. It tolerates a range of soil textures and pH levels, and withstands saline conditions, but it will not survive flooding for more than a few days. Fairway crested wheatgrass grows better in moderate shade than either standard crested wheatgrass or Siberian wheatgrass, but it does not persist in dense shade. It can establish even with some grazing during seedling establishment (Johnson 1986), although grazing of new seedings is not advised. Mature plants can persist with heavy and repeated grazing. Resistance to grazing abuse is a primary factor that has promoted seedings of this grass.

Fairway crested wheatgrass is generally less well adapted to low-elevation shrubland communities occupied by Wyoming big sagebrush and salt desert species than are other crested wheatgrasses. Fairway crested wheatgrass plantings have established and persisted in arid regions for a number of years, but some of these have been lost during droughts. The species is suited to sagebrush communities that receive more than 10 inches (250 mm) of precipitation, but it should not be planted in communities receiving less than this amount. In the Southwest and areas with long warm summers, it will not persist unless annual precipitation exceeds 15 inches (380 mm) (Reynolds and Springfield 1953).

Thousands of acres of abandoned farmland and overgrazed rangelands have been seeded to fairway crested wheatgrass to provide spring-summer forage for livestock, soil stabilization, and weed control (Barnes and others 1952; Bridges 1942; Christ 1934; Hull 1974; Knowles 1956; Westover and Rogler 1947). In some situations, fairway crested wheatgrass has been seeded as a replacement for native grasses (Stark and others 1946). Many of these areas were disked or burned to remove existing competitive vegetation prior to seeding (Malechek 1986). In addition, extensive areas dominated by big sagebrush have been plowed, disked, burned, or sprayed to remove the shrubs, then seeded with this species and other introduced perennials to enhance livestock grazing (Plummer and others 1955; Robertson and others 1966). Fairway crested wheatgrass seedings have prevented the recovery of big sagebrush where vigorous stands of the grass have developed and the sagebrush seed source has been eliminated. Natural recovery of sagebrush, however, has occurred in other areas.

If seeded in mixtures, fairway crested wheatgrass can be drill seeded with other introduced grasses and broadleaf herbs that produce vigorous seedlings. It is capable of persisting with competitive sod-forming perennials, including intermediate wheatgrass and smooth brome. Although these two sodforming grasses may prevent the spread of crested wheatgrass, a bunchgrass, they do not eliminate it. Fairway crested wheatgrass is often planted in mixtures with alfalfa in mountain brush, ponderosa pine, and other upland communities to provide summer forage for game and livestock. Once established, both species persist if properly managed. Production of fairway crested wheatgrass may be enhanced by the presence of alfalfa. Fairway crested wheatgrass is also frequently seeded with alfalfa and late-maturing grasses to maintain herbage quality and diversity (Mayland 1986; USDA Forest Service 1937).

Fairway crested wheatgrass can be broadcast seeded with most revegetation species, including those that are slower to develop if appropriate planting designs are adopted. Drill seeding fairway crested wheatgrass with slower developing native shrubs and herbs is not recommended unless provisions are made to seed the species in separate rows or strips that are adequately spaced to minimize competition (Hubbard 1957). Planting bitterbrush in rows less than 2 ft (0.6 m) from fairway crested wheatgrass rows, for example, was found to significantly decrease vigor and growth of the shrubs (Hubbard and others 1962).

Fairway crested wheatgrass can be successfully interseeded in cheatgrass using conventional, deep furrow, rangeland drills that create openings about 4 to 6 inches (10 to 15 cm) wide. This reduces competition and permits establishment of the perennial grass. Areas with dense populations of annual weeds should be avoided. Fairway crested wheatgrass plantings have also been important in the control and elimination of halogeton and Russian thistle (Mathews 1986; Mayland 1986). The species has been particularly useful in replacing cheatgrass and slowing the spread of wildfires (Monsen and Kitchen 1994). Few other perennial grasses establish as well as crested wheatgrasses amid weedy competition.

Crested wheatgrass begins growth in early spring and provides considerable herbage during this period (Malechek 1986). Nutritive value is good for energy and fair for protein (Dittberner and Olson 1983). Crude protein, calcium, phosphorus, and ash decrease as plants mature in late May and June (Mayland 1986). The degree of use is rated as good for livestock and fair for wildlife (Dittberner and Olson 1983).

Fairway crested wheatgrass has stabilized eroding areas, reduced runoff, and provided a stable vegetative cover on many disturbed sites. It performs well as a pioneer species capable of stabilizing exposed substrata, and it does not require heavy fertilizer applications to maintain an acceptable cover. It is frequently used in big sagebrush communities to control weed invasions and stabilize watersheds, roadways, and mine disturbances. It furnishes soil protection on sites where high-intensity storms are common.

In many cases, however, fairway crested wheatgrass seedings have adversely impacted wildlife habitat. Conversion of native shrub and herb communities to solid stands of this grass have reduced cover and forage for big game and nongame animals (Marlette and Anderson 1984). Fairway crested wheatgrass seedings provide important supplements to deer diets in spring and fall. Elk, pronghorn antelope, and bighorn sheep also use it (Urness l986). These seedings, however, do not afford the diversity and quality of forage provided by native communities. A primary concern in seeding fairway crested wheatgrass is the resulting monotypic stands that often develop, reducing species diversity and habitat quality (DePuit 1986; Marlette and Anderson 1986). Development of technology for replacing fairway crested wheatgrass with more diverse native species to improve habitat characteristics is becoming a management objective in many areas.

Single species plantings of fairway crested wheatgrass normally persist as a monoculture, although invasion of a few other species may occur after 15 to 20 years. Marlette and Anderson (1984) found that invading species seldom comprise more than 10 percent of the total plant density. Stands of fairway crested wheatgrass have persisted for over 50 years in the Great Plains (Mayland 1986), and for over 30 years in the Intermountain West (Marlette and Anderson 1984; Plummer and others 1968). This species does not invade or migrate into disturbances of early successional communities occupied by annual weeds, and it has made only minor migrations into climax grasslands (Allred 1940).

Varieties and Ecotypes

Since its introduction in 1906, the crested wheatgrass complex has been studied intensively. Cultivars have been developed for a broad range of planting sites and conditions (Asay 1986; Dillman 1946). Selection and breeding programs are currently underway to select strains that are more drought tolerant and productive, and that remain green longer in summer. Rhizomatous forms of crested wheatgrass are being developed to provide low maintenance turf and roadway plantings. Breeding has been primarily within the diploid or tetraploid levels, but hybrids between standard crested wheatgrass and induced tetraploid fairway crested wheatgrass developed by Agricultural Research Service scientists in Logan, UT, are highly competitive on semiarid rangeland sites.

Scientists at the Agricultural Research Service, Crops Research Laboratory in Logan, UT, developed 'CD-II' crested wheatgrass from the original 'Hycrest' hybrid. Selections were made from Hycrest foundation seed fields based on vegetative vigor, absence of purple leaves in spring, freedom from disease and insects, and leafiness. From these clonal lines, a second evaluation was conducted for the same vegetative characteristics and for individual seed weight and emergence of polycross seed lots from deep seedings.

CD-II is leafier than Hycrest and produces more forage at low spring temperatures. Stand establishment and adaptation to arid conditions are comparable to Hycrest. Seed production is excellent, ranging from 600 to 800 pounds per acre (660 to 940 kg per ha). CD-II is recommended for semiarid sites at elevations up to 7,150 ft (2,345 m) receiving from 8 to 18 inches (200 to 450 mm) of annual precipitation (Asay and others 1997).

'Douglas' crested wheatgrass, developed by the Agricultural Research Service in Logan, UT, and released in 1994, is the first hexaploid (2n = 42) cultivar of crested wheatgrass released in North America (Asay and others 1995a) (fig. 2). It was named in honor of Dr. Douglas R. Dewey, who initiated research on the perennial Triticeae at the Logan laboratory. Douglas crested wheatgrass was derived from hybrids between a broad-leaved hexaploid accession from the former Soviet Union and hexaploid lines from Iran and Turkey (Asay and others 1996). Douglas was selected for its leafiness, retention of green leaves into summer, palatability to wildlife and livestock, and high in vitro digestibility. It produces larger seeds than diploid or tetraploid cultivars. Douglas should be fall seeded on sites receiving at least 12 to 15 inches (300 to 376 mm) of annual precipitation. Its seedling vigor and ability to establish from a 3-inch (7.6-cm) planting depth were greater than for 'Nordan', Fairway, or 'Ephraim', and equaled Hycrest (Asay and others 1996).

Douglas demonstrates promise for seeding in areas dominated by cheatgrass that are prone to frequent burning. It can he used to replace cheatgrass, and it can be planted in strips as a fuel or fire barrier. Douglas is less drought resistant than standard or Hycrest crested wheatgrass, but it remains green longer in summer, and plants are less flammable during this period. Fires that ignite in cheatgrass may burn into the firebreak provided by Douglas, but their advance is slowed.

The Forest Service, Utah Division of Wildlife Resources, Natural Resource Conservation Service, and the Agriculture Experiment Stations of Utah, Arizona, and Idaho released Ephraim crested wheatgrass in 1983. It was developed from an introduction from Ankara, Turkey, and planted by A. Perry Plummer at an arid range site in central Utah in the early 1940s where it survived for over 40 years. Seed and plants from this site were tested at additional locations throughout the Intermountain area (Plummer and others 1968).

Ephraim was the first tetraploid cultivar of crested wheatgrass released in the United States. It is a persistent, sodforming cultivar that produces as much herbage as Fairway. It is drought tolerant, and can be seeded in areas receiving as little as 10 inches (250 mm) of annual precipitation. Ephraim has persisted when planted in warm, dry areas of southern Utah and northern Arizona. It is also well adapted to pinyon-juniper and big sagebrush communities of the Intermountain region. Plants establishing in moister areas

Figure 2—Mule deer preferred 'Douglas' fairway crested wheatgrass to other cultivars of crested wheatgrass in a fall palatability study (RMRS photo).

produce rhizomes within 2 to 3 years (Stevens and Monsen 1985).

Ephraim is recommended for seeding in pinyon-juniper, ponderosa pine, mountain brush, and big sagebrush communities. It provides excellent ground cover and protection on disturbed soils. It is highly competitive with annual weeds, and can be used with Nordan and other cultivars of standard crested wheatgrass to reduce or control cheatgrass, medusahead, and other annual weeds. Seedlings of Ephraim are not as vigorous as those of Hycrest, but once established, they are extremely persistent in the face of drought, cold winters, and heavy grazing. Ephraim furnishes early spring herbage, and greens up in fall if late summer or fall moisture is received. It is not shade tolerant, but it does persist as an understory in big sagebrush and other shrub communities.

Ephraim is a competitive cultivar. Established stands have not allowed the entry of other perennials, even when subjected to heavy and prolonged grazing. Ephraim has been successfully seeded on mine disturbances in northern Nevada. It is also widely used to plant roadways and other disturbances in the Intermountain region. It is well adapted to infertile soils and moderately dry conditions.

Fairway crested wheatgrass was the first wheatgrass cultivar developed in North America. Released in 1927, it was selected from P.I. 19536, an introduction received from Western Siberia and developed by Agriculture Canada (Knowles 1956). It is shorter in stature, leafier, more procumbent and winter hardy, but less drought tolerant than most standard crested wheatgrass cultivars. Although initially developed for open parkways and turf plantings, Fairway has been widely seeded throughout the Intermountain region, and has proven better adapted to upland sites than standard crested wheatgrass. It is widely used in the mountain brush, ponderosa pine, pinyon-juniper, and mountain big sagebrush zones. Fairway is extremely long lived, and has been planted to provide forage, produce ground cover, and prevent the invasion and spread of weeds. Fairway seedlings are vigorous and capable of establishing amid some competition, but they are suppressed by dense cheatgrass. Fairway reseeds itself well, as an abundance of seeds are generally produced, even under semiarid conditions.

Fairway is well suited to a variety of site conditions and is recommended for seeding in mixtures with sod-forming grasses to provide erosion control. It produces tillers and short rhizomes, and provides excellent ground cover and high-quality forage. Herbage production of Fairway is usually less than that of standard crested wheatgrass, but Fairway produces a greater proportion of leaves. With age, standard crested wheatgrass develops an abundance of stems that become less palatable to grazing animals.

In 1984 the Agricultural Research Service in cooperation with the Utah Agricultural Experiment Station and the Natural Resources Conservation Service released Hycrest crested wheatgrass, the first interspecific hybrid of crested wheatgrass. Hycrest was developed by crossing an induced tetraploid of *A. cristatum* with natural tetraploids of *A. desertorum*. Reciprocal crosses were made to ensure that the cytoplasm of both species would be represented (Asay and others l985). Open pollinated progenies were then established at a nursery site in northern Utah. Eighteen clones were selected from these trials and planted in isolated crossing blocks to provide the first generation of the synthetic strain (Asay and others 1985).

Seedlings of Hycrest are more competitive than those of other cultivars. Hycrest competes well with cheatgrass, halogeton, and other weeds. Seeded Hycrest stands establish in competition with annual weeds; consequently, this cultivar has been useful in seeding sites where other weed-control measures cannot be fully implemented. In plantings made across the Intermountain region, Hycrest has established better stands and produced more forage during the first 2 years than either Nordan or Fairway (Alderson and Sharp 1994). Examination of plantings indicates that seedling vigor, stand establishment, and root growth of Hycrest generally exceed those of other crested wheatgrass cultivars. Hycrest has proven adapted to big sagebrush and pinyon-juniper sites, but it is not as drought tolerant as selections of standard or Siberian crested wheatgrass.

A diploid cultivar, ‘Parkway’, was developed from Fairway through several generations of recurrent selection for vigor, forage, and seed production (Alderson and Sharp 1994). Parkway was released in Saskatchewan in 1969 for use in hay and pasture production. Its yields exceed those of Fairway, as the plants are slightly taller, generally 19 to 30 inches (48 to 76 cm) in height. This cultivar has not been widely planted on range or wildland sites in the Intermountain region, but it can be used on many of the same sites as Fairway. It is not recommended for turf plantings.

‘Ruff’ crested wheatgrass is a diploid cultivar jointly released by the Agricultural Research Service and the Nebraska Agricultural Experiment Station in 1974. The parental material was derived from Fairway (Asay 1986). Ruff has a spreading bunchgrass habit and short, leafy culms (Alderson and Sharp 1994). It begins growth in early spring and is valued as a short-season pasture plant in drier areas of the Great Plains. In the Central Great Plains, its forage production equals that of Fairway (Alderson and Sharp 1994). Its seeds are relatively small, but its seedlings establish well from fall plantings. Ruff competes well with annual and perennial weeds and can be seeded as a conservation planting to protect soil and control weed invasion in Intermountain areas where Fairway is adapted. Ruff plantings become somewhat sodforming due to the broad bunching habit and seeding within the stand.

Agropyron dasystachyum
Thickspike Wheatgrass

Synonyms

Agropyron albicans
A. elmeri
A. griffthsii
A. riparium
Elymus lanceolatus

Description

Barkworth and Dewey (1985) transferred several species of *Agropyron* into the genus *Elymus*, and combined the former taxa *A. dasystachyum*, A. *dasystachyum* var. *elmeri*, and *A. dasystachyum* var. *riparium* with *E. lanceolatus* (Scribn. & Sm.) Gould. Arnow (1987) also combined several *Agropyron* species with *E. lanceolatus*. Barkworth and others (1983) and Barkworth and Dewey (1985) described four subspecies of thickspike wheatgrass:

E. lanceolatus ssp. *albicans* (Scribn. & Sm.) Barkw. & D. R. Dewey
E. l. ssp. *lanceolatus*
E. l. ssp. *psammophilus* (Gillett & Senn) A. Love
E. l. ssp. *yukonensis* (Scribn & Merr.) Love

Taxa now included in treatments of *E. lanceolatus* are similar in floral parts and growth form, thus simplifying identification. These taxa, however, occupy quite different ecological sites. Montana wheatgrass (formerly *A. albicans*) and streambank wheatgrass (formerly *A. riparium*), for example, differ greatly in areas of adaptation and require different management strategies.

Thickspike wheatgrass is a native, cool-season perennial (Barkworth and Dewey 1985; Hitchcock and others 1969; Looman 1982; USDA Forest Service 1914; Welsh and others 1987). The root system and long, rapidly developing rhizomes form a sod that varies with location and subspecies (USDA Forest Service l937; Wambolt 1981) (fig. 3). Plants may develop a dense and more or less continuous sod, or they may occur as open, irregular patches intermixed with other species. Stems are erect, 16 to 32 inches (40 to 80 cm) tall, and most often bluish green. Leaf sheaths have thin, overlapping edges that are smooth to slightly roughened. Blades are 0.04 to 0.12 inch (1 to 3 mm) wide, and 2 to 8 inches (5 to 20 cm) long. They are usually stiff and ascending with slightly rolled edges.

Figure 3—Thickspike wheatgrass is a widely distributed native, sod-forming wheatgrass (photo courtesy of Kevin Jensen, USDA ARS, Logan, UT).

The upper surface of the blade is furrowed, while the lower surface is smooth. The upper surface and sometimes the base of the lower surface are roughened. Auricles are about 0.08 inch (2 mm) long. The ligule is membranous and up to 0.04 inch (1 mm) long with ragged edges and a rounded apex. Inflorescences are 2.4 to 4.8 inches (6 to 12 cm) long. Spikelets are 0.4 to 0.6 inch (1 to1.5 cm) long, each with 3 to 12 loosely to closely overlapping florets. Tips of the glumes are subequal and firm, slightly roughened, and often with small hairs. Glume tips are acute or extended into short awns. Lemmas are 0.2 to 0.4 inch (6 to 9 mm) long, convex on the back, firm, and five to seven nerved. They are sparsely to densely hairy, and generally more hairy than the glumes. Lemma tips are awnless or extended into tiny awns. The palea is about as long as the lemma and obtuse at the tip.

Ecological Relationships and Distribution

Thickspike wheatgrass is widely distributed, occurring in Alaska, southward through the Western United States and Northern Mexico, eastward across Canada and much of the Great Plains, south to Kansas, and as far east as West Virginia (Arnow 1987; Ross and

Hunter 1976). It grows on sites ranging in elevation from 4,000 to 10,900 ft (1,220 to 3,300 m) that receive 8 to 20 inches (200 to 500 mm) of annual precipitation. Different ecotypes are adapted to soils that are well drained and sandy, sandy loams, loams, or heavy textured. It occurs on soils that are alkaline or weakly saline.

In the Western United States, thickspike wheatgrass is common in sagebrush, pinyon-juniper, mountain brush, aspen, moist open parks, and dry meadows (Wasser 1982). It occurs in desert and chaparral communities of the Southwest and in ponderosa pine and western spruce forests of the Northwest (Arnow 1987; Bernard and Brown 1977; Hitchcock and others l969; Sours l983). It is often regarded as a disturbance species, but it is also a major component of grama grass/needlegrass, Idaho fescue, bluebunch wheatgrass, and mountain brush/aspen communities. Thickspike wheatgrass is tolerant of moderate shade provided by associated shrubs, but it is not adapted to dense overstory cover. It recovers quickly following fires, and often flourishes in sagebrush and juniper communities following burning (Wright and Bailey 1982). It has persisted as a dominant species on burned sites for over 30 years (Harniss and Murray 1973).

Plant Culture

Thickspike wheatgrass initiates growth in early spring (Dittberner and Olsen 1983). New shoots emerge as early as March 1; flowering occurs from May to July. Seeds mature in late July and remain on the plant until mid-August (Blaisdell 1958). Dispersal of mature seeds normally occurs over a 2- to 3-week period. Seed from wildland stands is collected using reel-type harvesters mounted on four-wheel-drive vehicles or by hand stripping. Seed fields are harvested with conventional combines. Little debris is collected with the seeds, as the culms extend above the leaves and the seeds shatter readily. Purity of freshly harvested seed lots usually exceeds 80 to 90 percent with about 85 percent germination (Wasser 1982). Most seed used in wildland plantings is from named varieties grown under cultivation. Few wildland stands are large enough to support extensive harvesting. Seeds are slightly larger than those of crested wheatgrass, averaging about 154,000 per pound (339,500 per kg) (Wheeler and Hill 1957).

Seed germination is enhanced by a prechill of about 30 days, but some nonstratified seed will germinate in about 20 days under laboratory conditions. Compared to other wheatgrasses, germination and seedling development of thickspike wheatgrass is slow, but satisfactory stands generally develop over time. The seeding rate is sometimes increased to compensate for this problem.

Fall seeding is recommended. Seeds should be planted about 0.25 to 0.75 inch (0.6 to 1.9 cm) deep by drilling or by broadcasting followed by harrowing. Thick stands often develop when thickspike wheatgrass is seeded in drill rows on well-prepared seedbeds. When broadcast seeded with other species, thickspike wheatgrass tends to form irregular patches that add diversity to wildlife habitat. Development of new stands is aided by rhizome development. Seedlings of thickspike wheatgrass varieties compete well with annual weeds. The species should not be seeded directly with slower developing plants, but it can be seeded in alternate rows or on adjacent sites.

Uses and Management

Thickspike wheatgrass is often seeded alone on disturbances in big sagebrush and mountain brush communities to stabilize soil and control erosion. It is particularly well adapted to arid environments and does well on disturbed, slightly alkaline soils. It is seeded on sites such as mined areas, roadside disturbances, recreation areas, drainageways, and other sites that receive little maintenance and where a low sodforming grass is desired. Thickspike wheatgrass is also commonly used to control the spread of weeds, particularly annual grasses. It is often seeded for this purpose in waste areas and nonirrigated portions of cultivated fields.

Thickspike wheatgrass is widely used in range and wildlife plantings. Herbage production is less than for many other grasses, but it does provide excellent spring-fall and early summer forage. It remains green later into the summer than cheatgrass. Consequently, it can be seeded to extend the period of grazing in areas infested with this and other annuals. If moisture becomes available in fall, plants will green up and provide an important source of forage. Thickspike wheatgrass recovers quickly following burning, providing herbage and ground cover. It also reduces the spread of cheatgrass and other annual weeds as burned areas recover.

Populations of thickspike wheatgrass may have restricted ranges of adaptation. Consequently, attempts should be made to collect and seed local ecotypes. The two released cultivars, 'Critana' and 'Sodar', may not be adapted to all sites within the species range. Upland sites, including dry meadows and areas intermixed with aspen and conifer forests should be planted with ecotypes adapted to these areas.

Varieties and Ecotypes

'Bannock' thickspike wheatgrass, a composite of six collections from Oregon, Idaho, and Washington, was released in 1995 by the Natural Resource Conservation Service Plant Materials Center at Aberdeen, ID.

Bannock is a vigorous, leafy, long-lived, sodproducing variety. Its rhizome growth averages about 4 inches (10 cm) per year. It establishes quickly and develops a protective sod on dry sites. It is a more effective sodproducer than Sodar when seeded in the 8- to 10-inch (200- to 250-mm) precipitation zone. Plants are 18 to 24 inches (45 to 60 cm) tall, and may grow to 40 inches (100 cm) in height when irrigated. Leaves are abundant and are produced 8 to 12 inches (20 to 30 cm) up the stem.

Bannock is recommended for seeding in mixtures on arid rangeland sites and for conservation plantings to provide soil protection. It is useful for revegetating mined lands and other disturbances, and its highly competitive sod reduces the spread of cheatgrass and other annual weeds (USDA Natural Resourcess Conservation Service 2001). Inflorescences are large and the florets are awnless. Seed yields range from 250 to 400 pounds per acre (275 to 440 kg per ha).

The Natural Resource Conservation Service Plant Materials Center at Bridger, MT, and the Montana and Wyoming Agriculture Experiment Stations cooperatively released Critana thickspike wheatgrass in 1971. D. E. Ryerson collected the original material from a roadcut near Havre, MT, in 1960. Critana provides a low-stature ground cover and a dense sod that requires little maintenance. This cultivar exhibits excellent seedling vigor and establishes well, even in areas receiving low rainfall. Plants are strongly rhizomatous and produce low to moderate amounts of herbage. Leaves are small, fine, and palatable. Plants are tolerant of grazing and produce useful spring and early summer forage. Critana is best adapted to the Pacific Northwest, the Intermountain West, and the Western Great Plains. It is commonly seeded in Montana, Wyoming, and the western Dakotas on rangelands and mine sites receiving 10 to 16 inches (250 to 400 mm) of annual precipitation (Thornburg 1982). Critana can be used to stabilize infertile disturbances, provide soil protection in areas where some traffic can be expected, and control weeds. It has been successfully seeded and maintained along roadways, airport runways, dry drainageways, recreational areas, and mine disturbances (Alderson and Sharp 1994).

'Schwendimar' thickspike wheatgrass was released in 1994 by the Natural Resources Conservation Service Plant Materials Center at Pullman, WA. It was named for John Schwendiman who collected seed from its site of origin, a sandy, windblown area on the banks of the Columbia River east of the Dallas, OR, in 1934. Schwendimar is a rhizomatous, cool-season perennial with bluish, glaucous culms. It develops a dense and fibrous but shallow root system. Some roots extend more than 2 ft (0.6 m) from the plant. Seeds are relatively large. Seedlings establish well from spring or fall plantings. They are no more vigorous than those of other thickspike wheatgrass cultivars, but stands develop quickly. Schwendimar is recommended for areas with neutral, coarse-textured soils that receive 8 to 20 inches (200 to 500 mm) of annual precipitation. The variety can be used to quickly stabilize well-drained, droughty sites. It can also be seeded in mixtures to provide mid to late summer forage for wildlife and livestock. Plantings have persisted on a wide range of sites in the Columbia River Basin, but the variety has not seen extensive use outside this area (USDA Soil Conservation Service 1994).

Sodar was released as a streambank wheatgrass variety, but it is now considered a thickspike wheatgrass. The Idaho and Washington Agricultural Experiment Stations cooperatively released it in 1954. Sodar was developed by several generations of mass selection from material collected near Canyon City, Grant County, OR, and grown at the Natural Resource Conservation Service Plant Materials Center, Aberdeen, ID (Alderson and Sharp 1994).

Sodar is a rhizomatous, drought-resistant perennial, 20 to 30 inches (5 to 7.6 dm) tall that is used primarily for erosion control and conservation plantings. It is more drought tolerant and widely adapted to big sagebrush communities than Critana. In the Intermountain region, Sodar is seeded at elevations below 3,200 ft (975 m) on sites that receive 10 to 12 inches (250 to 300 mm) of annual precipitation. Sodar receives use on roadways, dry drainageways, destabilized watersheds, and mine disturbances. Sodar seedlings are vigorous and compete well with annual weeds; established stands restrict weed spread.

Sodar is not commonly seeded to provide livestock forage because of its low herbage production. Plants begin growth as early as standard crested wheatgrass and provide good spring forage. They remain green somewhat later in summer than standard crested wheatgrass. The presence of green leaves into the dry season can reduce the spread of fire. Sodar is more drought tolerant than most populations of bluebunch wheatgrass. Fall regrowth is generally limited. Sodar provides diversity and ground cover in dry communities where few other species are adapted. It can be established easily by drilling or by broadcast seeding and harrowing.

Agropyron desertorum
Standard Crested Wheatgrass or Desert Crested Wheatgrass

Description

Standard crested wheatgrass is an introduced, cool-season, generally nonrhizomatous, perennial bunchgrass that is similar to fairway crested wheatgrass in appearance (figs. 1 and 4). Dewey (l986) described characteristics that can sometimes be used to differentiate the two species. The spikelets of standard crested wheatgrass are subcylindrical and oblong to linear, diverging from the rachis at angles of 30 to 45 degrees. The glumes of standard crested wheatgrass are appressed to the lemmas, and the lemmas support a short, straight awn that is 0.1 inch (3 mm) or less in length. Fairway crested wheatgrass has broad, pectinate spikes and spikelets that diverge from the rachis at much greater angles (45 to 90 degrees), and its glumes are not appressed to the lemmas, thus the spike has a bristly appearance. Its lemmas are short with straight awns that may reach 0.2 inch (5 mm) in length.

Figure 4—Standard crested wheatgrass is a Eurasian introduction that has been widely seeded in semiarid areas of the Western United States (RMRS photo).

Arnow (1987) combined *A. cristatum*, *A. desertorum*, and *A. fragile* (= *A. sibiricum*) into a single species, *A. cristatum*, based on their morphological similarities. She also provided a key for separating standard and fairway crested wheatgrasses in the field using many of the same floral characteristics described by Dewey (1986). This key described the culms of fairway crested wheatgrass as often less than 1.3 ft (4 dm) tall and typically variable in height with both basal and cauline leaves. Culms of standard crested wheatgrass were described as often more than 1.3 ft (4 dm) tall and typically more or less equal in height with strictly basal leaves.

Spikes of standard crested wheatgrass are 6 inches (15 cm) long and 0.2 to 0.9 inch (5 to 23 mm) wide. Spikelets are 0.2 to 0.6 inch (5 to 15 mm) long, excluding the awns, sessile, and spaced 0.04 to 0.12 inch (1 to 3 mm) apart along the rachis. Each spikelet produces 3 to 10 florets, but the upper florets are sterile. Glumes are nearly equal, about 0.28 inch (7 mm) long, and linear to lanceolate with the tip often tapering to a short awn. Glumes and paleas are often rough along the keel. The lemma is 0.16 to 0.33 inch (4 to 8.5 mm) long and sometimes short pubescent. Leaf blades are 2 to 8 inches (5 to 20 cm) long and 0.08 to 0.2 inch (2 to 5 mm) wide. Most are flat or slightly bent along the midrib. Plants reproduce by seeds and tillers (Arnow 1987; Hitchcock 1950).

Ecological Relationships and Distribution

Standard crested wheatgrass is native to European Russia, the Caucasus Mountains, Western Siberia, and Central Asia (Weintraub 1953). It has been widely planted throughout North America in dryland and pasture seedings. In the Western United States it is extensively seeded in salt desert shrublands and in big sagebrush, pinyon-juniper, and mountain big sagebrush communities (Johnson 1986). Standard crested wheatgrass is typically less tolerant of shade, high-elevation conditions, and salty soils than fairway crested wheatgrass (Plummer and others 1958).

Standard crested wheatgrass is well adapted to the Northern Great Plains (Westover and others 1932) and the prairies of Western Canada (Hubbard 1949). Sarvis (1941) reported that crested wheatgrasses, including standard crested wheatgrass, progressed from a promising species in 1917 to the leading hay and pasture species in the Northern Great Plains. Lorenz (1986) reported that it had replaced smooth brome as the most important species planted in the Northern Great Plains of the United States and in Canada. It exceeds smooth brome in drought tolerance, forage production, seed production, ease of establishment, and preference by livestock as hay or pasture.

Standard crested wheatgrass has been seeded widely and has proven well adapted in almost all big sagebrush communities in the West. It is recognized for its ability to establish and persist in disturbances on semiarid lands. It is adapted to the high desert of eastern Oregon and similar areas throughout the Pacific Northwest (Jackman and others 1936). Leckenby and Toweill (1983) reported that it performed well in juniper/big sagebrush-antelope bitterbrush communities in Oregon. It is well adapted to the cold desert regions of Utah and Nevada. Standard crested wheatgrass and Russian wildrye have persisted better than any other species tested in seedings on winterfat/shadscale sites in south-central Utah. These two introduced grasses demonstrate the ability to persist for over 60 years without significant loss of vigor or stand density. Standard crested wheatgrass is also used in the warm desert regions of the Southwest, particularly pinyon-juniper and big sagebrush communities of northern New Mexico and Arizona (Reynolds and Springfield 1953) and the mid and lower elevation plant communities of the Four Corners area.

Although it is widely planted, standard crested wheatgrass it is not suited for some situations where it has been seeded (Hull 1963b; Johnson 1986). Standard crested wheatgrass is adapted to areas receiving 10 to 20 inches (250 to 500 mm) of annual precipitation. Stands often establish and persist on sites receiving less than 10 inches (250 mm) of annual precipitation, but favorable conditions must exist at the time of seeding and seedling emergence to assure establishment. Seedings have persisted for many years in very dry situations, but eventually succumb during periods of extreme drought. Standard crested wheatgrass is better adapted to dry sites than varieties of fairway crested wheatgrass, but it is less salt tolerant (Maas and Hoffman 1977). Dewey (1960) observed differences in salt tolerance among collections of both species, but concluded Fairway crested wheatgrass generally produced greater yields when grown under salt stress than did standard crested wheatgrass.

Plant Culture

Standard crested wheatgrass generally produces good seed yields when grown under cultivation on irrigated or nonirrigated sites. It is highly competitive and can normally be grown without serious weed problems. Seed yields vary among years, but some seed is normally produced. Considerable seed is harvested from dry farms or wildland stands during years of above average precipitation. Stable markets have developed for this species, and seed prices are generally low.

Seed production fields can be established rather quickly, normally within 2 years. Seed yield on dry lands averages about 250 to 300 pounds per acre (280 to 336 kg per ha) (Mayland 1986). For cultivated fields in the Great Plains, Intermountain region, and the Southwest, yields vary between 100 and 600 pounds per acre (112 to 672 kg per ha) (Reynolds and Springfield 1953; Westover and others 1932). Wide row spacings, 24 to 36 inches (61 to 91 cm), increase yields (Windle and others 1966). Knowles and Kilcher (1983) reported maximum yields resulted when stands were planted at 12 to 18 inches (30 to 46 cm) row spacings and fertilized with about 40 pounds of nitrogen per acre (45 kg per ha). Narrow spacings of less than 18 inches (46 cm) are not advisable. McGinnies (1971) found that during periods of below average rainfall, plantings with row spacings of 18 to 24 inches (46 to 60 cm) failed to produce harvestable crops.

Seed production continues for many years on fields that are kept free of weeds. Seeds shatter when mature, and they must be harvested before being dislodged by wind. Some debris can be removed during the combining process. Once seeds are harvested, they are easily threshed and cleaned using fanning mills. Seed quality standards are normally 95 percent for purity and 90 to 95 percent for germination. Seeds can be stored for 2 to 3 years or longer without appreciable loss in germination or seedling vigor.

Seeds germinate rapidly when placed in cool, moist environments. Love and Hanson (1932) found that seeds of crested wheatgrass placed in incubation at 25 °C (77 °F) produce a coleorhiza and several root hairs within 24 to 48 hours. Both the coleoptile and primary root were well developed within 72 to 96 hours. This explains, in part, why crested wheatgrass plants establish so well under arid conditions. Seedlings are capable of emerging and establishing within a short period before soil surfaces dry in spring. Plummer (1943) and Plummer and others (1958) concluded that the widespread success of crested wheatgrass establishment is due to the greater root length attained by developing seedlings at low temperatures when compared to many natives.

Seedlings can be established from both fall and spring plantings, but fall seedings are recommended. Seeds are drill seeded or broadcast and covered using a chain or harrow. Standard crested wheatgrass is often seeded on rough soil surfaces without any attempt to cover the seed. Although this practice is not advised, satisfactory stands are sometimes achieved. Planting at depths of about 0.5 to 0.75 inch (1.3 to 1.9 cm) enhances seedling emergence. Deep-furrow drilling has been recognized as a satisfactory means of planting rangeland sites (McGinnies 1959), especially where weeds are a factor. Evans and others (1970) concluded that deep furrows provide a favorable seedbed by reducing temperature extremes and moisture loss.

Hull and Klomp (1967) reported that drilling produces 10 times more seedlings than broadcasting and that drilled stands reach maturity much sooner. This is important if a single species is desired, but it produces more competition with other species, including recovering natives. Seeding closely spaced furrows at high rates is advisable for weed control. Broadcast seeding followed by chaining or harrowing to cover the soil can produce successful plantings. Broadcast plantings are not as prone to frost damage as drill seedings that promote more uniform seedling emergence.

Mixed plantings of standard crested wheatgrass and less competitive, slower developing species can be established by interseeding the species in alternate rows if adequate row spacing is provided (McKell 1986). Hubbard and others (1962), for example, found that antelope bitterbrush must be seeded at least 2 ft (0.6 m) from crested wheatgrass to assure initial seedling survival. Walker and others (1995) found that mixed seedings of standard crested wheatgrass and other introduced and native species on pinyon-juniper sites declined in diversity over a 30-year period. Crested wheatgrass increased at the expense of native plants during average or above average precipitation years. Monsen and Shaw (1983c) reported that crested wheatgrass, seeded as an understory with antelope bitterbrush, restricted shrub seedling recruitment over a 40-year period. Standard crested wheatgrass reduces natural reestablishment of big sagebrush and associated species in areas where annual precipitation is near the lower limit for the native species.

Recommended seeding rates vary considerably among regions. Rates of 8 to 12 pounds per acre (9 to 13.5 kg per ha) were commonly employed in early plantings. Drill seeding rows 6 to 12 inches (15 to 30 cm) apart at this rate provides competitive cover that will prevent weed invasion. For other plantings we recommend rates of 1 to 2 pounds per acre (1.1 to 2.2 kg per ha) to permit initial establishment of other seeded species and recovery of existing native herbs and shrubs. Attempting to manage for natural recovery by seeding standard crested wheatgrass with native species is, however, a questionable practice, as full stands of the wheatgrass may develop over time. Standard crested wheatgrass does not spread into adjacent areas, but seedling recruitment does occur within the planting. Few seedlings of other species establish in dense wheatgrass stands because the existing crested wheatgrass plants and emerging seedlings are quite competitive (Marlette and Anderson 1986). As large disturbances are seeded to standard crested wheatgrass, potential native seed banks are depleted over time, and recruitment of new plants is limited to the edges of the seedings. Areas seeded to this perennial wheatgrass are not likely to revert to a native composition.

Uses and Management

Standard crested wheatgrass has been used for a number of purposes. Westover and Rogler (1947) concluded that this grass has considerable value as a supplement to native range. It is perhaps the most widely seeded grass in the Intermountain region, because it is adapted to semiarid sites where native communities have been seriously altered, and where few other species establish. It can be grazed 2 to 3 weeks earlier than most native ranges, providing highly succulent forage for lactating livestock in early spring (Harris and others 1968). Considerable regrowth becomes available if fall precipitation occurs.

The ease with which this species establishes and its early spring growth favor its use to provide soil protection and control weeds such as halogeton and cheatgrass (Sharp 1986; Stoddart and others 1975). It is particularly important for seeding semiarid and arid sites (Lorenz 1986). Standard crested wheatgrass gained early recognition for its use in restoring degraded ranges during the drought of the 1930s (Lorenz 1986; Sarvis 1941). It remains an important species for seeding abandoned and degraded rangelands and is considered one of the most important species for weed and fire control in big sagebrush and salt desert communities.

Standard crested wheatgrass has also been used to convert big sagebrush and native bunchgrass ranges to crested wheatgrass monocultures. Extensive sagebrush acreages have been cleared and seeded with standard crested wheatgrass to provide a more palatable species for livestock forage (Frischknecht 1963). Some managers have promoted such conversions of native bunchgrass ranges because standard crested wheatgrass is more tolerant of grazing. Standard crested wheatgrass sometimes provides spring forage 2 or 3 weeks earlier than some native grass and brome grass pastures (Williams and Post 1941), but not as early as Sandberg bluegrass or muttongrass. Compared to bluebunch wheatgrass, standard crested wheatgrass can more rapidly activate buds, initiate new tillers, and better allocate limited carbon reserves to support regrowth (Caldwell and Richards 1986b).

Forage quality of standard crested wheatgrass is high during May and June, but declines rapidly as flowering begins (Malechek 1986). For this reason it is often seeded with perennial broadleaf herbs, including alfalfa, to enhance and sustain high-quality herbage later in the growing season. Mixed grass-legume seedings also substantially increase yields (Johnson and Nichols 1969; Schuman and others1982) and are recommended for sites exceeding 14 inches (350 mm) of annual precipitation.

Mixed seedings must be carefully managed to ensure that all species become established and persist. Competition from the grass coupled with selective grazing of legumes can restrict natural reseeding of the legumes. Rosenstock and Stevens (1989) found no recruitment of alfalfa in mixed crested wheatgrass seedings on pinyon-juniper sites in central Utah and attributed this to competition from established grasses. Mixed seedings of standard crested wheatgrass and forage kochia have been planted to provide midsummer and winter grazing not provided by the grass alone (Monsen and others 1990). Cattle graze these seedings during periods when the grass is dry and not grazed.

Standard crested wheatgrass has been widely used to seed drastic disturbances including mined lands, roadways, and degraded watersheds. It establishes and persists well on such sites and provides weed control and soil protection (DePuit 1986). It can be damaged by wildfires, but it normally recovers unless the burn occurs under extreme conditions.

The decision to use standard crested wheatgrass in wildlife improvement projects must be carefully considered. Because it is a competitive species that frequently gains dominance (Johnson and Nichols 1969; Schuman and others 1982; Stitt 1958), important habitat can eventually be lost. Increases in crested wheatgrass can also occur over periods of 10 to 40 years or more without livestock grazing (Monsen and Anderson 1993). Introduced grasses, including both standard and fairway crested wheatgrass, have been used to seed degraded big sagebrush, salt desert shrub, and pinyon-juniper communities. In some situations, these species are used to replace natives. Although both grasses furnish early spring herbage, they are not the species most preferred by mule deer (Austin and others 1994) or pronghorn antelope (Urness 1986; Yoakum 1980). Memmott (1995) reported that the nutritive qualities of various native shrubs exceeded those of crested wheatgrass in nearly all months. Seeding standard crested wheatgrass and other highly competitive introduced grasses has reduced the productivity of sage-grouse habitat. These grasses have greatly decreased the density and distribution of forbs and sagebrush in seeded communities and inhibited their natural establishment and successful reproduction. Yoakum (1983) concluded that broadleaf herbs and woody species are more important to pronghorn antelope than are seeded grasses.

Elk herds have benefited immensely from large revegetation projects in Utah. Animals have been attracted to these areas for winter grazing, and they use grass-herb seedings at all seasons. Sites seeded to standard crested wheatgrass, alfalfa, small burnet, and other grasses have successfully attracted animals in early spring, thus reducing damage to agricultural fields. To be fully successful, however, revegetation efforts must allow for the recovery of native species, and standard crested wheatgrass prevents this from occurring. Restoration of diverse native plant communities is essential to maintain ecologically sound and properly functioning systems. Converting extensive areas to a single introduced species is not advised.

Standard crested wheatgrass is a persistent perennial that can withstand annual grazing. Reynolds and Springfield (1953) recommend that use not exceed 55 percent in any year. Many stands seeded between 1932 and 1934 in southeastern Idaho have been grazed each year, and persist after 60 years (Hull and Klomp 1966). Standard crested wheatgrass has been used as a hay crop in dryland pastures (Stitt 1958), but more productive and better quality herbage is produced from mixed plantings. This species can be used as winter forage if supplements are provided.

Varieties and Ecotypes

Nordan, released in 1953, is the most widely used standard crested wheatgrass variety in the United States. It was selected from material received from the U.S.S.R. and planted at Dickerson, ND, by the Agricultural Research Service, Northern Great Plains Research Center. Nordan was selected for its large seeds, reduced awns, and good seedling vigor (Rogler 1954; Wolfe and Morrison 1957). It is a uniform, erect, and productive cultivar with excellent establishment attributes. Plants are palatable when green, but palatability is reduced as the dry stems attain maturity. Nordan generally produces high amounts of seed each year, even under arid conditions. This cultivar is widely adapted to sagebrush steppe communities, but it is also seeded in salt desert shrublands. It is one of the main cultivars planted in large restoration projects on semiarid lands.

'Summit' was developed and released in 1953 by Agriculture Canada at Saskatoon, Saskatchewan (Hanson 1959). This cultivar is similar to standard crested wheatgrass varieties grown in the United States. It was developed from materials obtained from the Western Siberian Experiment Station. Fairway-type plants were removed during the first year of increase (Alderson and Sharp 1994). Summit provides abundant forage, but problems associated with seed processing have limited its popularity and use (Asay and Knowles 1985b).

The Agricultural Research Service in Logan, UT, is currently investigating other selections of crested wheatgrass. Attention is being given to the development of a turf-type, more decumbent, and rhizomatous cultivar. In addition, studies are being conducted to combine leafiness, retention of forage quality, larger seed size, and vegetative vigor with the establishment traits and early growth of Hycrest.

Agropyron elongatum
Tall Wheatgrass

Synonyms

Agropyron elongatum ssp. *ruthenicum*
Elytrigia ponticum
Elymus elongatus ssp. *ponticus*
Lophopyrum ponticum

Description

Tall wheatgrass is an introduced, perennial, cool-season, bunchgrass (fig. 5). It is a tall, very coarse, productive, and late-maturing species. Culms are densely tufted, erect, leafy, and 16 to 42 inches (4 to 10 dm) tall. Leaves are flat or involute, 0.08 to 0.3 inch (2 to 8 mm) wide, and glabrous or with the upper surface scabrous or pubescent with short stiff hairs. Spikes are generally erect and 3 to 16 inches (8 to 40 cm) long with a continuous rachis. Internodes are mostly 0.3 to 0.8 inch (7 to 20 mm) long. Spikelets are solitary at each node, compressed at maturity, and 0.5 to 1.4 inches (13 to 35 mm) long. Each produces five to eight flowers. Glumes are typically 0.2 to 0.4 inch (6 to 11 mm) long, thick, hardened at maturity, conspicuously five to seven nerved, and rounded on the back. Lemmas are 0.4 to 0.5 inch (9 to 13 mm) long, thick, hardened, oblong to lanceolate, and truncate to acute at the apex (Arnow 1987).

Ecological Relationships and Distribution

Tall wheatgrass is a native of southern Europe and Asia Minor, where it occurs on saline meadows and seashores (Beetle 1955). Selections from Russia and Turkey were introduced in the United States in 1909, but discarded as being too aggressive. The species received favorable ratings in Athens, GA, in 1920, but it was ignored for another decade (Weintraub 1953).

Figure 5—Tall wheatgrass was introduced from southern Europe and Central Asia and is adapted to saline and alkaline soils (RMRS photo).

By 1930 newer introductions and studies prompted increased use of tall wheatgrass in the Western United States. Plants discovered growing in salt marshes were subsequently found well adapted to saline or alkaline soils of the Intermountain region. Tall wheatgrass is adapted to subirrigated and irrigated saline soils and poorly drained alkali soils at elevations to 6,560 ft (2,000 m) (Hafenrichter and others 1968). Seeding tall wheatgrass has increased forage production and quality on greasewood and saltgrass sites receiving 8 to 12 inches (200 to 300 mm) of annual precipitation. Tall wheatgrass is also adapted to sagebrush and mountain brush rangelands, but it has not performed well on acid soils of the Idaho Batholith. It survives extremely cold winter temperatures, even when soils are bare of snow. It is widely used in the Intermountain region, the Great Plains, and the Northwestern United States, and parts of South America.

Plant Culture

Seed of tall wheatgrass is produced in cultivated fields at mid- and low-elevation locations characterized by long growing seasons (Hafenrichter and others 1968). Seed fields should have deep, well-drained soils. Recommended row spacing is 36 to 42 inches (90 to 106 cm). Fields must be cultivated to control weeds and maintain proper spacing. Plants are leafy and quite tall, sometimes exceeding 6.5 ft (2.0 m) in height, but they must be irrigated and fertilized with nitrogen at 60 to 80 pounds per acre (67 to 89 kg per ha) to maximize yields. Seeds ripen in late summer, particularly when grown under irrigation. Foliage and dry seeds can be harvested with a combine when dry. If plants are too green to harvest directly, stands can first be cut, windrowed, and allowed to dry before combining. Yields vary from 300 to 500 pounds per acre (333 to 555 kg per ha) (Hafenrichter and others 1968). If properly managed, seed fields will remain productive for many years. Field-harvested materials are easily cleaned, as the seeds are large, smooth, and easily detached from the spikelet. Seed lots with over 90 percent purity and germination are commonly sold.

Late fall or early winter seeding is recommended for establishing tall wheatgrass in upland rehabilitation plantings. Meadows and wetlands that do not dry out in early spring may be seeded in late spring and summer. Sites requiring control of excess salinity or weedy competition may also be seeded in these seasons. Surface salts can be flushed from the seedbed by spring and early summer irrigation; mechanical weed control treatments may be continued until midsummer. Spring and summer seeded sites usually require irrigation before and after planting to assure seed germination and seedling establishment.

Seeds must be incorporated into the soil at 0.5- to 1.0-inch (1.2- to 2.5-cm) depths; deep furrow drilling is recommended. If surface salts are a problem for small seedlings, the deep furrows provide ridges where evaporation can occur, leaving salts on the ridge surfaces and reducing the salt content in the bottom of the furrows where the seeds are planted.

Tall wheatgrass has large seeds that can be planted with most equipment. Seeds germinate rapidly. Germinants are vigorous and develop quickly, producing seedlings that compete well with weeds. Tall wheatgrass is often seeded alone, but it can be successfully established in mixed plantings.

Uses and Management

Tall wheatgrass is adapted to valley bottoms that may be saline or alkaline, and to foothill communities. It is the most robust and erect bunchgrass currently under use for range and pasture plantings. On salty soils it has established better and produced higher yields than most other forage species tested. When seeded on low-value saltgrass sites it produces as much as 7 tons of forage per acre (15.5 metric tons per ha) (Richards and Hawk 1945) and 600 pounds of seed per acre (660 kg per ha). It will grow on sites with high water tables, but it will not survive flooding for extended periods.

Dewey (1960) found that tall wheatgrass was superior to other wheatgrass species in its ability to grow on salt affected soils. Salinity levels of 6,000 to 18,000 ppm increase yields of this species, resulting, in part, through reduction in competition with other plants. Forsberg (1953) found tall wheatgrass and slender wheatgrass were more resistant to saline conditions than other plants tested. These two species persisted in soils with conductivity readings as high as 15.13 mmhos per cm. Roundy and others (1983) found that tall wheatgrass and Great Basin wildrye cultivars were well suited to degraded saline and alkaline rangelands in arid regions of the West. Both species survived soil osmotic potentials as low as –3.5 MPa but grew very little below –1 MPa. Robertson (1955) reported that roots of tall wheatgrass penetrated to depths of more than 12 ft (3.7 m) in saline or alkaline soils.

Tall wheatgrass is less drought tolerant than standard crested wheatgrass, but it is considerably more drought tolerant than smooth brome. It does well on rangelands that receive more than 12 inches (300 mm) of annual precipitation. It provides excellent spring forage, as it is about 2 weeks earlier than most native vegetation. It is the latest maturing grass adapted to the continental climates of the West (Hafenrichter and others 1968). Some leaves remain green most of the summer. As plants mature, the leaves become coarse and less palatable, but even in winter large amounts are consumed by livestock and game animals. Heinrichs and Carson (1956) found that the protein content of tall wheatgrass was lower and the crude fiber content higher at all seasons than for other grasses used in dryland revegetation. Cook and others (1967) also reported lower levels of total protein for tall wheatgrass compared to selected species planted in central Utah. Total digestible nutrients and digestible protein for tall wheatgrass, however, are higher in the early leaf stages than for crested wheatgrass (Hafenrichter and others 1968).

Tall wheatgrass can be seeded in irrigated and nonirrigated pastures. On rangelands, plants may reach heights of more than 3 ft (1 m), while irrigated plants often attain heights of nearly 6 ft (1.8 m). Although tall and rank, tall wheatgrass produces abundant forage. It is often used for hay and provides good silage when cut between the heading and soft-dough stages. On rangelands it responds well to fall rains and greens up as moisture becomes available. With irrigation, plants provide green forage throughout the summer. It does not recover as well from clipping as other pasture plants, but it can be grazed during all seasons. Tall wheatgrass is often seeded alone and grazed during midsummer. Sheep as well as cattle use this species. Young lambs and ewes forage on tall wheatgrass from early spring to mid to late summer. Horses and dry cattle are often wintered on tall wheatgrass pastures.

Tall wheatgrass is generally seeded with other species on salt desert shrublands and in sagebrush and pinyon-juniper communities. Its production may equal or exceed that of crested wheatgrass under these conditions. It generally develops a dense stand when seeded on seasonally dry meadows and lowlands, but it forms more open stands on foothill benchlands. Once established, plants persist well, but spread from natural seeding is quite slow.

Tall wheatgrass is useful for planting disturbed wastelands where soil salinity prevents the establishment or growth of other species. It is planted along waterways and on roadway disturbances, abandoned croplands, and sites where grazing has eliminated native species. It is useful for controlling annual weeds, particularly chenopods. Tall wheatgrass is a useful cover crop and can be used to provide nesting cover, winter protection, and escape cover for upland game birds. It is commonly used to protect the soil and provide habitat for wildlife on farmlands where it is adapted.

Varieties and Ecotypes

‘Alkar’ tall wheatgrass was released in 1951 by the National Resources Conservation Service Plant Materials Center, in Pullman, WA. It was developed by mass selection from spaced plantings of materials introduced from the U.S.S.R. in 1932 (Hanson 1959). Alkar is a tall, very late maturing bunchgrass with large, coarse, blue-green leaves. This cultivar produces large seeds, and its seedlings are vigorous and fast growing. Alkar is tolerant of wet, alkaline soils and can be seeded on semiarid rangelands at elevations between 290 and 5,500 ft (90 to1,830 m). Because of its palatability, it receives use as a pasture plant on subirrigated and irrigated saline and alkaline soils (Alderson and Sharp 1994).

'Jose' was released in 1965 by the National Resources Conservation Service Plant Materials Center at Los Lunas, NM. It was selected from material received from Eurasia. Jose was developed as a pasture and hay crop. It is a uniform, medium-tall bunchgrass with green leaves. It is shorter and produces less seed and herbage than other tall wheatgrass cultivars. It is drought tolerant and very salt tolerant (Alderson and Sharp 1994).

'Largo' tall wheatgrass was cooperatively released in 1961 by the National Resources Conservation Service Plant Materials Center in Los Lunas, NM, the Utah Agricultural Experiment Station in Logan, UT, the Agricultural Research Service, Logan, UT, and the New Mexico Agricultural Experiment Station, Las Cruces, NM. It was developed as a forage species for seedings in Colorado, Utah, Arizona, and New Mexico, but Jose has largely replaced it.

'Orbit' was selected at the Agriculture Canada Research Station, Swift Current, Saskatchewan, in 1966. Alkar was selected for its winter hardiness, seed yields, and forage production. This cultivar is superior to Alkar in winter hardiness, but similar in seed and forage yields. It can withstand spring flooding for 3 to 4 weeks (Alderson and Sharp 1994).

'Platte' was selected at the Nebraska Agriculture Experiment Station in Lincoln, NE, and released in 1972 by the Agricultural Research Service and the University of Nebraska, Lincoln. It is a winter-hardy bunchgrass that spreads from short rhizomes and produces long, narrow leaves and rather large seeds. It is primarily used to seed saline and alkaline soils in the Great Plains (Alderson and Sharp 1994).

Agropyron intermedium
Intermediate Wheatgrass

Synonyms

Agropyron trichophorum
Elymus hispidus
Elytrigia intermedia
Thinopyrum intermedium
Thinopyrum intermedium ssp. *barbulatum*

Description

Intermediate wheatgrass is an introduced, cool-season, sodforming perennial (fig. 6). Stems are bluish green, robust, erect, and 16 to 48 inches (40 to 120 cm) tall. Leaf sheaths are typically ciliate, at least along one margin. Blades are 4 to 16 inches (10 to 40 cm) long, 0.2 to 0.4 inch (5 to 10 mm) wide, dark green to bluish green, and flat or involute. Blade surfaces are distinctly veined and glabrous to pubescent with short, stiff hairs. The ligule is generally flat, 0.4 to 0.8 inch (1 to 2 mm) long, membranous, and smooth to ragged along the edges. Auricles are well developed. Spikes are erect, 4 to 8 inches (10 to 20 cm) long, and slender. Internodes of the rachis are 0.24 to 0.80 inch (6 to 20 mm) long near the center of the spike. Spikelets are solitary at each node, compressed at maturity, and overlap only slightly, if at all. They are 0.35 to 0.8 inch (9 to 20 mm) long, 0.8 to 0.12 inch (2 to 3 mm) wide, and three to eight flowered. Glumes are thick and hardened, oblong to lanceolate, conspicuously three to seven nerved, and rounded to slightly keeled on the back with a blunt or pointed tip. Spikelets are awnless or awn tipped (Arnow 1987; Hitchcock 1950; Stubbendieck and others 1992).

Pubescent wheatgrass was previously considered a separate species from intermediate wheatgrass (Nevski 1934), but they differ only in the presence or absence of a pubescence on the spikes, seeds, and leaves.

Figure 6—Intermediate wheatgrass, a sodforming introduction, is seeded to provide hay, forage, and stabilization of disturbed sites (RMRS photo).

Dewey (1977) concluded that these are not sufficient differences for separation of species within this tribe, particularly as the taxa do not differ in greatly in geographical distribution, ecological adaptation, mode of reproduction, or cytological characteristics. Considerable variability, however, does occur within each form, and cultivars of each have been developed and released.

Ecological Relationships and Distribution

Intermediate wheatgrass and its pubescent form, pubescent wheatgrass, are distributed from southern Europe through the Middle East to Western Pakistan (Bor 1970). Both forms of the species were introduced into the United States from Central Asia in 1907 (Asay and Knowles 1985b). Additional introductions were received in the 1920s, but the value of the plant was not recognized until the 1930s (Weintraub 1953).

Intermediate wheatgrass is adapted to areas in the Northwest, the Intermountain West, and the Plains States. Both do well as understory species on well-drained dry sites in open stands of ponderosa pine and antelope bitterbrush. At low and midelevations, intermediate wheatgrass is adapted to open parks and extremely hot, well-drained sites on exposed slopes. Intermediate types are more shade tolerant than the pubescent types and they are better adapted to cooler and wetter situations. They perform better on upland benches occupied by Wyoming big sagebrush and in mountain big sagebrush, herblands, mountain brush, aspen, and fir communities receiving annual precipitation of 14 inches (350 mm) or more. Pubescent forms are more tolerant of sites with long, warm summers than are intermediate forms. They are better adapted to blackbrush, southern desert shrub, and some Wyoming big sagebrush communities receiving less than 12 inches (300 mm) of annual precipitation. Populations of intermediate wheatgrass seeded at low elevations will eventually shift to support individuals with pubescent characteristics. The reverse will occur if pubescent forms are planted in upland communities. Intermediate wheatgrass is less drought tolerant than standard crested wheatgrass, but it is equally cold tolerant. Pubescent forms withstand high summer temperatures of the blackbrush and southern desert shrub types better than standard or fairway crested wheatgrass.

Intermediate wheatgrass is adapted to soil types ranging from heavy-textured with low pH to coarse-textured granite materials with neutral or slightly acidic pH. Both the intermediate and pubescent forms are suited to droughty infertile soils, but the pubescent forms are better adapted to saline and alkaline soils.

Plant Culture

Intermediate wheatgrass seed is produced in nonirrigated and irrigated fields. Yields range from 250 to 500 pounds per acre (280 to 560 kg per ha) (Hafenrichter and others 1968). Good yields can be produced with limited fertilization and irrigation. Plants develop a competitive sod rather quickly, and renovation of seed production fields with mechanical tillage is required to maintain acceptable seed production. Intermediate wheatgrass produces seedstalks with large seedheads. Seeds ripen uniformly and remain on the plant, but can be easily separated from the inflorescence during cleaning. Immature florets can be removed using fanning mills and other separators. Seeds can be cleaned to provide high purity and germination levels. Seed viability is retained for a number of years when seeds are stored under warehouse conditions.

Seeds should be planted at depths of 0.5 to 1.5 inches (1.3 to 3.8 cm) using conventional drills. They germinate quickly when seedbed conditions are favorable and produce vigorous seedlings. Small seedlings and young plants are able to compete favorably with most other species. Unstable soils and weedy sites are often drill seeded with intermediate wheatgrass to provide permanent stands and uniform, competitive cover in 3 to 5 years. Seeding at rates below 2 pounds per acre (2.2 kg per ha) is recommended when planting mixtures for range and wildlife habitat improvement. Rates from 8 to 12 pounds per acre (9 to 13 kg per ha) are suggested for planting highly erodible roadways and watershed disturbances. Intermediate wheatgrass is one of the most successful grasses to establish from broadcast seedings on sites inaccessible to drill seeders. Patches or clumps normally develop when sites are broadcast seeded followed by chaining or harrowing; these can coalesce over time.

Intermediate wheatgrass is often seeded in mixtures with other herbs to provide forage and cover, but it is highly competitive and can suppress and replace many other species. Monsen and Anderson (1993) inventoried a 50-year old species trial in central Idaho and found that intermediate wheatgrass and sheep fescue were the two species best able to persist and displace other introduced and native grasses seeded in adjacent plots.

Uses and Management

Prior to about 1950, intermediate wheatgrass was not planted as frequently as the crested wheatgrasses and smooth brome in the Great Plains and Western regions of the United States. In the Intermountain area, it has gained importance and is now widely planted. It has been included in seed mixtures for big sagebrush, pinyon-juniper, mountain brush, ponderosa pine, aspen, spruce-fir, and open park herblands.

Because it is a sodformer that forms a dense root mass (Hafenrichter and others 1968), intermediate wheatgrass is used to improve ground cover and to stabilize erodible soils and watershed disturbances. It is adapted to infertile soils associated with roadway disturbances, mined lands, waterways, and other unstable sites. It has become one of the most important soil conservation species currently seeded. Most collections exhibit good seedling vigor, establish quickly, and spread rapidly, even during the first year. Plants remain green and provide effective ground cover throughout the growing season. Hafenrichter and others (1968) reported that intermediate wheatgrass produces better ground cover than smooth brome in spring, fall, and winter because it does not freeze as easily. It is a highly persistent species that retains vigor and density and performs better than orchardgrass and timothy when planted in mixtures on infertile soils.

Intermediate wheatgrass plants spread vegetatively, forming a dense, competitive sod. They are capable of increasing areas of occupation even when grown on harsh sites. Cultivars of intermediate wheatgrass usually produce a more aggressive and rapidly developing sod than do pubescent wheatgrass cultivars. When grown at low elevations and in more arid situations, intermediate wheatgrass forms patches that may be widely spaced. Although pubescent wheatgrass cultivars respond similarly, they are more likely to form a continuous stand on such sites. When grown at mid and upper elevations, intermediate wheatgrass develops a very complete and solid ground cover. Few interspaces remain, and the plants are very competitive. Under these conditions, intermediate wheatgrass spreads rapidly and can dominate and displace pubescent wheatgrass.

Intermediate wheatgrass is commonly seeded in irrigated and dryland pastures. It is suitable for seeding with alfalfa for hay production or rotational grazing. Plants are leafy, but not rank. They are generally in the early stage of flowering when alfalfa is ready to cut. At this stage, both species provide high-quality herbage. Annual clipping does not weaken stands of this grass, and plants are capable of recovery and regrowth from early spring and summer clippings. Pastures and even dryland seedings can be maintained with considerable grazing.

Intermediate wheatgrass matures 2 to 3 weeks later in summer than crested wheatgrass, and it provides much better herbage in mid and late summer (Cook and others 1956). It remains green in summer and fall in mountain brush communities and at higher elevations. Both pubescent and intermediate wheatgrass are palatable, but investigators have reported seasonal differences (Cook and others 1956; Hafenrichter and others 1968; Hyder and Sneva 1963). Austin and others (1994) found that 'Luna' pubescent wheatgrass received greater preference than other commonly seeded grasses when grazed in spring and fall by deer. Differences in palatability between cultivars of the two grasses are due in part to differences in their phenological development. Some intermediate wheatgrass cultivars mature later in the season and are more selectively used as pubescent growth forms become dormant (Cook and others 1956). In general, intermediate wheatgrass cultivars are more palatable to livestock for a longer grazing period than are pubescent wheatgrass cultivars.

Intermediate wheatgrass has been seeded in oak brush and mountain brush thickets. It is tolerant of some shade, and provides considerable herbage as an understory species. It begins growth earlier than the shrubs, and has been seeded to suppress shrub growth and provide more open communities. Intermediate wheatgrass withstands burning and can be used to seed woody sites that tend to burn frequently. Once established, it is highly persistent and capable of withstanding underground foraging by rodents.

Although intermediate wheatgrass provides useful herbaceous cover in aspen, mountain brush, pinyon-juniper, and sagebrush communities, this species can slowly replace native herbs and shrubs. Monsen and others (1996) found that extensive seedings in aspen and associated open parks in central Utah have replaced important broadleaf herbs, big sagebrush, antelope bitterbrush, and other associated species. Complete conversion may require as much as 20 to 30 years. This grass should not be seeded in areas where native species should be retained. Problems created by seeding intermediate wheatgrass, particularly in aspen and open park herblands, are quite serious. Removal of wheatgrass from such stands is difficult, and reestablishment of diverse communities is often not practical. This plant can restore ground cover and compete effectively with weeds, but it should not be planted in areas where retention or reestablishment of native species is desired. It is particularly restrictive to the establishment and survival of shrub seedlings. It is widely grown for pasture and hay crops from Nebraska to Manitoba, Canada, the Pacific Northwest, and to a lesser extent the Intermountain West.

Varieties and Ecotypes

Cultivars of pubescent and intermediate wheatgrass forms differ in growth and utility; individual cultivars should be carefully selected. Varieties of both forms will grow on the same sites and frequently hybridize, but there are some major differences between them. The first promising cultivar of intermediate wheatgrass was developed through selection from introduction 'PI 98568', received from Maikop, U.S.S.R., in 1932 (Hanson 1965). The South Dakota Agricultural Experiment Station later released this accession as 'Ree'. Additional cultivars developed from this accession include 'Chief', 'Greenar', 'Oahe', and 'Slate'. Some early cultivars including 'Amur' have been replaced by other, better-adapted cultivars. Only the most used cultivars are described here.

Intermediate Wheatgrass Varieties

Chief was released by Agriculture Canada in 1961 as a selection from the cultivar Ree. It was developed by mass selection of plants with high seed yields and good seed quality. It is primarily used in grass and alfalfa pastures and for hay production in the Canadian Prairie Provinces. Forage and seed yields are slightly higher than those of Ree (Alderson and Sharp 1994). This cultivar has not been widely used in the Intermountain region.

'Clarke' was released in 1980 by Agriculture Canada as a 20-clone synthetic. It was developed through eight cycles of recurrent selection to combine winter hardiness, drought tolerance, seedling vigor, resistance to aphid-virus infection, seed quality, and forage and seed production. It has been useful for hay and pasture production in dryland or irrigated fields in the Canadian Prairie region and the Northern Great Plains. It is extremely drought tolerant and winter hardy, and produces excellent seed yields (Alderson and Sharp 1994). Clarke is primarily used in irrigated pastures in the Western United States.

Greenar is a leafy and highly productive variety that was developed at the Natural Resources Conservation Service Plant Materials Center in Pullman, WA, from PI 98568, a collection of the Westover-Enlow expedition to the U.S.S.R. It was released in 1945 as P-2327 and renamed Greenar in 1956 (Alderson and Sharp 1994). This release is tall, leafy, productive, medium to late maturing, and mildly sodforming (Hafenrichter and others 1968). Plants are broadleaved and green to dark green. Greenar is widely seeded on rangelands, pasturelands, and hayfields in the West. It is used in conservation plantings because it produces considerable ground cover and develops an extensive and persistent sod. Greenar establishes well and is adapted to harsh, dry, exposed sites. It is not shade tolerant. Plants are disease resistant and begin growth in early spring. They retain green herbage late into the season. Greenar is well adapted to big sagebrush communities as well as higher elevation sites in aspen and mountain herblands. It has persisted well on such sites, even when grazed heavily by livestock. It remains green and palatable through the summer and fall months.

The South Dakota Agricultural Experiment Station released Oahe intermediate wheatgrass in 1961. It was selected from a Russian introduction, PI98568, that also provided material for the Greenar and Ree releases. Oahe was developed from two cycles of selection for high seed production, forage production, and rust resistance. It was developed for hay, pasture, and conservation plantings in the Northern Great Plains (Alderson and Sharp 1994). Oahe demonstrates some of the same vegetative traits as Greenar, but it is more drought tolerant. Both cultivars establish quickly and develop a dense sod. Oahe does not provide as much late summer and fall herbage as Greenar. Both cultivars are widely adapted for conservation and pasture plantings in the Intermountain region.

'Reliant' was selected at the Agricultural Research Service Northern Great Plains Research Laboratory in Mandan, ND, and cooperatively released by the Agricultural Research Service, Natural Resources Conservation Service, and the North Dakota Agricultural Experiment Station in Fargo, ND. It was selected for its vigor and resistance to leaf-spotting disease. Reliant is adapted to hay and pasture uses in the Northern Great Plains of the United States and Canada. It has not been extensively planted in the West, but appears useful in dryland pastures seeded with alfalfa.

'Rush' intermediate wheatgrass was released in 1994 by the Natural Resources Conservation Service Plant Materials Center, in Aberdeen, ID. It was originally received as *A. junceum*. Rush develops an extensive sod that provides useful ground cover. It is recommended for conservation plantings to control erosion on roadways, mine disturbances, and dry waterways (Alderson and Sharp 1994). Rush establishes well from direct seedings and spreads quickly. It is quite competitive and can restrict the occurrence of other species. It has an upright growth habit and provides considerable spring, summer, and fall forage.

The Nebraska Agricultural Experiment Station and Agricultural Research Service cooperatively released Slate intermediate wheatgrass in 1969. It was developed by blending equal quantities of seed from two unrelated strains, 'Nebraska 50' and a derivative of Amur (Alderson and Sharp 1994).

Slate is an upright variety with large, broad, light-green or blue-green leaves that produces a strong, spreading sod. It is primarily seeded in mixtures with other grasses and alfalfa in irrigated or nonirrigated pastures and hayfields in the Central Plains. Although it has not been seeded extensively in the West, it is a useful cool-season forage or hay crop. It is not tolerant of saline or alkaline soils.

The Idaho and Washington Agricultural Experiment Stations in Aberdeen, ID, and Pullman, WA, and the Natural Resources Conservation Service Plant Materials Centers in Aberdeen, ID, and Pullman, WA, released 'Tegmar' intermediate wheatgrass in 1968. It was developed from accession 'PI 109219' collected near Bolu, Turkey, in 1934 (Alderson and Sharp 1994). Plants are erect and rather small statured. They are about one-third to one-half the height of the most robust forms of intermediate wheatgrass. Leaves are light green to blue green with some hairs along the margins. Tegmar is one of the most commonly used cultivars in the Western States for stabilizing dry waterways, highly disturbed watersheds, and disturbed rangeland sites. Plants establish quickly and develop a dense, vigorous, rapidly spreading, and persistent sod that can reduce erosion and withstand some burial. Tegmar is adapted to warm and low-elevation sites. It has been seeded in lower mountain brush, big sagebrush, and salt desert communities. Plants furnish useful spring forage, but other cultivars may produce more succulent herbage in mid and late summer. Tegmar is frequently seeded alone on disturbed sites, particularly on areas with diverse topographical conditions and infertile soils.

Tegmar is not commonly seeded as a hay or pasture plant on irrigated sites because it does not provide late summer herbage. It responds poorly to clipping, and it is not as productive as other cultivars. It grows well in open stands with big sagebrush and other shrubs, but it is not shade tolerant. Once stands are established, it persists well, even when heavily grazed.

Pubescent Wheatgrass Varieties

'Greenleaf' was developed at the Agriculture Canada Research Station in Lethbridge, Alberta, by screening open-pollinated progenies for seedling vigor and tendency to creep. Greenleaf is a winter-hardy forage cultivar intended for pasture and hay production. It produces bright-green pubescent foliage, and it is fairly tolerant of saline soils and droughty sites. Greenleaf is used primarily for short-duration pasture forage in the Canadian Prairie region and the Northern Great Plains. It is similar to 'Mandan 759,' but it produces more vigorous seedlings. Greenleaf is superior to 'Topar' in forage production, seedling vigor, and winter hardiness (Alderson and Sharp 1994).

The New Mexico Agricultural Experiment Station and Natural Resources Conservation Service Plant Materials Center at Los Lunas, NM, released Luna pubescent wheatgrass in 1963. It was developed from materials collected by the Westover-Enlow expedition to the former U.S.S.R. and Turkey in 1934. Luna's primary use has been for irrigated pastures and revegetation of range and watershed disturbances (Alderson and Sharp 1994). It has become one of the most commonly seeded cultivars in the West.

Luna is a tall, highly productive cultivar that is widely seeded to furnish spring, summer, and fall herbage. Basal leaves are moderately pubescent, but the seedheads are usually glabrous. Its ability to remain green throughout the summer contributes to its popularity. It is adapted to open parks, aspen, spruce-fir, mountain brush, and juniper-pinyon woodlands. It is not shade tolerant, but it grows well on open, exposed slopes, particularly in areas with warm summer temperatures. Because of its drought tolerance, Luna is adapted to big sagebrush and southern desert shrublands. It requires 10 to 12 inches (250 to 300 mm) of annual precipitation, but it has been found to persist in areas where rainfall is considerably lower.

Luna seedlings establish quickly and are quite vigorous. Plantings reach maturity in 1 to 2 years, and provide some control of spread by annual weeds. Luna is commonly seeded as a dual-purpose species to control erosion and provide forage. Luna is planted on burned sites, roadways, and unstable watersheds to provide initial ground cover and supply forage or habitat. It provides a productive cover during periods of drought and heavy grazing. Luna is competitive and can exclude native species.

Topar pubescent wheatgrass was developed from 'PI ID7330' and cooperatively released in 1953 by the Washington, Idaho, Oregon, and California Agricultural Experiment Stations, and by the Natural Resources Conservation Service Plant Materials Centers at Aberdeen, ID; Pleasanton, CA; and Pullman, WA. Topar is typical of all pubescent and most intermediate cultivars in being a late-maturing, vigorous, sodforming selection, adapted to droughty sites (Alderson and Sharp 1994). It is seeded in aspen, mountain brush, pinyon-juniper, big sagebrush, and salt desert shrublands. Seedlings establish quickly and are very competitive. These characteristics contribute to use of this cultivar on disturbed, weedy, infertile sites. Plantings can be used to control weeds and furnish late-season herbage. Topar is also planted to control erosion and stabilize watersheds, roadways, and waterways. It has been seeded in mixtures to revegetate rangeland disturbances. Topar requires between 10 and 12 inches (250 to 300 mm) of annual rainfall. It is sufficiently drought tolerant for seeding spring and fall foothill ranges in the Intermountain area.

Topar is commonly seeded with Tegmar intermediate wheatgrass on well-drained, droughty exposures, where native vegetation has been lost as a result of grazing, wildfires, or other disturbances. Both grasses are capable of establishing on soils that dry quickly and may be subjected to prolonged periods of summer drought and high temperatures. Both have been used to colonize and stabilize unstable soils. Young seedlings are able to establish on erosive surfaces, where they stabilize the soil and suppress invasive species.

Agropyron sibiricum
Siberian Crested Wheatgrass

Synonyms

Agropyron fragile

Description

Siberian wheatgrass is an introduced perennial bunchgrass that is similar in appearance to both standard and fairway crested wheatgrass, but it has a much narrower spike (fig. 1). It is usually smaller in stature and develops narrower bunches with less foliage. Its leaves are finer and more decumbent. The spike is narrow, cylindrical, and usually about 2.3 to 4.7 inches (6 to 12 cm) long. The spikelets are somewhat spreading and develop directly from the rachis. Glumes and lemmas are awnless or with awns 0.04 to 0.08 inch (1 to 2 mm) long (Hitchcock 1950).

Siberian wheatgrass is part of the crested wheatgrass complex that consists of a series of diploids, tetraploids, and hexaploids (Dewey 1974). Diploids are represented primarily by the Fairway cultivar. The most commonly used tetraploids are standard crested wheatgrass and Siberian crested wheatgrass cultivars. Selection and hybridization have been accomplished within ploidy levels, but are primarily confined to the diploid and tetraploid populations, as hexaploid populations are very rare (Asay 1986).

Taxonomic changes have confused the identification of Siberian crested wheatgrass (Dewey 1986). Jones (1960) placed all crested wheatgrasses with narrow or cylindrical spikes in *A. sibiricum*. Dewey (1986) recommended acceptance of Tsvelev's (1976) treatment of the wheatgrasses, which identifies three species of crested wheatgrass—*A cristatum*, *A. desertorum*, and *A. fragile*. Tsvelev's decision to combine *A. sibericium* with *A. fragile* resulted in the acceptance of *A. fragile*, as it is the older of the two names. Some authors (Arnow 1987) have recently grouped all crested wheatgrasses into one species, *A. cristatum*.

Ecological Relationships and Distribution

Siberian crested wheatgrass occurs in eastern Russia, the Caucasus, Western Siberia, and Central Asia (Weintraub 1953). In Central Asia it is distributed from the Caspian Sea to Lake Balkhash (Dewey 1986). In the United States, the first introduction was received in about 1906, but the plant was not successfully grown until the 1920s (Weintraub 1953). Dewey (1986) reported that about 50 accessions entered the United States between 1906 and 1940. This exceeds the number of *A. desertorum* introductions during this period, but published references to it are infrequent. Most accessions were apparently grouped within the broad crested wheatgrass category.

Siberian crested wheatgrass is more tolerant of drought and alkali soils than is standard crested wheatgrass. Consequently, it performs better at lower elevations in big sagebrush and salt desert shrublands. In the Intermountain area it is adapted to upper benchlands supporting mountain brush and pinyon-juniper communities and to the extensive Wyoming big sagebrush and shadscale communities

Siberian crested wheatgrass is ecologically better adapted to arid shrublands of the Intermountain area than standard or fairway crested wheatgrass. It grows in soils ranging from well-drained and sandy to heavy-textured clay loams. Young plants are able to establish on soils that dry quickly in spring and remain dry throughout the summer. This plant demonstrates tolerance to consecutive years of drought when planted in the lower regions of the big sagebrush zone. It is capable of surviving the hot, dry summers of warm desert communities. It is not shade tolerant and generally grows better in regions receiving less than 12 to 14 inches (300 to 350 mm) of annual precipitation.

Plant Culture

Annual seed production of Siberian crested wheatgrass is lower than that of fairway or standard crested wheatgrass. However, good seed crops can be produced on both irrigated and nonirrigated fields. Yields averaging 200 pounds per acre (225 kg per ha) for dryland plantings and 400 pounds per acre (450 kg per ha) for irrigated sites are common. Seed can be harvested with combines and cleaned with air-screen separators. Cleaned seed lots normally are of high viability and purity. Seeds are slightly smaller than those of other wheatgrasses.

Cleaned seed lots are usually free of large debris, and the seeds can be metered through most seeding equipment. Seeds should be planted between 0.5 to 0.75 inch (1.3 to 1.9 cm) deep to support germination and establishment. Young and Evans (1986a) found that germination characteristics of Siberian wheatgrass were similar to those of fairway and standard crested wheatgrass. Hyder and Sneva (1963) reported that morphological and phenological development of Siberian and crested wheatgrass were very similar. However, when grown under rangeland conditions, seed maturation of Siberian crested wheatgrass is often 7 to 10 days later than for standard crested wheatgrass.

Seedlings of Siberian crested wheatgrass cultivars are less vigorous than those of most fairway or standard crested wheatgrass cultivars, but established plants are persistent. Seedling establishment strategies differ among the crested wheatgrasses. Siberian crested wheatgrass seedlings do not grow as quickly or become as large during the first growing season, as the plants adjust to drought by becoming dormant earlier in the season. Young plants may remain small for 1 to 2 years if growing conditions are unfavorable. Plants, however, generally develop satisfactory stands, even during periods of drought and in areas where few other revegetation species are adapted. Plummer and others (1968) ranked seed germination, initial establishment, growth rate, and persistence of this species as excellent.

Siberian wheatgrass can be established with limited seedbed preparation. Seeds must be covered to assure acceptable establishment; stands can be planted by drilling or broadcast seeding followed by chaining or harrowing. Seeding directly into weedy sites should be avoided, but established plants do compete favorably with annual weeds. Seedlings are quite hardy, and few succumb to frost.

Uses and Management

Siberian crested wheatgrass is less widely planted than other crested wheatgrasses, primarily due to its lower productivity. Most rangeland and pasture plantings are conducted to supply forage for grazing animals, and other, more productive, species are usually planted. Siberian wheatgrass is more drought resistant than most introduced grasses, and it is better able to establish and provide a ground cover in drier habitats. It provides useful, more consistent spring and fall herbage on drier sites than other crested wheatgrasses. It is also a formidable competitor with annual weeds.

Siberian wheatgrass can be seeded at low rates with bottlebrush squirreltail and Sandberg bluegrass to stabilize Wyoming big sagebrush and salt desert communities. Seedlings develop slowly, allowing establishment of big sagebrush and other shrub seedlings. Siberian wheatgrass is adapted to soil disturbances; it is seeded on roadway and mine disturbances in arid regions. It is often seeded along dry streambeds where soil stabilization is required.

Leaves of Siberian crested wheatgrass are usually finer and remain green later into the summer than those of other crested wheatgrasses. Siberian crested wheatgrass is seeded with Russian wildrye to provide later spring and summer pastures. It is also seeded on disturbances in pinyon-juniper and big sagebrush communities to restore forage for big game and domestic livestock. Although it is somewhat less competitive than either standard or fairway crested wheatgrass, it is not compatible with native herbs and shrubs, and should not be seeded in areas where recovery of native communities is desired.

Varieties and Ecotypes

The Idaho Agricultural Experiment Station, Moscow, and the Natural Resources Conservation Service Plant Materials Centers at Aberdeen, ID, and Pullman, WA, cooperatively released the cultivar ‘P-27’ in 1953 (fig. 7). It was developed from material designated ‘PI 108434’, obtained in 1934 from Kazakhstan, U.S.S.R., and from the Institute of Plant Industry, Leningrad, U.S.S.R., by the Westover-Enlow expedition (Hanson 1959). It was evaluated in field and nursery plantings beginning in 1935. Individual clones were selected in 1949 and served as a basis for further increase (Alderson and Sharp 1994). P-27 is primarily used in range seedings. Plants are leafy and fine stemmed. They are characterized by good seedling vigor, high seed yields, and drought tolerance. This cultivar has been the primary accession available for large seedings.

Figure 7—‘P-27’, a leafy and fine-stemmed cultivar of Siberian wheatgrass, was released in 1953 and has been widely used (photo courtesy of Loren St. John, USDA Natural Resources Conservation Service, Aberdeen Plant Materials Center, Aberdeen, ID).

'Vavilov' Siberian wheatgrass was released in 1994 by the Agricultural Research Service, the Utah Agricultural Experiment Station, and the Natural Resources Conservation Service in Aberdeen, ID. It was named to acknowledge the contribution of the N. I. Vavilov Research Institute of Plant Industry, St. Petersburg, Russia, to the range grass plant breeding program of the Agricultural Research Service. Vavilov was derived from accessions obtained from the Vavilov Research Institute; the Stavropol Botanical Garden, Stavropoal, Russia; the Eskisehir Plant Breeding Station, Eskisehir, Turkey; and selections from the cultivar P-27 (Asay and others 1995b). The parental accessions were selected for their retention of green color and vegetative vigor in late summer. Breeding populations were also screened for seedling vigor, seed production, plant type, and response to drought, disease, and insects. Vavilov spikes intergrade from the long narrow forms typical of Siberian crested wheatgrass to shorter, wider spikes more typical of standard crested wheatgrass (Asay 1995a,b). A tetraploid, Vavilov is fully interfertile with standard crested wheatgrass and the Hycrest cultivar.

Vavilov is a particularly important cultivar because of its seedling vigor. It is comparable to Hycrest and consistently better than P-27 in terms of seedling emergence and vigor. Vavilov is also more productive than P-27 (Asay and others 1995b). It is recommended for seeding semiarid sites at elevations below 6,800 ft (2,100 m) that receive 8 to 17 inches (200 to 450 mm) of annual precipitation.

Agropyron smithii
Western Wheatgrass or Bluestem Wheatgrass

Synonyms

Elytrigia smithii
Elymus smithii
Pascopyrum smithii

Description

Western wheatgrass is a native, rhizomatous, long-lived, cool-season perennial that produces an open and highly uniform sod (fig. 8). Stems are erect and 12 to 24 inches (30 to 60 cm) tall. Leaves are typically blue green, but the entire plant may have a grayish-blue cast that varies among populations. Leaf sheaths are normally glaucous and rough. Leaf blades are about 4 to 10 inches (10 to 25 cm) long and mostly 0.04 to 0.08 inch (2 to 4 mm) wide. They are usually firm, stiff, and taper to a sharp point. The upper surface of the leaf is rough and distinctly ridged or grooved along the nerves while the underside is usually smooth. Green leaves are flat to involute; when dry they remain stiff and erect, but the edges curl toward the midrib. Auricles are often well developed. Ligules are about 0.04 inch (1 mm) long. Spikes are stiff, erect, and about 2.8 to 6 inches (7 to 15 cm) long with one or two spikelets per node. Spikelets are to 0.4 to 0.8 inch (1 to 2 cm) long and overlap each other by about one-half their length. Glumes are firm, unequal, linear-lanceolate to lanceolate, and gradually tapering from the base to a short awn. The first glume is 0.25 to 0.45 inch (6 to 12 mm) long and the second 0.3 to 0.6 inch (7 to 15 mm) long. Lemmas are 0.04 inch (1 mm) long and firm with obscure nerves and a pointed tip or short awn (Arnow 1987; Asay 1995a,b; Hitchcock 1950; Sarvis 1941; Stubbendieck and others 1992).

Ecological Relationships and Distribution

Western wheatgrass is morphologically similar to thickspike wheatgrass, but it differs in having asymmetrical glumes (Cronquist and others 1977). Western wheatgrass has recently been placed in a separate genus and renamed *Pascopyrum smithii* (Rydb.) Love (Dewey 1984; Love 1980). *P. smithii* is the sole member of this genus. Dewey (1975) considers its putative parents to be thickspike wheatgrass and beardless

Figure 8—A comparison of growth forms of western wheatgrass demonstrates some of the variation in leafiness in this species (RMRS photo).

wheatgrass. Its adaptability to heavy saline and alkaline soils and its forage qualities reflect the input of these parental species (Dewey 1984).

Western wheatgrass occurs across the western two-thirds of Canada and the United States, from Alaska and British Columbia to Quebec, and southward through the Western and Central United States (Arnow 1987; Asay 1996) east of the Cascade Mountains to New Mexico (Hanson 1972), the Central and Northern Great Plains, and the Texas Panhandle (Hanson 1972; Hitchcock and others 1969). It is the only octoploid wheatgrass native to North America (Asay 1995a,b).

Ecotypes of western wheatgrass varying in stature, color, and sodding traits occur in a variety of plant communities. On the Central Great Plains, it is abundant in lowlands, and may occur as nearly pure stands aligning watercourses (Sarvis 1941). Throughout this region it grows with blue grama, sideoats grama, alkali sacaton, buffalo grass, and needlegrasses. In the Western United States it is often the dominant grass in salt desert, big sagebrush, mountain brush, and pinyon-juniper communities. In Utah it rarely occurs on slopes above 6,900 ft (2,130 m) (Arnow 1987), but it grows at higher elevations in Wyoming and Colorado (Dittberner and Olsen 1983). Western wheatgrass often grows in association with bluebunch wheatgrass and needle-and-thread on upland benches and with bottlebrush squirreltail and Sandberg bluegrass in Wyoming big sagebrush and salt desert communities.

Beetle (1955) ranked this species as the most alkali tolerant of all North American wheatgrasses. It is commonly found on heavy clay soils with moderate alkalinity in salt desert shrublands. It is common in cold desert uplands of northern Utah, western Wyoming, and eastern Idaho where salty outcrops occur with Wyoming big sagebrush, winterfat, and various saltbush species. It is also common in dry valley bottoms, swales, and dry drainages where periodic flooding occurs (Rogler 1973). Although western wheatgrass exists on fine-textured soils, it grows on well-drained bottomlands, open plains, and benchlands of lower mountain and foothill ranges in the Intermountain region (Stewart and others 1939). It occurs in areas receiving 10 to 20 inches (250 to 500 mm) of annual precipitation, but performs well in the 10- to 14-inch (250- to 360-mm) zone. It is sometimes an important understory species in ponderosa pine and pinyon-juniper, but it is not shade tolerant and is usually restricted to openings between trees.

Plant Culture

Seed production of native western wheatgrass stands in the Northern Great Plains is generally greater than from stands in more arid regions. Released cultivars have improved seed production capabilities compared to wildland collections. Yields ranging between 150 and 300 pounds per acre (168 to 336 kg per ha) are expected from cultivated fields with irrigation (USDA Natural Resources Conservation Service 2002). Yields from dryland fields are half those of irrigated fields. Fields require regular tillage to maintain proper spacing and prevent overcrowding by sodding. Plants flower in June, and seeds ripen in August or September (Wambolt 1981), later than for many other grasses. Seed stalks are erect and project above the leaves, facilitating combine harvesting. Seeds are large, firm, and easily separated from the spikelet using standard cleaning equipment.

Western wheatgrass seeds, particularly those from wildland collections, do not germinate readily or uniformly, resulting in erratic establishment (Beetle 1955; Ferguson and Frischknecht 1985; Monsen and McArthur 1985). The seeds often exhibit low or delayed germination at warm temperatures between 66 to 73 °F (19 to 23 °C) (Brown and Hallman 1984; Plummer 1976), but alternating temperatures of 59 to 80 °F (15 to 30 °C) tend to promote germination.

Erratic germination decreases survival in rapidly drying seedbeds. Although slow- or late-developing grass seedlings may succumb to competition with weeds, western wheatgrass seedlings are extremely drought tolerant. When seeded in mixtures with more aggressive species, poor and spotty stands may develop. Increasing the seeding rate usually does not improve plant density. However, when seeded in weed-free, but harsh environments typical of mine disturbances, this grass establishes satisfactorily. Seed germination and establishment characteristics of recently developed cultivars are much improved over previously used wildland collections.

Established plants are vigorous and drought resistant. Plants spread vegetatively from rhizomes, forming open, irregular patches, even when seeded alone. Western wheatgrass can be seeded with slower developing native species, including shrubs.

Uses and Management

Western wheatgrass is one of the most important native forage grasses of the Northern Great Plains (Sarvis 1941) and the Intermountain West (Stewart and others 1939; Vallentine 1961). It has not been planted as extensively on range and wildland sites as crested wheatgrass and intermediate wheatgrass because its seedling establishment is less reliable and its herbage yields are lower. Western wheatgrass begins growth relatively early in spring, and plants mature late in the season. Standing plants cure well, remaining palatable and nutritious. Energy values are rated good (Dittberner and Olson 1983). Livestock and game graze it during most seasons. Because it provides good winter grazing, it is often managed to provide late fall and winter pastures (Sarvis 1941).

Western wheatgrass has been reduced or eliminated from many Western rangelands by continuous and prolonged grazing. Close and repeated clipping can reduce yields and weaken stands (Wasser 1982). However, plants have demonstrated the ability to recover if protected from grazing. Plants spread quickly from rhizomes and are able to repopulate abandoned lands (Rogler 1973; Weaver and Albertson 1956). Considerable recovery has been noted in Wyoming big sagebrush and pinyon-juniper communities protected from grazing for 1 to 20 years. Plants have increased during periods of drought (White and others 1978) and replaced annual weeds. Sarvis (1941) reported that western wheatgrass recovers so quickly in noncultivated fields that it has been called "go-back" grass. Rate of recovery is based on plant vigor, density, and the presence of other species.

Western wheatgrass is particularly important for restoring semiarid communities because it is one of the few species adapted to these sites and it can be established successfully. It grows in association with other native species on sites that have been seriously altered and are occupied by annual weeds. It can be seeded with bluebunch wheatgrass, slender wheatgrass, bottlebrush squirreltail, Sandberg bluegrass, and related broadleaf herbs to reestablish native communities and promote secondary succession.

Western wheatgrass has been used to revegetate mine disturbances. Although establishment from direct seeding is slow, plants spread by rhizome development and stabilize exposed soils (Thornburg 1982). This grass is particularly useful for controlling erosion of sandy soils (Scheetz and others 1981) and for providing protective ground cover throughout the entire year. It establishes quickly on barren mine wastes that are free of competitive weeds. Established sod is very persistent, but not restrictive to seedling invasion by some native herbs and shrubs.

Western wheatgrass is also commonly planted on saline seeps associated with mine disturbances (Rogler 1973). It grows well on loam and clay loam soils and fine-textured mine wastes, and it persists on soils with moderate alkalinity (Reitz and Morris 1939; Wambolt 1981), overflow sites, and subirrigated wetlands with poor drainage. It also withstands short periods of flooding.

Western wheatgrass recovers from wildfires and prescribed burning through rhizome proliferation (Wasser 1982; White and Currie 1983). Aboveground stems may be burned, but little heat is transferred to the root meristematic tissue (Gartner and others 1978).

Varieties and Ecotypes

Considerable variability exists among populations of western wheatgrass, and use of local or adapted materials is recommended. However, sufficient seed cannot be harvested from wildland stands to plant large projects. Consequently, for most seedings, the best adapted of the currently available cultivars must be selected.

The Natural Resources Conservation Service in Los Lunas, NM; the Colorado Agricultural Experiment Station in Fort Collins; and the New Mexico State Highway Department in Santa Fe, cooperatively released 'Arriba' western wheatgrass in 1973. It was developed from a collection obtained in 1957 from a site near Flagler, CO, at an elevation of 4,970 ft (1,530 m) that receives annual precipitation of nearly 16 inches (400 mm). Seed production was increased by selection through five generations (Alderson and Sharp 1994). Seeds of Arriba germinate rapidly and uniformly, providing vigorous seedlings. Seed production of this cultivar exceeds that of other tested accessions. Plants establish quickly and spread rhizomatously. Herbage yields are good, but less than those of the variety 'Barton' when grown in pastures. Arriba has performed well on arid mine sites. It has also done well when seeded on semiarid shrublands. It produces dark green foliage that is sought by grazing animals. Young plantings establish quite well, even on infertile sites. Arriba and 'Rosana' are the two most widely seeded cultivars of western wheatgrass in the Intermountain region.

Barton western wheatgrass was cooperatively released in 1970 by the Natural Resources Conservation Service Plant Materials Center at Manhattan, KS; the Kansas Agricultural Experiment Station, and the Agricultural Research Service. The original seed was collected from native grassland in Barton County, KS. It is used in the Midwest to stabilize disturbed soils. It is the most productive cultivar currently available (Alderson and Sharp 1994), and it is also strongly rhizomatous. It has not been extensively seeded in the Intermountain area.

The Nebraska Agriculture Experiment Station and the Agricultural Research Service cooperatively released 'Flintlock' in 1975. It is a broad-based cultivar genetically, derived from materials collected in central and southwestern Nebraska and northwestern Kansas. Flintlock produces aggressive rhizomes. It is commonly used for conservation plantings, dryland hay production, and early-season pastures in the Central Great Plains (Alderson and Sharp 1994).

'Rodan' was developed from materials collected in the Missouri River bottoms near Mandan, ND. The Agricultural Research Service, the Natural Resources Conservation Service, and the North Dakota Agriculture Experiment Station released it in 1983. Rodan is primarily adapted to the Great Plains of the United States and the prairies of Canada. This cultivar was selected for its seed production and drought tolerance. It is used primarily for revegetation of disturbed lands. It is also planted for grazing and hay production because it yields well on dry sites (Alderson and Sharp 1994).

The Natural Resources Conservation Service Plant Materials Center at Bridger, MT, and the Montana Agricultural Experiment Station released 'Rosana' western wheatgrass in 1972. It was selected from materials harvested in native meadows near Forsyth, MT, and developed for seeding irrigated hayfields and pastures. It has also been successfully planted on rangelands and mine disturbances (Alderson and Sharp 1994). Seed is readily available. Rosana is one of the most widely used cultivars in the Intermountain region. Its range of adaptability, however, has not been adequately defined.

Rosana has been used to control weeds and provide ground cover because it produces a closed sod soon after establishment. Seedlings are vigorous and establish well, particularly when seeded in mixtures or planted on harsh sites. Moderate to good amounts of light blue-green herbage are produced annually.

'Walsh' was developed from southern Alberta and southwestern Saskatchewan collections and released in 1982 by Agriculture Canada. It is a dual-purpose cultivar, adapted for pastures and hay production. It is also extensively seeded to revegetate disturbed lands in Canada. Walsh is tolerant of saline soils, drought, and periodic flooding (Alderson and Sharp 1994).

Agropyron spicatum Bluebunch Wheatgrass

Synonyms

Agropyron inerme
Agropyron spicatum var. *inerme*
Elymus spicatus
Elytrigia spicata
Pseudoroegneria spicata

Description

Bluebunch wheatgrass (fig. 9) is a perennial, cool-season, native bunchgrass (Arnow 1987; Hitchcock 1950; Stubbendieck and others 1992). Plants are rarely rhizomatous. Stems are erect and 24 to 40 inches (60 to 100 cm) tall. Sheaths are glabrous or puberulent. Blades are flat or involute, 0.04 to 0.08 inch (1 to 2 mm) wide, and 2 to 10 inches (5 to 25 cm) long. The upper surface normally has small hairs, but the underside is smooth. Auricles are well developed. Ligules are membranous and about 0.04 inch (1 mm) long. Spikes are typically erect, slender, and 2.4 to 8 inches (6 to 20 cm) long with a continuous rachis. Spikelets are rarely more than one per node, five to eight flowered, and mostly 0.4 to 0.8 inch (1 to 2 cm) long. Those near midlength on the spike rarely exceed the internodes by more than one-third their length. Glumes are mostly unequal, somewhat oblanceolate, three to seven nerved, 0.18 to 0.47 inch (4.5 to 12 mm) long, and obtuse to acute or rarely awn tipped. Lemmas are 0.28 to 0.51 inch (7 to 13 mm) long, acute or terminating in a widely divergent awn.

Both diploid (2n = 14) and autotetraploid (4n = 28) forms occur in the West, but tetraploids are primarily limited to eastern Washington, northwestern Idaho (Hartung 1946), and Canada. Dewey (1966) concluded that bluebunch wheatgrass has been involved in the phylogeny of several other grasses. Beardless wheatgrass has been designated a separate species by some authors, but Heller (1900), Beetle (1961), and Cronquist and others (1977) combined it with bluebunch wheatgrass. Beardless wheatgrass lacks the distinctive divergent awn, a recessive trait of bluebunch wheatgrass (Asay 1995a,b). Stebbins and Fung (1953) presented cytogenetic evidence demonstrating that both varieties are completely interfertile. Both hybridize freely and produce fertile progeny. Daubenmire (1960) concluded that the cespitose growth forms of

Figure 9—Bluebunch wheatgrass is one of the most important native bunchgrasses (photo courtesy of Kevin Jensen, USDA ARS, Logan, UT).

bluebunch wheatgrass are adapted to arid grasslands and semideserts, while rhizomatous forms require more mesic sites.

The cultivar 'Secar' was originally identified and released in 1980 as a bluebunch wheatgrass. Asay (1995a,b) later referred to it as "thickspike wheatgrass" because it is morphologically similar to bluebunch wheatgrass, but genomically aligned with thickspike. It is now considered a separate taxon, Snake River wheatgrass (*Agropyron spicatum* ssp. *laceolata*), originally designated *Elymus lanceolatus* ssp. *wawawaiensis* (Carlson 1986), and more recently *Elymus wawawaiensis* (Natural Resource Conservation Service 2002). Snake River wheatgrass, which includes Secar, is most prevalent along the lower Snake River drainage of central Idaho (Asay 1996). Since Secar was initially considered a variety of bluebunch wheatgrass and as it is ecologically and morphologically aligned with this species, we have treated it as a bluebunch wheatgrass in this text.

Ecological Relationships and Distribution

Bluebunch wheatgrass occurs from Alaska to Saskatchewan and south to California, Arizona, New Mexico, and Texas (Arnow 1987). On the Palouse Prairie it frequently occurs in pure stands, but it is most often codominant with Idaho fescue and Sandberg bluegrass (Miller and others 1986). It is often a dominant species on grasslands of the Pacific Northwest. In areas of the Intermountain area receiving 7 to 30 inches (150 to 760 mm) of annual moisture it grows in association with big sagebrush and antelope bitterbrush (Stoddart 1941; Wright and Bailey 1982). Bluebunch wheatgrass generally occurs on sagebrush flats, low foothills, and benchlands (Pickford 1932). It is not highly shade tolerant, but it does occur in pinyon-juniper, mountain brush, aspen, ponderosa pine, and spruce-fir forests. It forms distinctive and important associations with ponderosa pine at mid and upper elevations in Oregon, Washington, Montana, and Idaho, but it is equally important in more arid grass or shrub communities on dry, well-drained slopes.

Bluebunch wheatgrass occurs in some unique plant communities. It exists in restricted areas with low sagebrush, alkali sagebrush, and black sagebrush in Nevada (Zamora and Tueller 1973); pygmy and stiff sagebrush in Idaho, throughout the extensive steppes of Washington (Daubenmire 1970); and in the sagebrush-grass steppes of Colorado (Francis 1983) and southern Idaho (Hironaka and others 1983).

Bluebunch wheatgrass occurs on soils that vary in texture, depth, and parent materials. It is often found on coarse, well-drained mountain slopes (Tisdale and Hironaka 1981). It is not tolerant of alkaline or saline soils, but is does grow on dry, calcareous soils.

Plummer and others (1968) reported that this grass exhibits considerable variation. Some beardless and bearded forms have similar areas of adaptation, but some exist in differing sites. Plummer and others (1968) concluded that sod-forming strains are superior to bunch types for seeding game ranges with variable topography in Utah, because they are adapted to a wider range of moist to dry habitats. Daubenmire (1960) noted that caespitose individuals prosper in arid grasslands in eastern Washington and northern Idaho, and that rhizomatous types dominate in more mesic grasslands. Dewey (1970) suggested that the presence of rhizomes may result from introgression with thickspike wheatgrass. A greater chance for introgression would occur at upper elevations where thickspike wheatgrass is more common. Rhizomatous types are not always restricted to more mesic conditions, and moderately spreading growth forms are sometimes found growing in drier situations. Some rather extensive rhizomatous populations occur in pinyon-juniper, antelope bitterbrush, and big sagebrush communities. Since this species occurs over such a wide range of sites, and exhibits considerable difference in vegetative characteristics, selection and use of specifically adapted ecotypes is recommended.

Plant Culture

Seeds of bluebunch wheatgrass cultivars are commonly produced under cultivation. Wildland stands normally produce seed crops most years (Stewart and others 1939), and plants are capable of producing some seeds even during periods of drought.

Plants grown under cultivation are usually planted in rows spaced 24 to 36 inches (60 to 90 cm) apart. Satisfactory crops can be grown under irrigation or if sufficient moisture is available, under dryland conditions. If irrigation is required, application is made prior to pollination or the late boot stage. In fields that dry rapidly, irrigation soon after harvest may be required to ensure fall regrowth and tillering. Under cultivation, bluebunch wheatgrass fields normally produce 300 to 385 pounds of seed per acre (336 to 430 kg per ha) (Hafenrichter and others 1968). Seeds ripen early, generally by mid-July. Moderate amounts of fertilizer are required to maintain productivity. Bluebunch wheatgrass develops an extensive root system, and properly spaced plantings are normally somewhat competitive with weeds. Seeds usually ripen uniformly, but mature seeds shatter quickly. Fields can be swathed when seed is in the soft-dough stage and then combined; however, direct combining is most practical. Bluebunch wheatgrass seed is easily cleaned, but awns must be removed from some cultivars and wildland collections. Infertile florets can be removed during cleaning. Seed viability from wildland collections may be less than 60 percent.

Bluebunch wheatgrass is best sown in fall, but it will establish from early spring plantings if moisture conditions are favorable. Seeds can easily be planted with most drills or other seeders. Seeds are of moderate size and should be planted at depths of 0.5 to 1.5 inches (1.3 to 3.8 cm). Seedlings are not as vigorous or competitive as those of cheatgrass (Harris 1967), but they establish and persist well when planted in weed-free seedbeds. Bluebunch wheatgrass seeds germinate fairly uniformly, seedlings grow rapidly, and mature stands will develop in 2 to 3 years. Young plants develop extensive root systems, and after about 2 years they provide considerable competition.

Dewitt (1969) compared the germination rates of 51 accessions of bluebunch wheatgrass in an attempt to select sources capable of germinating at cooler temperatures and competing more successfully with cheatgrass seedlings. Although differences among collections were noted, they were not great enough to be of practical importance. Improvement of germination rate and emergence success through selection of larger seeds from different populations appears possible (Kitchen and Monsen 1994). As additional ecotypes are selected for wildland seedings, emphasis on development of seedling vigor and establishment traits should be emphasized.

Bluebunch wheatgrass has often been replaced by crested wheatgrass in range and wildlife seeding projects. However, bluebunch wheatgrass develops strong stands, and it can be seeded as a major component of native mixtures. Established seedings of bluebunch wheatgrass are very persistent (Hafenrichter and others 1968; McGinnies and others 1983; Plummer and others 1955). Native stands eliminated by grazing have been reestablished by direct seeding. Monsen and Anderson (1993) found that bluebunch wheatgrass plantings established in south-central Idaho in 1927 persisted through two wildfires and prevented invasion of introduced perennial grasses during a 64 year period.

Bluebunch wheatgrass stands can be restored with protective management if some residual plants remain. Considerable increase in plant density was noted on a number of sites in the Intermountain West between 1989 and 1994, during a period of extended drought. Although bluebunch wheatgrass seedlings are not able to compete with annual weeds as successfully as crested wheatgrass seedlings (Harris 1967), they are quite hardy. Bluebunch wheatgrass can be seeded in areas where it once dominated to reduce weed encroachment and provide a permanent cover. When seeded in disturbances where residual native species still occur, established bluebunch wheatgrass usually allows for natural spread and encroachment of other native species.

Seedings of bluebunch wheatgrass and other adapted native herbs are required to restore native shrub and herb associations. Antelope bitterbrush, Stansbury cliffrose, and mountain big sagebrush have been eliminated from many game ranges through excessive grazing by wild ungulates. In many cases, cheatgrass and other annual weeds have invaded and become the dominant vegetation. Reestablishment of native shrubs by interseeding and transplanting shrubs in clearings within annual grass stands has been successful, but without reestablishment of the native understory, the seeded shrubs are unable to reproduce naturally.

Planting success is dependent, in part, on adaptability of the seeded ecotype. Nearly all seedings using bluebunch wheatgrass are conducted using seed of three available cultivars: 'Goldar', Secar, and 'Whitmar'. Although these are useful and widely used cultivars, each has specific areas of adaptation. Goldar and Whitmar are better adapted to uplands and most moist sites, while Secar is better adapted to the lower ranges, particularly in the Snake River drainage. None are universally adapted throughout the entire range of this grass. In addition, none of these cultivars are well adapted to Great Basin sites. As additional releases or seed sources become available, planting success is likely to improve.

Uses and Management

Bluebunch wheatgrass is one of the most important, productive, and palatable native grasses in big sagebrush communities. It is a major species in sagebrush-grass, pinyon-juniper, and ponderosa pine communities. It is valuable because of its widespread distribution and because it provides excellent forage in spring, summer, and fall (Vallentine 1961). It is also used in winter at certain locations. Bluebunch wheatgrass begins growth in early spring as soil temperatures approach 42 °F (17 °C) and air temperatures reach 58 to 77 °F (24 to 32 °C) (Anderson 1991). Although differences in palatability occur among ecotypes (Willms and others 1980), this grass is palatable to most classes of domestic stock and big game, and supplies excellent herbage even after growth has ceased. It cures well and in many locations it is used as winter forage by wildlife (Peek and others 1979).

Reestablishment of bluebunch wheatgrass is desirable over a broad range of sites. This species has been reduced from extensive areas by poorly regulated grazing (Anderson 1991; Blaisdell and Pechanec 1949; Forsling and Dayton 1931; Rickard and others 1975). Loss of bluebunch wheatgrass and related species has resulted in rapid invasion by annual weeds, particularly cheatgrass (Christensen 1963; Cottam and Evans 1945; Daubenmire 1940; Pickford 1932). Christensen (1963) reported that mechanical disturbances and frequent fire also reduced the occurrence of the species. This change in species composition has diminished forage production and species diversity, and increased fire frequency. As a result of overgrazing by domestic animals, cheatgrass and other annual exotic weeds have displaced bluebunch wheatgrass communities across extensive areas of the West (Christensen 1963; Cottam and Evans 1945; Daubenmire 1940; Pickford 1932). Christensen (1963) reported that mechanical disturbances and frequent fires have also reduced the occurrence of this species.

Reestablishment of bluebunch wheatgrass and associated herbs has been hindered by a lack of adapted seeds and by the competitive ability of cheatgrass and other weeds. Elimination and control of weeds is essential if bluebunch wheatgrass communities are to be restored. Although bluebunch wheatgrass seedlings and those of many other perennial grasses are not as competitive as cheatgrass and other annual weeds, reestablishment of bluebunch wheatgrass communities by careful management and artificial seeding are the most practical solutions to weed invasion and spread.

Bluebunch wheatgrass plants are particularly sensitive to season and intensity of grazing. Most plants succumb from repeated moderate to heavy clipping in late spring at the height of the growing season (Daubenmire 1940). Hyder (1972) found that species such as bluebunch wheatgrass produce culms late in the growing season when the apical meristems are elevated as internode elongation proceeds. These meristems are susceptible to removal by grazing, and further growth must originate from axillary buds at the base of the plant. Defoliation during spring, when vegetative growth is proceeding rapidly and the apical meristem is elevated, is most detrimental (Stoddart 1946b). Miller and others (1986) concluded that plants can withstand use early in the growing season if conditions permit adequate growth after grazing.

Rickards and others (1975) found that 50 percent use for 2 consecutive years on previously protected sites resulted in a 26 percent decrease in the basal area of bluebunch wheatgrass. Heady (1950) concluded that clipping once to a 6-inch (15-cm) height at flowering was too severe to permit plants to maintain themselves. Wilson and others (1966) found bluebunch wheatgrass may be eliminated by grazing to a 1-inch (2.54-cm) stubble height for 3 consecutive years during the boot stage. Mueggler (1975) found that bluebunch wheatgrass plants growing with competition may require 8 years to approach normal vigor following late spring clipping.

Bluebunch wheatgrass plants do not curtail root growth following defoliation (Richards 1984). This reduces the availability of carbon reserves for shoot development (Caldwell 1984; Richards 1984). Crested wheatgrass has often been planted as a substitute for bluebunch wheatgrass because it has a much greater capacity to allocate limited carbon resources to foliage regrowth following clipping or grazing (Caldwell and others 1981; Caldwell and Richards 1986b; Richards and Caldwell 1985).

Many bluebunch wheatgrass communities have been converted to crested wheatgrass and intermediate wheatgrass seedings because these species withstand more intensive late spring and summer grazing. Most wildland sites are not managed as intensive pastures, and costs for site conversion usually do not justify this effort. Plummer and others (1955) found that bluebunch wheatgrass, including beardless bluebunch wheatgrass, is more productive than crested wheatgrass on poor sites. These investigators also found that on sites receiving more than 10 inches (250 mm) of annual precipitation, yields of bluebunch wheatgrass are comparable to those of crested wheatgrass, but fluctuate less than those of introduced wheatgrasses. Bluebunch wheatgrass is now widely used to restore native communities. Plantings in the big sagebrush, pinyon-juniper, and ponderosa pine types are successfully seeded with this species when planted alone or in mixtures.

Bluebunch wheatgrass is an important species for wildlife. It provides useful forage, and along with woody shrubs furnishes cover and protection. Bodurtha and others (1989) found that mule deer preferred bluebunch wheatgrass communities that approximated the composition of climax communities during both spring and summer grazing in Oregon. Deer and elk selectively graze Utah pinyon-juniper sites that are seeded with bluebunch wheatgrass.

Bluebunch wheatgrass furnishes ground cover and soil protection for steep slopes in watersheds where erosion is a serious problem. It is particularly important in semiarid environments where loss of ground cover creates major watershed problems and disturbances are difficult to restore. It provides excellent cover in ponderosa pine and pinyon-juniper woodlands where seasonal storms can generate considerable runoff.

Bluebunch wheatgrass is fire tolerant and regenerates vegetatively following burning. Only small amounts of litter accumulate near the base, limiting fuel buildup and potential fire damage to root crowns (Antos and others 1983). Leaves and stems are coarse and burn quickly, transferring little heat to the soil (Wright 1985). Although bluebunch wheatgrass usually survives fires, postburn production, ground cover, tillering, and seed production vary among burns. Crown cover can be reduced over 52 percent following wildfires (Conrad and Poulton 1966), and foliage production normally decreases for 2 to 3 years (Daubenmire 1975b; Muggler and Blaisdell 1958).

Varieties and Ecotypes

Only three cultivars of bluebunch wheatgrass are currently available. Additional populations or ecotypes are needed. Individual ecotypes differ in adaptability, and local collections should be seeded where available releases are not adapted.

Anatone bluebunch wheatgrass is a selected germplasm originating from Asotin County, WA, at an elevation of 3,200 to 3,600 ft (975 to 1,097 m). It exhibits good seedling vigor and is recommended for use on bluebunch wheatgrass sites receiving at least 10 inches (25 cm) of annual precipitation (Monsen and others 2003).

Goldar bluebunch wheatgrass was initially selected by the Natural Resource Conservation Service Plant Materials Center at Pullman, WA, but it was moved to the Plant Materials Center in Aberdeen, ID, where it was released in 1989. Seed was originally collected from an open ponderosa pine community on the Umatilla National Forest near Asotin, WA, at an elevation of 1,000 to 1,550 ft (310 to 475 m) in 1934. Goldar was developed by mass selection from spaced plantings (Alderson and Sharp 1994).

Goldar is a diploid form of bluebunch wheatgrass, an ecotype of *A. s.* ssp. *spicata* (USDA Soil Conservation Service 1989). This is a vigorous cultivar, representative of material found in northeastern Oregon and southern Washington. It is a leafy, productive, and densely tufted bunchgrass that produces some tillers and short rhizomes. It is relatively drought tolerant when compared with Whitmar. Goldar produces seeds with the typical divergent awns of the species; these must be removed prior to seeding.

Goldar is recommended for seeding rangeland sites to improve native diversity and to provide wildlife habitat and forage for grazing animals. It is adapted to sites receiving 12 to 14 inches (300 to 360 mm) of annual precipitation. In the Intermountain West, it has done well on pinyon-juniper and upper benchlands occupied by mountain big sagebrush. It has survived when seeded in disturbed Wyoming big sagebrush communities receiving at least 12 inches (300 mm) of annual precipitation. It is not as drought tolerant as Secar, but it is much more palatable and remains green later in the season. It provides considerable fall greenup, and develops a very dense and competitive ground cover. Plants cure well and are grazed as winter pastures. Overseeding Goldar on depleted big sagebrush communities by aerial seeding and chaining has been very successful. This cultivar provides useful herbage in mixed and single-species plantings. It is particularly useful for grazing in spring and early summer. Goldar is sensitive to grazing during the vegetative stages of growth.

'NewHy' RS hybrid wheatgrass was developed by artificially crossing quackgrass (2n = 6x = 42) and bluebunch wheatgrass (2n = 4x = 28). The Agricultural Research Service, Forage and Range Research Laboratory, Logan, UT, the Utah Agricultural Experiment Station, and the Natural Resource Conservation Service released this cultivar in 1989. NewHy was derived from two germplasms ('RS-1') and ('RS-2') released in 1980 (Asay and Dewey 1981). The initial RS hybrid population was established in 1962. These plants were only partially fertile, but fertility and growth characteristics were improved through an eight-generation selection process. The primary objectives in the selection process were to combine the vigor, productivity, salinity tolerance, and persistence of quackgrass with the drought tolerance, caespitose growth habit, and seed and forage quality of bluebunch wheatgrass (Asay and others 1991). Caespitose types were emphasized, but annual rhizome development of NewHy ranges between 1.6 and 3.3 ft (0.5 and 1.0 m) per year.

NewHy can grow in saline soils (Currie and others 1986); its salt tolerance approaches that of tall wheatgrass. NewHy is most productive on slightly saline or alkaline sites receiving about 17 inches (330 mm) of annual precipitation. Seed quality varies among lots. When seeded alone, a seeding rate 8 to 17 pounds per acre (9 to 19 kg per ha) is sufficient. Poor seed germination can result in weak stands, but as plants develop, tillering and rhizome development in the third and fourth year provide more complete cover. NewHy provides high-quality forage, comparable to that of intermediate wheatgrass. Plants begin growth in early spring and remain green until late in the growing season. On dryland ranges NewHy provides late spring grazing and competes well with weeds. It tolerates moderate grazing and recovers quickly following use, an improvement over bluebunch wheatgrass.

P-7 bluebunch wheatgrass is a multiple-origin polycross generating by mating 23 open-pollinated, native-site collections and two cultivars from Washington, Oregon, Nevada, Utah, Idaho, Montana, and British Columbia. P-7 is intended to provide increased genetic diversity upon which natural selection may operate within a single germplasm. It is intended for use on semiarid to mesic sites in the Intermountain Region. P-7 has very good seed yields. Genetically, P-7 corresponds to the "P" metapopulation, which includes native populations in southeastern Washington, northeastern Oregon, and western Idaho, the region from which the great majority of the P-7 components originated (Jones 2002a).

Secar was selected at the Plant Materials Center at Pullman, WA, from a collection obtained by J. L. Schwendimann near Lewiston, ID, in 1938. Originally considered a bluebunch wheatgrass, it was later identified as Snake River wheatgrass. The Agricultural Research Service; the Idaho, Oregon, Montana, and Wyoming Agriculture Experiment Stations; and the

Natural Resources Conservation Service Plant Materials Center in Pullman, WS, released Secar in 1980. Secar is a densely tufted bunchgrass with many fine leaves and stems. Seeds are small and mature early in the season. This cultivar is more drought tolerant and better adapted to harsh sites than other bluebunch wheatgrass cultivars. It is slower to establish and less productive than the more robust cultivars.

Secar is adapted to low-elevation sites in the Pacific Northwest receiving 8 to 12 inches (200 to 300 mm) of annual precipitation (Alderson and Sharp 1994). Secar is also seeded in Wyoming big sagebrush communities on the Snake River Plain of southern Idaho, and in northern Nevada and central Utah. It is less productive than Goldar when seeded on more upland sites, but it produces considerable herbage under arid conditions. Secar is well adapted to sites with long, hot summers, as it enters dormancy in late spring or early summer. It forms closed stands when seeded in rows spaced less than 28 to 30 inches (71 to 76 cm) apart. Established stands, particularly in low rainfall areas, are somewhat competitive with annual weeds. Secar is fire tolerant and recovers well following wildfires. Herbage is not as selectively grazed as other cultivars or ecotypes. Secar establishes well when seeded in mixtures with other natives.

The 'SL-1' germplasm was developed and released by the Agricultural Research Service Forage and Range Research Laboratory in Logan, UT, in 1990. It is a hybrid derived from the diploid form of bluebunch wheatgrass and thickspike wheatgrass. The initial F1 hybrid was made in 1965 by crossing a bluebunch wheatgrass collection obtained in Utah with a Nevada collection of thickspike wheatgrass (Dewey 1965). The F1 hybrid was completely sterile, but use of colchicine permitted development of a fertile amphiploid population. Further selection was made for improved fertility, seed production, seed size and vigor, herbage production, leafiness, and drought tolerance (Asay and others 1991).

Seed set of the SL-1 population approaches that of the parental species, but seed fertility varies between 34 and 50 percent (Maughan 1988). The hybrid differs from both parents in being leafier and producing larger culms and leaves. Rhizome development ranges from a caespitose growth habit to plants that spread 1 to 3.3 ft (0.3 to 1.0 m) per season (Asay and others 1991).

SL-1 exhibits usefulness in plantings on sites where either parent occurs. The SL-1 germplasm is quite vigorous and productive, supplying forage and remaining green late into the summer. Considerable fall greenup occurs, extending the period of grazing. The plant is also useful as a ground cover and could be planted to reduce erosion in semiarid areas. Plants establish well by direct seeding and appear capable of controlling weeds.

Whitmar beardless bluebunch wheatgrass was originally released as beardless wheatgrass and is awnless or nearly awnless. It was released in 1946 by the Washington, Idaho, and Oregon Agricultural Experiment Stations, and by the Soil Conservation Service Plant Materials Centers at Aberdeen, ID, and Pullman, WA. Whitmar was developed from material collected from native Palouse Prairie grasslands near Colton, WA. Original collections were growing at an elevation of 2,780 ft (845 m) on a silt loam soil in an area receiving 20 inches (500 mm) of annual precipitation (Alderson and Sharp 1994).

Whitmar is considered an intermediate growth form. It is erect or semierect with moderately abundant, medium-coarse stems and leaves. The cultivar provides good spring and fall herbage and it is a good seed producer (Alderson and Sharp 1994). Whitmar is primarily used in the Pacific Northwest. Although initially seeded in the Intermountain area, it has been replaced by Goldar and Secar.

Agropyron trachycaulum
Slender Wheatgrass

Synonyms

Agropyron caninum
Agropyron latiglume
Agropyron pauciflorum
Agropyron subsecundum
Elymus pauciflorus
Elymus subsecundus
Elymus trachycaulus

Description

Slender wheatgrass (fig. 10) is a diverse complex of several taxa. It is a native, short-lived, cool-season, strongly tufted perennial that occasionally produces rhizomes (Cronquist and others 1977; Goodrich and Neese 1986; Hitchcock 1951; Welsh and others 1987). Stems are green or bluish green and 20 to 60 inches (0.5 to 1.5 m) tall. Sheaths are smooth and glabrous or rarely hairy. Blades are ascending to lax. They are usually narrow and flat or involute, 2 to 10 inches (5 to 25 cm) long, 0.08 to 0.16 inch (2 to 6 mm) wide, and scabrous to pilose on the upper surface. Spikes are 1.6 to 8 inches (4 to 20 cm) long and stiffly erect. Spikelets are overlapping, 0.35 to 0.60 inch (9 to 16 mm) long, and three to seven flowered. Glumes are glabrous or scaberulous, 0.25 to 0.60 inch (6 to 15 mm) long, 0.04 to 0.12 inch (1 to 3 mm) wide, and abruptly tapered to an acute or awn-tipped apex. Lemmas are blunt or end in a short awn. The second glume is about two-thirds the length of the lemma.

Slender wheatgrass and four related taxa described by Hitchcock (1950) have been combined as varieties of

Figure 10—Slender wheatgrass grows at higher elevations than other native bunchgrasses and is often used for reseeding forest disturbances (RMRS photo).

Agropyron trachycaulum or placed in synonymy with this species (Cronquist and others 1977). Arnow (1987) followed Gould (1947) in treating the complex in *Elymus*. Bearded wheatgrass is the most important taxon included in this group. It is similar to slender wheatgrass in areas of occurrence and growth characteristics, but it is more productive, robust, and longer lived (Hafenrichter and others 1968).

Ecological Relations and Distribution

Slender wheatgrass occurs in Alaska, much of Canada, and southward through the West, Central, and Northeastern portions of the United States, and in Northern Mexico (Arnow 1987). It requires at least 15 to 20 inches (38 to 51 cm) of annual precipitation. Consequently, it is usually found at higher elevations and on deeper soils than most other wheatgrasses. In the Midwest, it is largely limited to soils with moderate water-holding capacity (Sarvis 1941). Slender wheatgrass normally grows in association with aspen, spruce-fir, and mountain herblands (Mueggler and Campbell 1986). It is not tolerant of dense shade, and becomes quite abundant following timber cutting and fires. It is a common species in open park herblands (Eckert 1975; Ellison 1954) and open areas in mountain brush and ponderosa pine forests. It is less important in pinyon-juniper woodlands, but it can be quite abundant in local areas. Slender wheatgrass occupies some mountain big sagebrush benchlands, and it is a common constituent in river bottoms and on alluvial soils in stream and valley bottoms.

Slender wheatgrass can be a relatively short-lived species, but it reseeds and spreads well by natural seeding, exceeding most other wheatgrasses in this characteristic. Long-term ecological studies on the Wasatch Plateau of central Utah revealed that this species was one of the few native grasses to persist, although at a low density, after many years of heavy grazing (Monsen and others 1996). As grazing was discontinued, this species regained dominance rather quickly in some areas, but its position fluctuated with changes in climatic events and recovery of associated species.

Slender wheatgrass has been able to persist in many overgrazed mountain herblands. It persists on sites where annual weeds, including tarweed, have become dominant. It invades openings and spreads to occupy harsh sites. It has also been able to persist amid disturbances where gophers are extremely destructive. It is not a weedy invader, but it is able to persist and spread due to its seeding abilities and short-term growth characteristics.

Plant Culture

Slender wheatgrass produces an abundance of seeds when grown on wildland sites or in cultivated fields. Hafenrichter and others (1968) reported that seed production of irrigated plantings averaged 800 pounds per acre (896 kg per ha). Plants are self-fertile (Fulbright and others 1982), and viable seed crops are produced most every year. Seeds are large, detach easily, and can be combined and cleaned without difficulty. Seeds retained in warehouse storage lose little viability after 5 to 10 years.

Slender wheatgrass normally requires cool prechilling for germination. Fall seeding is recommended, but seeding high mountain ranges in early spring or summer is successful if summer rains maintain moist seedbeds. Stewart and others (1939) recommend seeding 5 to 12 pounds of seed per acre (5.6 to 13.4 kg per ha). Seeds benefit from drill seeding and placement of seeds in the soil at depths of 0.5 to 1.0 inch (1.3 to 2.5 cm). This species can be seeded in mixtures with other grasses and broadleaf herbs. It is an important native grass that can be seeded with slower developing herbs without suppressing their seedling development.

Slender wheatgrass can serve as an important pioneer species; its seedlings are vigorous and capable of establishing on harsh sites. In addition, it is able to establish and compete with weedy species, particularly cluster tarweed and knotweed. It can also be interseeded into sites disturbed by grazing that support species such as western yarrow, Letterman needlegrass, dandelion, and Rydberg penstemon to improve diversity and stimulate natural recovery. Because it is short lived, the density of slender wheatgrass in undisturbed herblands fluctuates annually, recovering through natural seeding.

Uses and Management

Slender wheatgrass was one of the first native grasses included in early restoration plantings (Sampson 1913). It became a widely used species for planting range and wildland sites in the Intermountain West (Forsling and Dayton 1931), the Northern Great Plains, and Canada (Sarvis 1941). It was initially recognized as a desirable forage species that is easily established and adapted to a wide range of sites (Forsling and Dayton 1931). Slender wheatgrass was not used in cultivated pastures until specific cultivars were developed for that purpose. The short-lived nature of this plant resulted in the unexpected decline of some early seedings, but as this characteristic was better understood, slender wheatgrass became an important revegetation species.

Slender wheatgrass is a dual-purpose species. Growth begins in midspring and continues through summer and fall if moisture is available. It is usually more preferred by cattle than by sheep (Vallentine 1985). Its foliage cures well and provides useful winter herbage (Sarvis 1941). Although slender wheatgrass produces a moderate amount of herbage, it is highly nutritious and palatable. However, the plant can become "stemmy" as it reaches maturity. Slender wheatgrass withstands intense use, but it is not as tolerant of grazing as western wheatgrass. Plants remain vigorous with moderate to heavy grazing. Grazing at the time of flowering and seed set, however, can diminish plant vigor. Slender wheatgrass is preferred by elk, bighorn sheep, deer, and other wildlife (Hallsten and others 1987). It provides forage and cover for wildlife. Animals seek and graze the green herbage throughout the summer.

Native and seeded stands of slender wheatgrass are often managed as meadow hayfields or as pastures. New plantings grown under cultivation remain highly productive for 3 or 4 years; yields diminish substantially thereafter. The cultivar 'Primar' was developed for pasture use and is seeded with sweetclover or red clover in conservation and pasture plantings (Hafenrichter and others 1968). Field production of mixed seedings can be maintained at a higher level for longer periods of time than if the grass is seeded alone.

Slender wheatgrass is used primarily to restore disturbances and rehabilitate native communities. It is widely planted to reestablish desirable cover on mountain meadows and open park herblands. It can be interseeded into existing cover with minimal site preparation. Once plants become established and seed crops develop, new plants establish from seed. Native stands can also be managed to allow for natural recovery. Slender wheatgrass is commonly seeded in mixtures with other grasses and broadleaf herbs.

Slender wheatgrass can be used to quickly restore ground cover and control erosion. This species can be planted in forested regions following fires to provide soil protection. New seedings establish quickly, furnishing excellent cover the first growing season. Plants establish well on open, exposed soil. This grass is also seeded on overgrazed ranges where soil stability is a concern (Plummer and others 1955). Price (1938) noted that differences occurred among ecotypes, and found that successful plantings could be established in low-elevation communities if adapted ecotypes were seeded. Bridges (1942) reported the success of seeding abandoned farms, dry meadows, and mountain mesas in New Mexico, using local ecotypes of slender wheatgrass.

Slender wheatgrass provides a useful native substitute for intermediate wheatgrass, smooth brome, and fairway crested wheatgrass seedings in areas where it is adapted. It can be used in mixtures with other natives to reestablish native communities. Its wide range of adaptation from mountain big sagebrush communities (Beetle 1952) to subalpine types (Stewart and others 1939) makes this species a useful plant for restoring native understories and rehabilitating harsh disturbances.

Varieties and Ecotypes

Five slender wheatgrass cultivars have been released. Because this species includes numerous regional ecotypes, it is important that adapted sources are planted. Some seed can be harvested from wildland stands, but most seed must be field grown to supply the amounts required for larger projects.

'Adanac' slender wheatgrass was released in 1990 by Agriculture Canada for use in hay and pasture production in Saskatchewan. It is slightly more productive than 'Revenue' for hay production. It is not commonly grown in the Western United States.

'Primar' slender wheatgrass was cooperately released by the Washington, Idaho, and Oregon Agricultural Experiment Stations; the National Resources Conservation Service Plant Materials Center at Pullman, WA, and the Agricultural Research Service, Plant Science Research Division in 1946. It was developed from materials collected in 1933 near Beebe, MT. Primar is a vigorous, early-growing, and long-lived selection. It is primarily seeded with sweet clover in pasture mixtures, conservation seedings, or as a green manure crop to improve soils (Alderson and Sharp 1994). Early spring growth exceeds that of other collections, and plants remain green throughout the summer. Plants generally persist for fewer than 5 years on sites receiving less than 15 inches (380 mm) of annual precipitation; they are much longer lived on sites receiving more than 18 inches (460 mm) of annual rainfall (Schwendiman and Law 1946). Seedings are extremely vigorous. When grown for hay, this cultivar provides abundant yields. Plants are free of smut, and the species can be seeded for pasture use on a wide range of soils.

The Natural Resource Conservation Service Plant Materials Center at Bridger, MT, and the Montana and Wyoming Agricultural Experiment Stations released 'Pryor' in 1988. It was collected along a dry drainage in a saline upland between Pryor and the Beartooth Mountains of Montana. It produces large seeds and vigorous seedlings. Pryor has been used primarily for conservation and reclamation planting in Montana and Wyoming (Alderson and Sharp 1994). It is drought tolerant and adapted to saline soils.

Revenue slender wheatgrass was developed and released in 1970 by Agriculture Canada, Saskatoon, Saskatchewan, from seed of a single plant collected in 1963 near Revenue, Saskatchewan. It is recommended for use as a pasture variety because stands can be maintained for 3 to 5 years. This cultivar is superior to Primar in salinity tolerance, establishment, forage production, and seed yields. It provides considerable leafy herbage, and plants are free of smut (Alderson and Sharp 1994). Revenue is widely seeded in pastures and on rangelands in the Western United States.

'San Luis' was cooperatively released in 1984 by the Colorado, Utah, and New Mexico Agricultural Experiment Stations; the National Resources Conservation Service; and the Upper Colorado Environmental Plant Center at Meeker, CO. It was developed from plants collected in San Luis Valley, Rio Grande County, CO. Plants establish quickly, provide effective cover, and are relatively long lived. San Luis is recommended for sites above 5,800 ft (1,800 m) that receive at least 14 inches (350 mm) of annual precipitation (Alderson and Sharp 1994). It is widely seeded throughout the Intermountain area, particularly on drier sites than are seeded with Revenue. It is commonly seeded on range and wildland sites, including roadway and mine disturbances.

Agrostis stolonifera
Redtop or Carpet Bentgrass

Synonyms

Agrostis alba
Agrostis palustris
Agrostis gigantea
Agrostis depressa

Description

The taxonomic history and resulting synonymy of this species is complex (Kartesz and Kartesz 1980). Hybridization has further confused the issue (Bradshaw 1958). Linnaeus based *A. alba* on a *Poa*, apparently *P. nemoralis* (Cronquist and others 1977). Hitchcock and others (1969) applied the name *Agrostis alba* and recognized three varieties: *A. a.* var. *alba*, *A. a.* var. *palustris*, and *A. alba* var. *stolonifera*. These varieties had previously been treated at the species level (Hitchcock 1950). Other more current treatments, including Arnow (1987) and Cronquist and others (1977), combined these varieties into *A. stolonifera*.

Redtop, or carpet bentgrass, is an extremely long-lived rhizomatous and often-stoloniferous perennial that sometimes forms large mats (fig. 11). The presence or absence of stolons, rhizomes, or both is reported to be habitat related. Stems are erect to decumbent and range from 0.7 to 4.9 ft (0.2 to 1.5 m) in height. Leaf blades are flat or folded, smooth to strongly roughened, and 0.08 to 0.8 inch (2 to 20 mm) wide. Ligules on the upper leaves are 0.2 to 0.28 inch (5 to 7 mm) long. Panicles are oblong to elliptical, 1.6 to 15.7 inches (4 to 40 cm) long, and 0.4 to 5.9 inches (1 to 15 cm) wide with the branches eventually spreading. Spikelets are single flowered, 0.06 to 0.1 inch (1.5 to 3.5 mm) long, and green to reddish purple with an awnless, or rarely short-awned lemma. The common name redtop refers to the characteristic reddish hue of the panicle.

Ecological Relationships and Distribution

Redtop is one of the most important and widely distributed members of its genus in the United States. Native to Eurasia and North Africa, it was introduced to North America prior to 1750 as a lawn, meadow, and pasture grass. It now occurs throughout the northern temperate region, growing in shallow water, wet meadows, and along streambanks on moderately moist

Figure 11—Redtop, a long-lived, mat-forming perennial introduced as a lawn, hay, and pasture grass, has spread widely and now occurs in moist areas of many Western plant communities (photo courtesy of John Kinney, USDA Forest Service, Rocky Mountain Research Station, Boise, ID).

pinyon-juniper, aspen, and spruce-fir communities (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). The species occurs over a broad elevation range, from sea level to about 10,000 ft (3,050 m), but mostly below 8,000 ft (2,440 m) (USDA Forest Service 1937).

Plant Culture

Plants flower from June to early September. Abundant seed crops are produced most years. Seeds are easily harvested, but they shatter readily when mature. Seed production fields yield about 75 pounds per acre (84 kg per ha) (De France 1953). Viability of newly harvested seed is generally high. Seedlots are normally cleaned to at least 90 percent purity; germination is often at least 90 percent. There are 5 to 6 million seeds per pound (5.6 to 7.2 million per kg) (De France 1953).

Redtop seeds are small and benefit from surface seeding. Planting depth should not exceed 0.25 inch (0.63 cm). The species establishes well by broadcast seeding followed by light harrowing to cover the seed. This technique works especially well when spring or fall seeding on wet surfaces, which may crust if compacted by drill seeding. Seeding rates can be easily adjusted to provide the desired seed density. A carrier may be added to regulate the seeding rate and seed distribution. Redtop is normally not seeded alone, particularly in irrigated or dryland pastures. When planted in mixtures, seeding rates vary between 2 and 4 pounds per acre (2.2 and 4.5 kg per ha). Rangeland and watershed seedings normally do not require heavier seeding rates.

Although redtop seeds germinate early, seedlings are weak and can be suppressed by other species. Thus, establishment is often poor. Mature stands, however, are very persistent. Plantings established over 50 years ago on the Wasatch Plateau have survived and flourished. Plants develop a low growth form and spread by producing a vigorous sod. Redtop does not spread aggressively beyond the original planting site in rangeland seedings, irrigated pastures, or seed production fields. It does increase in density, and spreads by extension of the root system.

Uses and Management

Redtop is recognized as a useful cultivated grass for wetland areas. It has been used extensively with other species in irrigated pastures (Weintraub 1953). Its area of distribution is similar to that of Kentucky bluegrass, but it is more tolerant of acidic, poorly drained, and clay soils (Balasko and others 1995). It responds well to fertilization, but it is not a high-producing species for hay production. Although other wet meadow species may be more productive, redtop does grow through the summer if moisture is available, and it can provide green herbage when foliage of other species has dried. Redtop is not highly palatable, and it does not tolerate close and repeated grazing. However, it is useful for game and livestock.

Redtop receives considerable use in some areas. It is seeded in wet and semiwet meadows in aspen and mountain herblands, particularly in areas where erosion is a major concern (Stubbendieck and Jones 1996). Redtop is also well adapted to acidic soils and has promise for treating disturbances at high elevations. It is a vigorous grower and will form good turf in a short time, making it valuable for use as a soil binder in reclaiming eroded drainages and stabilizing slopes, banks, gullies, and waterways. It is also commonly seeded in mixtures with other species, including alfalfa, to provide pasture and hay (Weintraub 1953). Redtop and several other stoloniferous species introduced from Europe are used extensively in turf culture, especially for use on golf courses.

Redtop has been seeded to protect disturbed riparian sites and high-elevation herblands because seed of many desirable native species is not available. Plantings have provided excellent ground cover and herbage, but they have maintained dominance on planted sites. Natural recruitment of native species has not occurred. Redtop should not be recommended or seeded if recovery of native species is desired.

Varieties and Ecotypes

‘Streaker’ was developed in Idaho for pastures, reclamation, and turf plantings. It is presently the only cultivar available (Jacklin and others 1989).

Alopecurus arundinaceus
Creeping Foxtail
Reed Foxtail

Synonym

Alopecurus ventricosus

Alopecurus pratensis
Meadow Foxtail

Synonym

None.

Description

The genus *Alopecurus* consists of about 50 species distributed throughout the Temperate and Arctic Zones of the Northern Hemisphere (Boe and Delaney 1996). Its name, *Alopecurus,* is derived form the Greek words

Alopex meaning fox, and *oura* meaning tail, referring to the characteristic cylindrical panicle. The two most common forage species in this genus are meadow foxtail and creeping or reed foxtail. These two perennial species are similar in taxonomy, growth form, site requirements, and uses. Consequently, they will be discussed together.

Linnaeus named meadow foxtail *A. pratensis* in 1753, and the name has never been changed. Hitchcock (1950) classified creeping foxtail as *A. arundinaceus*, and this name continues in use. Creeping foxtail and meadow foxtail are separated taxonomically by the position and extension of the awn. The awn of creeping foxtail arises below, or rarely above, the middle of the lemma. It is straight or slightly bent, and measures 0.04 to 0.1 inch (1 to 3 mm) in length. The awn is either included or exerted (Arnow 1987). The awn of meadow foxtail is attached near the base of the lemma and is bent or geniculate.

Creeping foxtail is a rhizomatous perennial that ranges from 1.6 to 3.9 ft (0.5 to 1.2 m) in height (fig. 12). Culms are solitary or in small clusters. Leaf blades are flat, 0.3 to 0.5 inch (8 to 12 mm) wide, glabrous above and rough below. Ligules are 0.04 to 0.20 inch (1 to 5 mm) long. Panicles are purple or dark colored, spike-like, cylindric, 1.6 to 3.9 inches (4 to 10 cm) long, and up to 0.3 inch (8 mm) wide. Spikelets are one flowered and laterally compressed, disarticulating below the equal glumes. Diagnostic characters for this species include the glume tips, dark purple spikelets, and shortly exerted awns (Arnow 1987).

Meadow foxtail is a stout, nonrhizomatous perennial ranging from 1.3 to 2.6 ft (4 to 8 dm) in height, but sometimes reaching 3.3 ft (1 m) (fig. 13). Roots sometimes develop from the lower culm nodes. Leaf blades are flat, roughened on both surfaces, and 0.12 to 0.24 inch (3 to 6 mm) wide. Ligules are 0.08 to 0.14 inch (2 to 3.5 mm) long and covered with short, fine, soft hairs. Ligule margins are irregularly serrate to entire. Panicles are 1.4 to 3.4 inches (3.5 to 8.5 cm) long and 0.2 to 0.3 inch (5 to 7.5 mm) wide. Spikelets are ovoid and one flowered. Glumes are subequal, often with green nerves, and relatively large, measuring 0.12 to 0.20 inch (3 to 5.2 mm) in length. Keels of the glumes have long, soft, unmatted hairs; those on the lateral nerves are appressed. Lemmas are 0.12 to 0.20 inch (3 to 5 mm) long and usually glabrous, but sometimes with hairs near the keel apex.

Figure 12—Creeping foxtail, a rhizomatous introduction, grows on wet sites over a wide elevational range. Seeded to provide hay, forage, and erosion control, it has become weedy along waterways (photo courtesy of Kevin Jensen, USDA Agricultural Research Service, Logan, UT).

Ecological Relationships and Distribution

Creeping foxtail and meadow foxtail are widespread in Europe and temperate Asia (Strelkova 1938). Creeping foxtail was introduced in the United States in 1935 (Stevens 1963), and is now naturalized in the Great Plains, Pacific Northwest, and Intermountain regions (Hafenrichter and others 1968; Sutherland 1986). Meadow foxtail was introduced in North America in the mid-1800s (Wheeler 1950), and it has naturalized across Canada and the northern half of the continental United States (Hitchcock 1950; Scoggan 1978). Both species are long lived, winter hardy, and adapted to high-elevation meadow sites, including those with poorly drained, acidic soils. Both have a high tolerance to flooded and frozen soils (Stroh and others 1978) and are capable of persisting on sites where standing water may be present for more than a month. They are seeded as pasture and hay crops in wet meadows and have spread along waterways and moist drainages.

Plant Culture

Panicles mature from the apex toward the base. Seeds near the panicle apex may shatter before seeds near the base mature, and seeds can shatter within a

Figure 13—Introduced in the mid 1800s, meadow foxtail has become naturalized on high-elevation sites in Canada and the Northern United States (RMRS photo).

few hours after reaching maturity (Wheeler and Hill 1957). Consequently, seeds must be harvested when the greatest number of seeds are mature, but before they disperse. Seeds tend to darken or turn black during maturation, a trait that aids in selecting harvest dates. Seeds can be combine harvested by raising the cutter bar above the leaves to remove seed heads and some stem material. Harvesting can also be accomplished using strippers that dislodge the seeds by flailing or brushing. Seed can be harvested when slightly green if it is allowed to dry before processing. Seed yields are not usually as high as for other pasture species, but yields between 268 to 400 pounds per acre (300 to 450 kg per ha) have been reported (Hafenrichter 1968). Meadow foxtail and creeping foxtail usually produce good-quality seeds that can be cleaned to relatively high standards. Seed germination and purity each normally exceed 80 to 85 percent.

Spring or fall seedings can be successful in wet meadows, as seeds germinate rapidly on moist seedbeds. Ten to 14 pounds of seed per acre (11.2 to 15.7 kg per ha) is adequate for planting irrigated pastures. In most rangeland situations, lower rates provide adequate stands. When seeded in mixtures, particularly with legumes or other pasture grasses, 3 to 5 pounds per acre (3.4 to 5.6 kg per ha) is sufficient. Seeds can be distributed on the soil surface or planted in shallow furrows at a depth of less than 0.5 inch (1.3 cm). Surface-sown seed should be harrowed or covered using a light drag. The planted unit consists of a caryopsis enclosed in a light, fluffy, membranous covering that can bridge or flow irregularly in most conventional seed boxes. Consequentially, adaptors are required to move seed uniformly through drills or other planting machinery.

Creeping foxtail has been seeded primarily on range and wildland sites. It has established well without irrigation from both drill and broadcast seedings. Dispersed seeds germinate quickly, allowing plants to spread and develop competitive stands rather quickly. Mature plants compete well with other species, and ultimately dominate areas where the species is adapted. Although seedlings of creeping foxtail and meadow foxtail appear to be weakly competitive when seeded in cultivated pastures with other species, both plants are aggressive natural spreaders on rangelands (Plummer and others 1968). They spread by root proliferation and natural seeding, particularly the latter (Lewis 1958b).

Uses and Management

The foxtails were among the first perennial grasses used to rehabilitate disturbances on mountain rangelands. Both species are well adapted to subalpine grasslands, aspen forests, and mountain brushlands. They have been widely planted in irrigated and nonirrigated pastures in mountain valleys, wet and semiwet meadows, and riparian zones. They have also performed well on drier sites where supplemental irrigation is not available. Plants are equally adapted to meadow sites in lowlands or in subalpine sites at elevations over 10,000 ft (2,857 m). Both foxtails are shade tolerant, and have persisted well as understory species in aspen forests. Regrowth following grazing can occur beneath an aspen canopy throughout the summer, even though these sites are shaded (Piper 1944).

Foxtails are usually planted as pasture or forage species. They begin growth in early spring, earlier than most other forage species, including timothy and orchardgrass. Plants often emerge through snow cover and begin growth when the soil is still frozen (Stroh and others 1978). In addition, they produce an early seed crop that is used by a variety of animals. Plants continue growth during mild winters (Hafenrichter and others 1949).

Geese, big game animals, and other wildlife species are attracted to the foxtails throughout the growing season, but particularly in spring and fall (Boe and Delaney 1996). Plants produce considerable herbage early in the season, and recover quickly from grazing or clipping, as only about 20 percent of all shoots are reproductive (Rumburg and Siemer 1976). Domestic livestock are also attracted to foxtail plantings in midsummer because new shoots are produced throughout the growing season. Upland game birds seek the cover and seeds provided by both species.

Both foxtails are best used to support high stocking management, but have reportedly depressed animal gains, possibly due to the presence of an unidentified antiquality component (Rode and Pringle 1986; Voigt and Sharp 1995). Both species are grown for hay production, particularly in high-elevation areas with short, cool growing seasons where few hay or pasture species are adapted. On such sites early summer pastures are important, particularly hayfields that can be cut or harvested early, but which can recover and be intensively grazed later in the season.

Foxtails are commonly seeded with legumes to improve yields and forage quality (Boe and Delaney 1996). They have been seeded with various clovers, birdsfoot trefoil, and alfalfa for pasture and hay production. On rangelands they are more commonly seeded with alfalfa, although some plantings with cicer milkvetch have also produced excellent pastures.

Creeping foxtail plants have been noted to spread as much as 4 ft (1.2 m) over a 3-year period (Stroh and others 1978). Consequently, they can outcompete associated species, including sedges and rushes. Plants also form dense rooting systems that provide excellent soil protection. Hart and others (1980) reported that creeping foxtail suppressed Canada thistle. These species have been used on high-elevation disturbances to stabilize watersheds, waterways, streambanks, and aspen disturbances. In these situations, however, they have gained dominance and prevented the recovery of native species.

Varieties and Ecotypes

'Dan' meadow foxtail was developed from material collected in Poland (Alderson and Sharp 1994). It is used primarily on low-elevation sites, while 'Mountain', developed in Ontario, Canada, is a more upland variety that is seeded in semiwet meadows associated with mountain brush, aspen, and conifer communities. Mountain greens up in early spring and again in fall. Neither variety has been seeded to any extent in the Intermountain West.

'Garrison' creeping foxtail is a pasture and hay grass that is adapted to waterways, wetlands, and other areas with high water tables. It was developed from Western European material growing near Max, McLean County, ND (Alderson and Sharp 1994). Garrison is seeded extensively in wet and semiwet pasture renovations. It can be seeded directly into weak stands of forbs and perennial grasses, including saltgrass. Its seedlings establish slowly, but established plants are highly productive and spread aggressively. Garrison survives periods of complete inundation and exhibits moderate tolerance of saline and alkaline soils.

Aristida purpurea Purple Threeawn or Red Threeawn

Synonyms

Aristida fendleriana
Aristida glauca
Aristida wrightii
Aristida longiseta

Description

The perennial *Aristida* complex has been treated as five separate species as listed above. The morphological characters used to distinguish the species involved a continuum of features including beak length (awn column), beak twisting, awn length, panicle length, panicle branching, lemma roughness, and leaf position (Cronquist and others 1977). These characters apparently vary from one extreme to another in any given population. Some even appear to differ on the same plant from year to year depending upon changing environmental conditions. Considerable differences in plant stature and leaf and stem numbers have also been noted. Due to this extensive variability, Cronquist and others (1977) included all taxa in *Aristida purpurea* and recognized three varieties: *purpurea*, *glauca*, and *robusta*. Regional ecotypes occurring in specific environments have also been described (USDA Forest Service 1937).

Plants of the threeawn complex are tufted perennials that range from 0.5 to 2.1 ft (1.5 to 6.5 dm) tall. Culms are smooth and hairless and sometimes branched at the lower nodes. There are long, soft, white hairs at the apex of the sheath. Leaf blades are inrolled or involute, and rarely flat, glabrous to slightly roughened on the upper side, 0.04 to 0.08 inch (1 to 2 mm) wide, and 2 to 3.9 inches (5 to 10 cm) long. They are often curved or flexuous on small plants and straight on large ones. Ligules are scarcely 0.02 inch (0.5 mm) long and consist primarily of a fringe of hairs. Panicles are 2.4 to 9.8 inches (6 to 25 cm) long and narrow to somewhat spreading. Panicle branches are usually appressed and closely clustered. Spikelets have narrow, linear glumes of uneven lengths that are sometimes awned. The lemma is about 0.4 to 0.6 inch (9 to 15 mm) long (including the awn column), often grading into a thin, twisted awn column or beak. The three awns that radiate from the awn column are subequal in length and have a purple hue. Plants flower from March to September (Cronquist and others 1977).

Ecological Relationships and Distribution

Purple threeawn is commonly found in dry, sandy soils of desert valleys, plains, mesas, and foothills. It is distributed from British Columbia throughout the Western and most of the Central States and south into Central Mexico at elevations ranging from 2,500 to 10,000 ft (763 to 3,050 m) (fig. 14). In the United States it is especially important in the Southwest. Purple threeawn is often abundant along stock driveways, roads, and abandoned farmlands. It invades disturbances where animals have burrowed, or where plowing or grazing have reduced or eliminated native vegetation. It is often found on south- and west-facing slopes where soil temperatures may be abnormally high (Evans 1967). At midelevations it grows with sand dropseed, needle-and-thread, and bluebunch wheatgrass. At lower and warmer sites it occurs with sideoats grama, Indian ricegrass, and bottlebush squirreltail.

Purple threeawn often grows in nearly pure stands. It may also be found intermixed with other native bunchgrasses as a codominant species or as a minor component of bunchgrass/sagebrush communities. Daubenmire (1970) suggested that purple threeawn distribution patterns indicate that its presence and distribution are regulated by edaphic conditions. Purple threeawn is reported to invade disturbances previously occupied by bluebunch wheatgrass, and it is often considered an early seral species (Evans 1967). However, this species is widespread and often present in undisturbed situations (Küchler 1964). It is not as heavily grazed nor eliminated as quickly by grazing as bluebunch wheatgrass.

Figure 14—Purple threeawn is distributed from British Columbia to Mexico (RMRS photo).

Plant Culture

Plants begin growth in early spring, generally by April (Evans and Tisdale 1972). Flowering occurs in mid-June and seeds mature in early September. Some viable seeds are normally produced, even during dry years (USDA Forest Service 1937). The divergent awns and sharp callus are important for natural dispersal and seeding, as they anchor and position the seed in the soil (Evans 1967).

Purple threeawn is not widely used in revegetation projects. At present, most seed is collected from wildland stands using modified hand or vehicle-mounted equipment. Seed collection and processing is hindered by the long awns. Removal of the awns is necessary to reduce volume for storage and to plant seeds with conventional drills or other seeding equipment. Fall seeding at a rate of 6 to 10 pounds per acre (6.7 to 11.2 kg per ha) is recommended if the species is planted alone. Drill seeding is generally required to place the seed at a depth of 0.5 to 1.0 inch (1.3 to 2.5 cm). Evans and Tisdale (1972) reported purple threeawn seeds required treatment at high temperature to initiate germination. Little seed germination was recorded until seeds were subjected to air temperatures exceeding 104 °F (40 °C).

Purple threeawn has been successfully seeded in mixtures with other native species. It competes well as a seedling. Root systems develop rapidly, allowing young plants to establish and persist, even during periods of moderate drought. Plants may require 3 to 5 years to fully develop. They recover well following disturbance, spreading from natural seeding. Developing stands and mature stands allow reestablishment of associated native shrubs and forbs.

Purple threeawn recovers quickly following burning due, in part, to the production of some seed each year. Seeds tolerate high temperature resulting from fires (Sampson 1944), and some may persist in the soil as a seed bank, aiding in natural recovery over time. Numerous small seedlings of purple threeawn may be found following fire and other disturbances. This plant is especially adapted to rapidly establish and spread due to the awns that facilitate dispersal and planting. Small and developing seedlings are able to compete with cheatgrass and other weeds. Seedling survival and growth of young plants in weedy competition indicates this species could be used to contain weeds and facilitate natural community recovery. Mature purple threeawn plants respond somewhat differently to burning. Fire can kill clumps that have an accumulation of large amounts of litter, but in most situations burning may remove dead material but few plants are killed (Evans 1967).

Uses and Management

Although not generally considered a highly palatable species, purple threeawn produces considerable early spring forage that is used by livestock and big game animals (Dittberner and Olson 1983). The USDA Forest Service (1937) identified it as an important forage plant in some areas, but noted that considerable differences existed among ecotypes. As awns develop, plants become less attractive to grazing animals, and can cause injuries if the awn attaches to or penetrates the skin, face, and eyes. Palatability is rated as poor to fair as the awns appear. The nutritional value of the species becomes somewhat more important in midsummer, fall, and winter months (Evans 1967), as it maintains some green foliage when other species are normally dry.

Purple threeawn is an important understory species in many shrubland communities that occupy dry slopes and sites critical as winter and spring-fall ranges for big game. In addition, these sites are subject to invasion by annual weeds if the understory is disturbed. The presence of annuals has resulted in a serious decline of many woody species due to competition and increased fire frequency. Consequently, it is important to maintain understory species that are compatible with associated shrubs.

Purple threeawn is adapted to disturbed sites and soil conditions where few other species exist. Kindell and others (1996) reported that ecotypes differ in their adaptation to local conditions. In many areas attempts to replace these ecotypes with more palatable introduced perennial grasses have diminished species diversity and resulted in a loss of habitat. Restoring and maintaining purple threeawn is essential to the health of many rangelands.

Purple threeawn has been successfully seeded on big game ranges in central Utah, and on disturbed roadways and mined sites in the Intermountain West. It has established and developed when seeded in mixtures or alone. Seed prices remain high, as demand is sporadic. Seed production fields have not been developed. Use of this species will likely increase as reestablishment of native species on foothill and lower elevation sites becomes more important.

Varieties and Ecotypes

There are no releases.

Arrhenatherum elatius
Tall Oatgrass

Synonyms

Avena elatior
Avena bulbosa

Description

Linneaus (1753) described tall oatgrass (*Arrhenatherum elatius*), naming it *Avena elatior*. Its current binomial, *Arrhenatherum elatius*, was assigned by Presl (1819). Tall oatgrass is a short-lived perennial bunchgrass, often rooting from the first nodes. The plant is erect and not truly rhizomatous. Culms arise from the bulblike base and are loosely tufted, ranging from 2.3 to 5.9 ft (7 to 18 dm) in height. Leaf blades are flat, smooth to somewhat roughened, and 0.1 to 0.2 inch (3 to 6 mm) wide. Ligules are 0.04 to 0.12 inch (1 to 3 mm) long, obtuse, and covered with very fine, ciliate hairs. Panicles are 5.5 to 9.8 inches (14 to 25 cm) long, narrow, and bear flowers to the base. Spikelets are shiny and two flowered with the first floret staminate and the second perfect. The florets disarticulate as a unit. Glumes are membranous and unequal, measuring about 0.2 to 0.3 inch (5 to 7 mm) in length. The awn of the first lemma is bent, about 0.4 to 0.6 inch (10 to 14 mm) long, and it is attached midlength on the lemma. The awn of the second lemma is small, straight, and attached at the lemma apex. It is rarely absent. Plants flower from late May through July (Arnow 1987).

Ecological Relationships and Distribution

Tall oatgrass is native to Eurasia, but it is now circumboreal (Arnow 1987). Introduced to the United States in 1807, it has been widely cultivated and is now distributed across the United States (Weintraub 1953) and Southern Canada. It is found in pastures and hayfields in the Pacific Northwest, the Intermountain and North-Central States, and the desert Southwest. It is well adapted to subhumid and irrigated conditions (Hafenrichter and others 1949). Although primarily used as a pasture plant, it has escaped cultivation and spread to waste areas, particularly those with rich soils. It has been seeded on rangelands and watersheds in the Intermountain region, and has spread to occupy sites in mountain brush, aspen, and mountain herbland communities. It tolerates shaded areas, and has spread to forested and wooded types. Plants are moderately salt tolerant, and have been planted in saltgrass meadows in the West (Weintraub 1953) (fig. 15).

Plant Culture

Tall oatgrass is a rapidly developing species with vigorous seedlings that is planted to provide pasture and forage. It is also harvested for seed, as good seed crops are generally produced each year in cultivated pastures and on most rangeland plantings. Seeds are borne on long, narrow panicles. Individual seeds are light, fluffy, and short awned. Seed crops can be

Figure 15—Tall oatgrass has been widely planted on saltgrass sites across the West (RMRS photo).

difficult to harvest because seeds shatter readily when mature. Light winds and combines or other machinery can dislodge the seed and reduce the harvest. Seeds are difficult to process.

Tall oatgrass can be difficult to seed through drills because the seeds often clump together to form balls that impede the flow through the drill. This problem can be corrected by processing the seed to separate the fluffy material. When seeded with seeds of other species, tall oatgrass seeds are often carried through the planting device in the mixture. Tall oatgrass seed can be distributed adequately by aerial or broadcast seeding methods. Plummer and others (1968) reported that seeds germinate without special treatment, and uniform stands are easily established from either drill or broadcast seedings. New plants grow rapidly and begin spreading from seed within 2 to 3 years if rodents or insects do not destroy the seed crops.

Uses and Management

Tall oatgrass has been used primarily as a pasture and hay crop in the Intermountain area. It is generally seeded on areas such as mountain meadows characterized by cool, moist conditions. It is commonly seeded as a mixture with other species to provide diversity and improve forage quality and yields (Weintraub 1953). The hay is harvested early in the season, and it is palatable and nutritious (Irwin 1945). Tall oatgrass produces a reasonable amount of herbage in both pasture and rangeland plantings. Yields of few other species exceed those of this grass.

Tall oatgrass is palatable and grazed by game and livestock. Its erect growth habit and abundant leaves provide considerable herbage in early spring. Excessive use in the early stages of growth can weaken the stand (Hafenrichter and others 1968). Although its palatability diminishes in midsummer and fall on rangeland sites (Plummer and others 1968), it cures well when harvested as hay (Stubbendieck and Jones 1996). Ordinarily, tall oatgrass begins to grow a few weeks earlier and remains green later in the fall than most other native grasses, thus extending the grazing period for livestock and wildlife (USDA Forest Service 1937). Plants retain only moderate amounts of edible forage in late fall and winter on game ranges.

On Western rangelands, tall oatgrass has become an important species for seeding subalpine, aspen, and mountain brush communities. It is planted on range and watershed disturbances to quickly stabilize and protect the soil. It is also commonly used to seed forest lands following wildfires. Plants are moderately salt tolerant, and the species has been used for seeding saltgrass meadows. Individual tall oatgrass plants are not long lived, surviving for 6 to 10 years. Natural recruitment occurs if associated vegetation does not fill in and occupy openings (Hull and Holmgren 1964). Grazing management can affect long-term survival of individual plants and seedings.

Although the ecological impacts of seeding tall oatgrass on deteriorated aspen and mountain herbland communities are not well understood, it is apparent that seeding this species in disturbed situations does not seriously interfere with natural recovery of native grasses and broadleaf herbs. Tall oatgrass was planted on mountain herbland disturbances of the Wasatch Plateau in the 1930s and 1940s. Excellent grass stands developed and soil erosion was stabilized. Within 10 to 30 years tall oatgrass essentially disappeared. Natural recovery of native species began before the decline of the seeded grass. Obviously this grass can better serve to provide initial ground cover and facilitate the recovery of native species than more persistent perennial grasses, such as smooth brome, that are commonly used in these situations.

Varieties and Ecotypes

'Tualatin' tall oatgrass was developed from materials collected in Chile, Italy, and Belgium (Alderson and Sharp 1994) in an effort to provide a cultivar that does not shatter rapidly (Hanson 1972). It has been seeded at sites throughout the Intermountain West in Gambel oak thickets, aspen and conifer forests and associated openings, and in subalpine communities to provide soil stabilization, forage, and community enhancement. It is not aggressive and can be seeded with other perennial species. Tualatin grows well in full sunlight, and it also exhibits good shade tolerance. Plants are relatively short lived, but they will spread from seed if the seedheads are not grazed. Tualatin was selected for its rapid establishment and excellent forage characteristics. It has not been seeded to any extent in the Intermountain West. This cultivar is leafier than most common lines, but seed is not currently maintained or available.

Bouteloua curtipendula
Sideoats Grama

Synonyms

Chloris curtipendula
Cynodon curtipendula
Andropogon curtipendula
Melica curtipendula

Description

Sideoats grama is a widespread, native, warm-season, perennial midgrass. It is the largest grama species, reaching heights of 0.7 to 3.3 ft (0.2 to 1 m) (Stubbendieck and others 1986). Plants are tufted with scaly, slender to stout rhizomes. The species is descriptively named based on the characteristic spikes that are predominately on one side of the seedhead (fig. 16). Culms are slender, erect, and smooth with a purplish tint at the nodes. Leaves are blue green and flat to involute. The ligule is reduced to a fringe of hairs, approximately 0.04 inch (1 mm) long. Panicles are 5.5 to 8.0 inches (14 to 20 cm) long with 25 to 80 pendulous short-stalked, spikelike, branches that disarticulate readily as a unit when mature. Each branch produces two to eight spikelets, each with one perfect floret. There is sometimes a vestigial spikelet. Glumes are papery and often purple tinged. The fertile lemma is three nerved with the lateral nerves ending as short awns that are 0.12 to 0.24 inch (3 to 6 mm) long (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). There are two varieties of sideoats grama that are segregated by growth form: *B. c.* var. *curtipendula* arises from creeping rhizomes while *B. c.* var. *caespitosa* forms clumps.

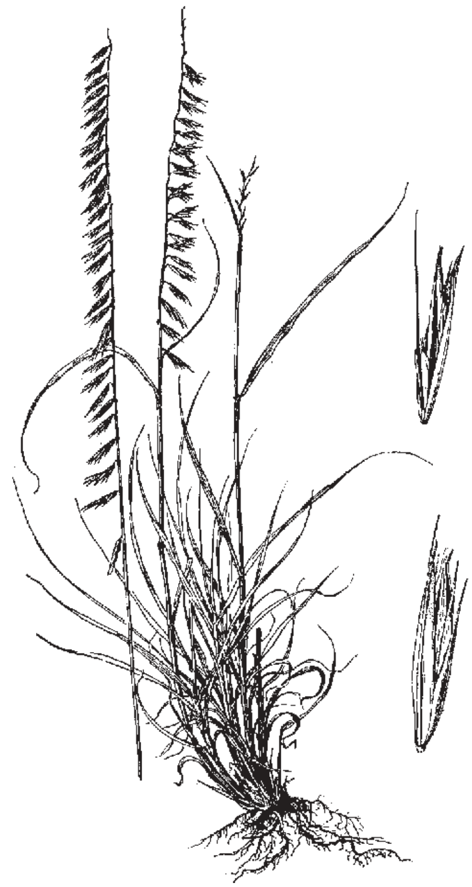

Figure 16—Sideoats grama, a native warm season perennial, is named for the spikes arranged largely along one side of the inflorescence (Hitchcock 1950).

Ecological Relationships and Distribution

Sideoats grama is widely distributed throughout much of North America. It ranges from Saskatchewan east to Ontario, and from Michigan south to southeastern California through Mexico to Central America to Andean South America (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; USDA Forest Service 1937), growing on plains, prairies, and foothills. It often grows in canyons and on low-elevation mesas, scrublands, weedy meadows, open woodlands, and steep rocky slopes at elevations from 3,000 to 8,000 ft (915 to 2,440 m). It is especially abundant in the central and southern mixed prairies of North America. Rhizomatous *B. c.* var. *curtipendula* occurs over the vast majority of the species range, while nonrhizomatous *B. c.* var. *caespitosa* occurs in the Southwestern United States and in Central and South America.

Sideoats grama is most abundant on fine-textured soils ranging from deep to shallow, but it also occurs on sandy to dry, rocky soils (Nicholson and Bonham 1977). It is better adapted to calcareous or moderately alkaline conditions than to neutral or acidic soils.

It is fairly drought resistant; root growth continues during dry periods (Weaver and Albertson 1956). Seminal roots rapidly extend deeper into the soil when subsurface soils are wet, reducing plant dependency on fluctuating moisture availability near the surface (Simanton and Jordan 1986). Abundant rhizome reproduction may then occur following precipitation events (Weaver and Albertson 1956).

Sideoats grama is climax-dominant or codominant over much of its range (Great Plains Flora Association 1986). It also occurs in early seral communities on disturbed sites, and it generally increases following drought (Weaver and Albertson 1956). In the Intermountain West, sideoats grama can be a climax indicator in big sagebrush, pinyon-juniper, and ponderosa pine communities, and an associated species in shrub communities including black greasewood and true mountain mahogany. It is often found growing with other grasses such as bluebunch wheatgrass, western wheatgrass, prairie junegrass, blue grama, and Idaho fescue.

Plant Culture

Sideoats grama reproduces from rhizomes, tillers, and seed. Rhizome production and tillering are most common in sandy soils. Natural reproduction from seed occurs when sufficient moisture is available for seed production, germination, and establishment (Simanton and Jordan 1986). Seed production and quality varies with precipitation and grazing pressure (USDA Forest Service 1937). Germination is generally rapid when sufficient moisture is available. Seedling vigor is good compared to that of other warm-season grasses, even on harsh sites.

Seed can be cleaned and processed without damage. Seeds are small, but easily planted with most seeding equipment. Shallow planting at depths of 1 inch (2.5 cm) or less is required. Seeds flow freely through drills, but they can be scattered by wind if broadcast aerially. In more southern areas of the West, seedings conducted prior to summer rains are more successful. Late fall and early spring seedings have been more successful in the northern portion of its range. Drought tolerance and good germination and seedling vigor contribute to its establishment and success. Because of its size and vigorous rate of growth, sideoats grama is quite competitive, and can be planted in mixtures or seeded alone. When seeded in mixtures with other species, it most often develops in small patches. It can be successfully seeded with a number of native shrubs, as it does not restrict seedling establishment.

Because sideoats grama is naturally distributed over a wide area, ecotypes with different areas of adaptation are abundant. Local seed sources or varieties with known adaptation to the seeding area are recommended for seeding.

Uses and Management

Sideoats grama provides valuable forage for all classes of livestock and big game (Dittberner and Olson 1983). Although plants are palatable and nutritious throughout most of the year, palatability is greatest in summer and fall and declines in winter (Stubbendieck and others 1986; White 1986). This species differs from other warm-season species because it produces important green herbage in spring. Mature stems are usually not eaten (Towne and Owensby 1983). Birds seek out the seed, and small mammals feed on the seeds and foliage (Wasser 1982).

Sideoats grama has been successfully used in rangeland seedings and on critically eroding areas, waterways, and mined lands. If competitive species such as pinyon, juniper, and big sagebrush are reduced, density as well as forage and seed production of sideoats grama tend to increase. Following drought, sideoats grama generally increases dramatically. Although less tolerant of grazing than blue grama, sideoats grama tends to replace taller grasses on abused ranges. It will gradually decrease if continually grazed during the growing season. This species, however, has the ability to recover naturally from destructive grazing, but recovery can be slow in some situations. Strong natural recovery is an important characteristic of this species because many disturbances within its range cannot be artificially seeded. Established seedings are fire tolerant. Sideoats grama is more site specific than many other perennial grasses, and ecotypes should be planted on soils and sites where they are adapted. Sideoats grama has proven only moderately adapted to harsh disturbances. It is receiving increased use as an ornamental grass.

Varieties and Ecotypes

‘Killdeer’ was selected for its outstanding vigor, leafiness, and fair seed production. It was originally collected near Killdeer, ND, in an area that receives 15 inches (380 mm) of annual precipitation. It has been seeded with good success in the Dakotas.

‘Niner’ originated near Socorro, NM, at 4,200-ft (1,280-m) elevation on a site that receives an average of 9 inches (230 mm) of annual precipitation. It demonstrates superior seedling vigor, strong establishment, and high seed and forage production in dry areas. It is recommended for use in New Mexico, Colorado, southern Utah, and northern Arizona.

'Pierre' exhibits outstanding vigor, excellent leafy forage production, and good disease resistance. It has been successfully seeded in South Dakota and in the surrounding States and Canadian Provinces. Its origin is near Pierre, SD, in a 16-inch (410-mm) precipitation zone.

'Vaughn' originated near Vaughn, NM, in a 13.5-inch (340-mm) precipitation zone at 5,930 ft (1,810 m). It is best adapted to areas in western Texas, New Mexico, southern Colorado, southern Utah, and northern Arizona. It is a good seed and forage producer, and it has received some use in the Intermountain West.

Bouteloua eriopoda
Black Grama

Synonyms

Chondrosium eriopodum
Bouteloua brevifolia

Description

Black grama is an important native, warm-season, perennial grass that exhibits a variety of growth forms over its range of occurrence. Tufted plants 10 to 28 inches (25 to 70 cm) in height develop from a hard, knotty, woolly base. The slender culms are solid, densely white-woolly, spreading, and sometimes stoloniferous at the lower nodes. They remain green up to the second node from the stem apex during some winters. Clusters of leaves emerge from the nodes in spring. Leaves are mostly basal, narrow, and pointed. They are generally twisted and involute near the top, hairy above, and smooth below. Roots are finely divided and generally confined to the upper 10 inches (25 cm) of soil (Arnow 1987; Cronquist and others 1977; Great Plains Flora Association 1986; Judd 1962). Inflorescences consist of one to six slender, comblike spikes borne on the sides of the inflorescence (fig. 17). The spikes are narrow, flaglike, and do not drop at maturity.

Vegetative growth begins as soon as adequate moisture becomes available. The growth period usually lasts from July to October, depending upon temperature and precipitation. The vigor of black grama plants is largely determined by the amount of precipitation received during the previous summer (Canfield 1939). Flowering occurs from June or July through August. Seeds usually mature in late September and disperse in October and November (Nelson 1934).

Ecological Relationships and Distribution

Black grama is a major warm-season grass of arid and semiarid grasslands in Texas, New Mexico, and Arizona. It also occurs in southern California, Utah, and Wyoming. It is a climax species in a number of grassland communities and occurs in early seral communities on disturbed sites. It is most often found in grasslands on dry, rocky hills and uplands and lower elevation mesas on well-drained, sandy and gravelly soils. Common associated species include dropseeds, threeawns, broom snakeweed, mesquite, and yucca. Black grama can survive on harsh sites characterized by low rainfall, high temperatures and evaporation, and strong winds (Nelson 1934). It is generally considered tolerant of drought. During dry periods, however, large tufts have been observed to break up and form smaller clumps, with a reduction in ground cover, but an increase in plant number.

Plant Culture

Stands are maintained and increased through seed production, stolon proliferation from old tufts, and tillering (Heizer and Hassell 1985). Reproduction varies widely with precipitation and grazing pressure (Canfield 1939). Two periods of flowering may occur in moist years (Canfield 1939). During a drought year, very little, if any, flowering occurs, and seed production is limited (USDA Forest Service 1937). In addition, uneven distribution of precipitation in summer may prevent seed from maturing (Nelson 1934). Black grama seed fill and germination are often poor. Heizer

Figure 17—Black grama inflorescences consist of one to six slender, comblike spikes (Hitchcock 1950).

and Hassell (1985) reported seed fills of only 7 to 10 percent for seed from native stands, while Campbell and Bomberger (1934) reported that germination may be as high as 41 percent once every 10 years.

In favorable years ground cover is increased through tillering, perhaps the most important means of regeneration (Campbell and Bomberger 1934). On ungrazed ranges, black grama forms uneven stands of large tufts that die in the center during drought, forming many smaller tufts. When favorable conditions prevail, these small tufts enlarge through lateral spread, and can again form a continuous cover (Nelson 1934). Stolons required two growing seasons to establish new plants. New stolons are produced during one growing season, while tillers develop and root during the second growing season (USDA Forest Service 1937).

Uses and Management

Black grama is used by all classes of livestock and wildlife (Stubbendieck and others 1986), and it was once a mainstay forage for livestock production in many areas of the Southwest. It is highly palatable and nutritious in summer and winter. During winter and early spring it can provide forage when other sources are scarce or unavailable (Canfield 1934).

Although black grama can withstand recurrent grazing by livestock, it spreads very little on heavily grazed ranges. Excessive use impairs its vigor, and overgrazed plants will die out during drought periods. Tillering is dependent on plant vigor during the previous year. Repeated cropping of black grama to 2 inches (5 cm) may prevent lateral spread. Damage may be especially severe in overgrazed areas that have deteriorated as a result of wind erosion (Canfield 1939). Regeneration by stolon production can occur during favorable years on conservatively grazed ranges (Nelson 1934). Stolon production is negligible on ranges that are excessively grazed year after year. In addition, drought-induced mortality and competition from less desirable and more competitive species can lead to a loss of black grama plants and a reduction in ground cover and forage.

Black grama is seldom used in range seedings because it is a slow starter and it is best adapted to harsh environments. Heizer and Hassell (1985) recommended that black grama be seeded only to stabilize soil on critically eroding areas. Black grama has good potential for ornamental use.

Varieties and Ecotypes

As a result of low seed quality, high seed costs, and the difficulty of establishment, black grama has not been seeded to any great extent. Two varieties are available; little research has been conducted to develop additional varieties.

'Nogal' is less erect than 'Sonora' and adapted to drier areas. Seed production is generally low, and supplies are limited and expensive (Alderson and Sharp 1994).

Sonora demonstrates outstanding leafiness, vigor, forage production, and vegetative spread, along with good seed set and seed production. It is adapted across much of the species range. Seed is expensive and supplies are very limited.

Bouteloua gracilis
Blue Grama

Synonyms

Actinochloa gracilus
Atheropogon gracilus
Bouteloua oligostachya

Description

Blue grama is a low-growing, densely tufted, warm-season perennial bunchgrass. The short rhizomes that develop from its base often create thick mats. Culms are 6 to 12 inches (15 to 30 cm) tall. Leaves are grayish green and turn to gray or straw colored with age. They are persistent, numerous, mostly basal, and sometimes hairy around the collar. Leaf sheaths are smooth to silky haired. Blades are flat to involute, characteristically curled or rolled inward with maturity, roughened above and smooth below, 0.04 to 0.08 inch (1 to 2 mm) broad, and 2 to 6 inches (5 to 15 cm) long. Ligules are sometimes membranous at the base and often fringed with hairs that are about 0.01 to 0.03 inch (0.2 to 0.7 mm) long. Inflorescences usually consist of two short, comblike pedicellate spikes that range from 0.5 to 2.0 inches (1.2 to 5.3 cm) in length and become sickle shaped at maturity (fig. 18). Each spike bears about 30 to 80 fertile spikelets, terminating with a single terminal sterile spikelet. Fertile spikelets produce one perfect floret and one or two sterile terminal florets. Glumes are one nerved. The first glume is 0.08 to 0.14 inch (1 to 3.5 mm) long, linear, and translucent. The second is subequal to the lemma, 0.16 to 0.24 inch (4 to 6 mm) long, purplish, and three awned. The terminal awn arises between two teeth and is 0.02 to 0.06 inch (0.5 to 1.5 mm) long. Lateral awns are 0.04 to 0.08 inch (1 to 2 mm) long with short, stiff hairs along the nerves. The callus, a swollen node at the base of the lemma, is densely hairy (Arnow 1987; Hitchcock 1950). Spikes become golden brown and tend to curve backward at maturity or when the plant is suffering from drought. Seeds do not disseminate rapidly at maturity.

Blue grama produces an efficient, widely spreading root system (Briske and Wilson 1977). Numerous roots develop from short rhizomes. Fine fibrous roots

Figure 18—Blue grama spikes curve backward and are golden brown when mature (Hitchcock 1950).

are mostly concentrated near the soil surface, but some extend deeper.

Ecological Relationships and Distribution

Blue grama is a widely distributed climax species that occurs throughout the Great Plains from Alberta and Manitoba south to Mexico, and from southern California eastward from southern Nevada and Utah, Arizona, New Mexico, and Texas (Great Plains Flora Association 1986; Hitchcock 1950; Stubbendieck and others 1986). Blue grama is a major component of the short grass prairie. It is also found in scattered sites in the Eastern United States. In the West, it is the most widespread and important species of its genus. It occurs in grass and sagebrush communities on dry plains and foothills, and sometimes in pinyon-juniper and ponderosa pine woodlands and mountain meadows of the Intermountain area. At midelevations it grows on sandy loam or rocky soils. It is often associated with galleta, sand dropseed, western wheatgrass, bluebunch wheatgrass, needle-and-thread, and broom snakeweed.

Blue grama exhibits considerable variability in its growth habit and general appearance throughout its north-south range. In the north it tends to form a sod under favorable moisture conditions. In the south and at lower elevations it tends to form patches and not a complete cover. It is also a taller, more vigorous bunchgrass (Griffiths 1912). Blue grama normally remains dormant in spring, greening quickly with summer precipitation. It is peculiar in that it flowers from July through September. Because of its root system, blue grama is highly drought resistant (Ward and others 1990; Wilson and Briske 1979; Wilson and others 1976); it is one of the most important soil-binding grasses where adapted in the arid West. It has the ability to become dormant during drought periods, but resumes growth when temperatures and moisture conditions become favorable. It is a rapidly growing species, reaching maturity in 60 to 70 days (USDA Forest Service 1937). It produces highly palatable forage in late summer and early fall when other forage is scarce. Blue grama is resistant to grazing, but it is most productive when lightly grazed in late summer. It is highly fire tolerant, but it is not shade tolerant.

Blue grama is adapted to a variety of soil types, but it most abundant on well-drained, sandy and sandy loam soils of uplands. It can also be found on alkaline and coarse-textured soils. In Arizona it is common on infertile, acidic soils (Nicholson and Bonham 1977). It is a common and important species on rocky outcrops, including mesas, canyon slopes, deep sandy soil on plains, and some midelevation grasslands.

Plant Culture

Blue grama reproduces from seed, rhizomes, and tillers. Good seed crops are produced during years with favorable moisture conditions. Seed quality is generally low, varying with year and location. Wind, water, and animals disperse the seed (Albertson and Weaver 1944). Adequate surface soil moisture is required for a 2- to 4-day period to support germination and initial seminal root growth. Lacking lateral seminal roots, seedlings die when the surface soil dries out before the seminal root elongates to deeper soil (Wicklow and others 1984). Critical factors for successful establishment of blue grama seedlings are seminal root initiation, good soil moisture for at least 6 weeks after emergence, and initiation of adventitious roots (Bock and Bock 1986; Albertson and Weaver 1944).

The entire spikelet, including the awned fertile floret and the awned and densely bearded rudimentary floret(s), is planted so the fertile florets are not separated during cleaning. These units are light and fluffy and cannot be seeded through a conventional grain drill. Specially designed seed drills facilitate uniform flow from the seed box to the soil. Shallow planting on firm seedbeds improves seeding success. As a result of its wide distribution, blue grama is highly ecotypic. It is important to use seed sources adapted to the edaphic and climatic conditions of the area being seeded.

Uses and Management

All classes of livestock and many wildlife species graze blue grama (Dittberner and Olson 1983). High-quality forage, drought tolerance, and a desirable growth habit make it one of the most important range grasses in areas where it is adapted. Although more palatable than most co-occurring species, blue grama has increased on many overgrazed ranges (Bock and Bock 1986; Weaver and Albertson 1956). Its persistence is attributed to its vigorous root system, rhizomatous habit, and its ability to maintain adequate root carbohydrate reserves following grazing (Buwai and Trlica 1977). Following grazing, some lower leaves generally remain near the soil surface and provide photosynthetic surface for plant recovery. With continuous heavy grazing and trampling, particularly on fine soils, blue grama may become sodbound and decline in forage production.

Blue grama is a rapidly growing species and usually matures in 60 to 70 days. It is tolerant of grazing, but yields the greatest return when grazed lightly in summer during its period of rapid growth. It can also be utilized in fall and winter. Grazing has often eliminated the upright forms, leaving the less productive, sodforming types. This is especially true in the Southwestern United States.

Blue grama can be nutritious throughout the year. It greens up early and grows rapidly following summer storms. Its fine leaves are low in fiber and high in protein when green, making it an exceptional forage. Protein and carbohydrate content are greatest during early bloom, decreasing toward maturity. About 50 percent of its nutritive value, however, is retained at maturity, making it an excellent fall or winter forage (National Academy of Sciences 1971). In the Southwest, productivity of the shorter growth form of this species is relatively low. Growth of the shorter variety begins in May and June, providing very little green forage during spring and early summer.

Because of its drought hardiness and ability to protect soils, blue grama is used extensively for protection of critical eroding areas. It is also used for watershed stabilization and mined-land revegetation, as well as for low maintenance turf plantings.

Varieties and Ecotypes

'Hachita' was collected from an elevation of 4,000 ft (1,220 m) in the Hachita Mountains of southern New Mexico in an area with an average annual precipitation of 10 inches (250 mm). Hachita exhibits greater drought tolerance and somewhat better seed and forage production than 'Lovington'. It is well adapted to areas in New Mexico, southeastern Colorado, and the panhandle area of Texas and Oklahoma that receive at least 8 inches (200 mm) of annual precipitation. It has been seeded with some success in the four corners area of Utah, Colorado, Arizona, and New Mexico (Alderson and Sharp 1994).

Lovington is a good forage and seed producer and is generally well adapted in areas of eastern New Mexico, southeastern Colorado, and northwestern Texas that receive at least 12 inches (300 mm) of annual precipitation. It has not been seeded to any extent in the Intermountain West.

Bromus anomalus
Nodding Brome

Synonyms

Bromus frondosus
Bromus ciliatus var. *montanus*

Bromus ciliatus
Fringed Brome

Synonyms

Bromopsis ciliata
Bromus richardsonii

Description

Nodding brome is a tall, nonrhizomatous perennial existing as small tufts with culms 24 to 30 inches (6 to 10 dm) tall. Culms are typically puberulent, at least at the nodes. Leaf blades are flat, 0.12 to 0.20 inch (3 to 5 mm) broad, sometimes slightly incurved or involute, and smooth or sometimes with silky hairs. Ligules are small, 0.02 to 0.04 inch (0.5 to 1 mm) long. and slightly irregularly toothed. Panicles are 2.8 to 5.5 inches (7 to 14 cm) long, loose or open, and usually nodding. Spikelets are 0.67 to 1 inch (17 to 25 mm) long and slightly compressed. They produce 5 to10 flowers. Glumes are mostly minutely pubescent, or sometimes hairless. The first glume is 0.20 to 0.28 inch (5 to 7 mm) long and three nerved, or rarely one nerved. The second glume is 0.25 to 0.31 inch (6.5 to 8 mm) long and three to five nerved. Lemmas are 0.35 to 0.47 inch

(9 to 12 mm) long, five to seven nerved, rounded on the back, and hairy. The awns are relatively short, about 0.06 to 0.12 inch (1.5 to 3 mm) in length.

Nodding brome closely resembles fringed brome, and is known in some cases to hybridize with this species. Fringed brome is also a nonrhizomatous, tufted, native perennial with drooping or ascending branches (fig. 19). Arnow (1987) reported that although both species occupy similar habits in Utah, they appear to be maintaining their integrity as distinct species. Only 3 percent of all specimens examined exhibited any intermediacy. Nodding brome typically has pubescent glumes and awns are 0.04 to 0.16 inch (1 to 4 mm) long. In comparison, the glumes and culm nodes of fringed brome are glabrous, and its awns range in length from 0.08 to 0.24 inch (2 to 6 mm) long (Arnow 1987).

Ecological Relationships and Distribution

Both nodding brome and fringed brome range from British Columbia and Saskatchewan south through the Western United States and Mexico, and east to the Dakotas and Texas (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). In the Intermountain region, nodding brome and fringed brome are found on overlapping sites. Both occur on a variety of habitat types including dry to moderately moist sagebrush, mountain brush, aspen, spruce-fir, ponderosa pine, lodgepole pine, mountain herblands, grassy meadows, and riparian communities at 5,460 to 10,890 ft (1,680 to 3,350 m) elevation (Arnow 1987; Bartos and Mueggler 1981; Bradley and others 1992a). Nodding brome is more common in drier, more open communities in the mountain brush, pinyon-juniper, ponderosa pine, and aspen types than fringed brome.

Figure 19—Nodding brome forms small, nonrhizomatous tufts with loose, open, panicles (Hitchcock 1950).

Mueggler and Campbell (1986) reported that fringed brome is more common in shaded aspen and conifer communities, and nodding brome is more prevalent in open communities at lower elevations. Both species occur as early, mid, and late seral species. They often occur as dominant understory species in subalpine fir, Engelmann spruce, aspen, and blue spruce types (Alexander and Ronco 1987; Bradley and others 1992a; Moir and Ludwig 1979). Both nodding brome and fringed brome are important species in aspen and conifer forest types including open meadows and grasslands. In addition, nodding brome is equally important in mountain brush, pinyon-juniper, and sagebrush types, occurring in various shrub and herb associations (Allman 1953; Bartos and Mueggler 1981). Fringed brome is commonly encountered on moist to seasonally dry habitats, including shaded and open parks. It grows well on semiwet or moist soils in valley bottoms and meadows. It is adapted to poorly drained conditions (Mattson 1984), but also grows on well-drained and rocky substrates (Butterwick and others 1992; Crouch 1985).

Plant Culture

Nodding brome and fringed brome have not been extensively used in restoration programs. Limited testing has been conducted to evaluate either species for range or watershed plantings. Both species exhibit similar characteristics in relation to seed germination and stand establishment. Seed viability and germination of wildland collections are normally quite high. Seeds of both species can be harvested, cleaned, and seeded as easily and successfully as other species of brome. Plummer and others (1968) reported that seeds of nodding brome germinate easily without special treatment. Hoffman (1985) found that seeds of fringed brome are nondormant, and nearly all seeds germinated with conventional treatments. Initial establishment and growth of both species is normally greater than for smooth brome. Plants of both species tend to form small clumps, and do not persist as long as sodforming species of brome.

Both nodding brome and fringed brome usually form full stands when seeded alone, even on irregular terrain. They provide more open stands than sodforming bromes, including smooth brome. Nodding brome plantings established in central Utah persisted as nearly solid stands for 10 to 30 years, but were slowly invaded by associated grasses and broadleaf herbs. Although stands decreased in density, the grass remained important and spread by natural recruitment to adjacent openings. Natural spread of both nodding and fringed brome is quite successful, equaling that of most perennial grasses adapted to mountain communities.

Seeds of both nodding brome and fringed brome are large and easily seeded through most drills. Seedlings of both species also establish well from broadcast distribution and harrowing to cover the seed. Seeds can be aerial seeded under aspen, oak, or other shrubs and trees prior to leaf fall. Planted in mixtures or alone, both species can be seeded at rates used for smooth brome, between 2 to 4 pounds per acre (2.2 to 4.5 kg per ha).

Nodding brome and fringed brome are highly compatible with other species and can be seeded in mixtures without suppressing establishment or growth of associated herbs. Both species are less competitive than smooth brome and could be planted in areas where smooth brome has been recommended.

Uses and Management

Both species furnish excellent forage and ground cover. They are rated as among the best forage grasses on Western rangelands (Dayton 1931). Plants are grazed readily in spring and summer by livestock, deer, and elk (Humphery 1960). The foliage of both species can become tall and rank at maturity and is less palatable in late summer. However, both species can be removed by close grazing (Humphrey 1960). Livestock and wildlife graze seedheads before and after the seeds have matured. New basal leaves are produced in fall and selectively grazed. Domestic sheep seek the plants in mid and late summer as seeds mature and after fall greenup.

Nodding brome and fringed brome have often been misidentified and planted in areas where they are not adapted. Nodding brome is better suited to open aspen communities and sites at lower elevations. It can be planted in the upper sagebrush and mountain brush types to provide forage for wildlife. This species should be more widely used to plant oak brush sites following wildfires to control erosion and reestablish a native understory. It can also be planted in pinyon and juniper restoration projects where it is native. Nodding brome is not as productive as smooth brome or mountain brome. It is less palatable than smooth brome, but equal to mountain brome. Fringed brome normally grows at somewhat higher elevations than nodding brome, and it is better adapted to shaded communities. It is also more common in tall forb types at high elevations.

Nodding brome and fringed brome can be planted on open disturbances, including forested sites and mountain brush fields burned by fires. They can be mixed with other species, including natives, and planted by aerial seeding to control erosion and restore native communities. Where the distributions of these two bromes overlap, mixed plantings are recommended. Although neither nodding brome nor fringed brome form dense sod, both establish quickly and provide satisfactory cover. Both prefer deep and rich soils, but they are also encountered on shallow, well-drained soils.

Nodding brome and fringed brome have been grown to a limited extent in hay meadows, providing yields as high as 2 tons per acre (2,250 kg per ha) (Dayton 1931). Seed production fields have not been established for either species, thus large seedings are not feasible. Observation and management of wildland stands suggest both species could be grown under cultivation without special care. Both species grow well in association with other herbs, and are useful grasses for restoring disturbed watersheds. Plants establish quickly from direct seeding, and spread to stabilize small openings. Neither species is invasive; both can be seeded in mixtures with native broadleaf herbs to restore complex communities.

Both nodding brome and fringed brome should be utilized in restoration plantings, and could be used to replace smooth brome where reestablishment of native communities is required. To date, ecotypes of these species have not been identified, but seed should be collected and planted within areas of occurrence. Moving high-elevation collections to lower and drier sites is not advised.

Varieties and Ecotypes

There are no releases.

Bromus carinatus
Mountain brome, California brome

Synonyms

Ceratochloa carinata
Bromus marginatus
Bromus breviaristatus
Bromus polyanthus

Description

Mountain brome is a member of a highly polymorphic complex of related taxa (Arnow 1987). It has sometimes been recognized as three or more separate species (Hitchcock 1935), usually including *B. marginatus*, *B. polyanthus* (both perennials with awns less than 7 mm long), and *B. carinatus* (an annual or biennial with awns more than 7 mm long). *B. marginatus* is pubescent throughout, while the spikelets of *B. polyanthus* are glabrous (Cronquist and others 1977). *B. marginatus* and *B. carinatus* are morphologically quite variable but scarcely distinct from each other. *B. marginatus* interbreeds with both *B. carinatus* and *B. polyanthus* (Wasser 1982). Plants with characteristics of all three species can sometimes be found within a single population. Hitchcock and others (1969) concluded there was no basis for the division of these taxa based on their annual or perennial growth habits. The following description of *B. carinatus* follows Arnow (1987) and Cronquist and others (1977) and includes these taxa.

Mountain brome is a tall, short-lived native perennial that often flowers during its first growing season (fig. 20). Culms are solitary or tufted, usually erect, 1.0 to 2.3 ft (6 to 14 dm) tall, and smooth to minutely hairy. Leaf blades are flat, 0.08 to 0.55 inch (2 to 14 mm) wide, rarely involute, and smooth to roughened or silky haired. Ligules are 0.04 to 0.12 inch (1 to 3 mm) long, smooth or with silky hairs, and irregularly serrate along the margins. Panicles are usually 4 to 12 inches (1 to 3 dm) long, loosely contracted, and nodding. Spikelets vary from one to four per branch. They are 0.6 to 2.4 inches (1.5 to 6 cm) long, strongly compressed, and produce 4 to 16 flowers. Glumes are lanceolate and strongly keeled. The first glume is 0.27 to 0.43 inch (7 to 11 mm) long and three- to five-nerved. The second glume is 0.35 to 0.51 inch (9 to 13 mm) long and five to seven nerved. Lemmas are 0.43 to 0.67 inch (11 to 17 mm) long, carinate keeled, and smooth to roughened. The apex is slightly notched to entire. Awns are 0.16 to 0.31 inch (4 to 8 mm) long. Anthers are small and included within the lemma.

Figure 20—Common on many high-elevation sites, mountain brome occurs in subalpine, mountain meadow, aspen, conifer, and mountain big sagebrush communities (RMRS photo).

Ecological Relationships and Distribution

Mountain brome is widespread in North America, occurring from Alaska and Canada south to California, Texas, and most of Mexico. It has been introduced in some Midwestern States and naturalized in Europe (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Mountain brome is common in both early and late seral communities. It occurs in the subalpine fir-Engelmann spruce zone and in high-elevation sedge meadows (Tisdale and Bramble-Brodahl 1983). In the Intermountain area, it is commonly found in aspen and conifer communities and in associated herblands and meadows (Ellison 1954; Mueggler and Campbell 1986). It also occurs in mountain big sagebrush communities. It is more common on cooler sites (Mooney 1985) in the lower elevations of these communities (Hironaka and others 1983; Tisdale and Bramble-Brodahl 1983).

Plant Culture

Mountain brome reproduces primarily by seed (USDA Forest Service 1937), although some tillering occurs (Stubbendieck and others 1992). Plants flower from late May to early August. Harlan (1945) reported that cross-fertilization is most common when growing conditions are optimum, while adverse conditions stimulate self-fertilization. In California, both open pollinating and cleistogamous florets are commonly found on the same plant (Hickman 1993).

Native stands frequently produce heavy seed crops, and a limited amount of wildland-harvested seed is sold each year. Agricultural production is required to meet the demands for seed of this species, and highly productive mountain brome seed fields have been established on low-elevation farmlands. Seeds are harvested by combining, and yields average about 250 pounds per acre (280 kg per ha) (Smith and Smith 1997). There are about 103,700 seeds per pound (228,000 per kg) (Smith and Smith 1997).

Seed germination of mountain brome is relatively high, normally exceeding 85 percent. Plummer (1943) reported a higher percentage of seeds germinated in a shorter time when exposed to alternating rather than constant temperatures during germination. Paulsen (1970) found that optimum germination occurred over a wide range of temperatures.

Satisfactory wildland stands can be established from either fall or spring plantings in weed-free areas. When planted alone, a seeding rate of 4 to 10 pounds per acre (4.4 to 11.2 kg per ha) is recommended. Seeds should be planted at depths of 0.25 to 0.50 inch (0.6 to 1.3 cm) (Jensen and others 2001). Seeds are large and can be planted with most drills or broadcast seeders.

Broadcast seed should be covered by light harrowing. This species establishes better than many other grasses when broadcast seeded. Mountain brome is frequently seeded in mixtures with other native species. It is also seeded with introduced species to provide ground cover and quickly stabilize severely disturbed sites. Consequently, the seeding rate for mountain brome may be adjusted so that it will provide adequate ground cover, but also permit establishment of other seeded species (Sours 1983). Seedings should be protected from grazing until plants are well established and seedheads are produced.

Uses and Management

Seedlings of mountain brome are vigorous and establish quickly, but plants may not produce seed for 2 to 3 years (Cronquist and others 1977). Stands of mountain brome generally consist of scattered plants, but they sometimes develop a dense sod. Mountain brome can increase in density when growing with other perennials. Plants, however, are short lived and must be allowed to set seed every 2 or 3 years to permit natural reseeding. If natural seeding does not occur, the species can be replaced by longer lived species. Hafenrichter and others (1949) reported that longevity and persistence are important characteristics to consider when selecting plant material of this species.

Mountain brome is seeded as an early successional species and establishes quickly on disturbed and weedy sites at mid to upper elevations. It is seeded alone or in mixtures on depleted livestock and game ranges, burns, roadways, and mined lands in forested areas. The species is effective for providing rapid, cold-tolerant cover and erosion control in moderate to high elevation watersheds, as it grows rapidly and produces deep, well-branched root systems (Stevens and others 1992). Mountain brome is also an excellent grass for pasture or hay (Sours 1983).

Mountain brome tolerates a wide variety of soil textures, but it most often occurs on medium-textured to loamy soils in the pH 5.5 to 8.0 range (Sours 1983). It is most productive on deep, rich, moist soils, but it can grow on dry, shallow, and infertile soils on disturbed sites. The species is winter hardy, moderately tolerant of shade and salinity, and weakly to moderately tolerant of drought and heat (Hassell and others 1983; Steele and Geier-Hayes 1993). It does not endure long periods of flooding or high water tables.

Mountain brome is palatable to livestock and big game (Stubbendieck and others 1992). It produces moderate amounts of high-quality herbage and receives considerable use in spring and early summer prior to seed dispersal (Hassell and others 1983). Elk use it in summer (Leege 1984; Stubbendieck and others 1992). Seedheads are used by birds and small mammals. The herbage becomes coarse and fibrous at maturity. Regrowth in summer is moderate, providing late fall forage. Fall regrowth is fair. Mountain brome is tolerant of grazing, but excessive use weakens the stands (Stubbendieck and others 1992).

Mountain brome is tolerant of wildfires (Brown and DeByle 1989), recovering from seed and surviving plants. Stands may be reduced initially, but they recover to prefire levels after a few years. Success of postfire seedings of this species has been variable. Established seedings are useful for stabilizing soil and providing cover and forage, but they may prevent recovery of native species or coseeded natives (Steele and Geier-Hayes 1993).

Varieties and Ecotypes

'Bromar' mountain brome was developed from native material collected near Pullman, WA (Alderson and Sharp 1994). It is adapted to streambanks, semiwet meadows, subalpine conifer forests, aspen, and upper mountain brush communities in the Intermountain West. Bromar has been widely used to stabilize logging, mining, roadway, and other disturbances. It does not spread aggressively, and it is compatible with other seeded or indigenous species. Livestock and big game use its forage, especially prior to the production of seedstalks. This variety exhibits good seedling vigor and spring greenup. It is, however, susceptible to head smut and fairly short lived (6 to 10 years). Bromar is a good seed producer; stands reseed naturally if not grazed excessively. Bromar should be fall seeded by drilling or broadcasting

'Garnet' mountain brome germplasm, released in 2000 by the Upper Colorado Environmental Plant Center, Meeker, CO (Englert and others 2002), originated from material collected near Garnet in Powell County, MT (Alderson and Sharp 1994), at an elevation of 5,800 ft (1,770 m). Garnet has been evaluated throughout the Intermountain West. It exhibits good stand longevity and excellent head smut resistance, two characteristics lacking in many populations of this species. Garnet is recommended for seeding on deep, fertile, mesic, medium-to fine-textured soils in areas receiving at least 15 inches (380 mm) of annual precipitation. It thrives in climates with cool, dry summers and good winter precipitation. It does not tolerate high water tables or flooding, but it does exhibit good shade tolerance and fair fire tolerance, and it is very winter hardy. Garnet is adapted to mountain brush and mountain big sagebrush communities. It is also seeded in openings in aspen and conifer forests and in subalpine areas. It is not aggressive and can be seeded in mixtures.

Bromus inermis
Smooth Brome, Hungarian Brome

Synonyms

Festuca inermis
Bromopsis inermis
Bromus pergans var. *purparescens*
Bromus pergans var. *longispicata*
Bromus pumpellianus
Bromus ciliatus var. *coloradensis*

Description

Smooth brome is a long-lived, strongly rhizomatous, sodforming perennial with the few culms about 5.9 to 17.7 inches (1.5 to 4.5 dm) tall. Leaf sheaths are smooth to silky haired. Blades are flat and broad, about 0.16 to 0.51 inch (4 to 13 mm) wide, rarely involute, and hairless or rarely silky haired on the upper side. Leaf margins and nerves are rough and hairy. Ligules are small, about 0.06 to 0.20 inch (1.5 to 5.0 mm) long, and irregularly serrate or reduced to a marginal fringe of minute hairs. Panicles are 2.8 to 9.1 inches (7 to 23 cm) long, moderately open, oblong, and erect. Panicle branches are ascending; the upper ones are appressed. Spikelets are 0.6 to 1.3 inches (1.6 to 3.2 cm) long, 4 to 10 flowered, very narrow and round when young, but becoming somewhat compressed with age. Glumes are hairless and smooth. The first glume is 0.18 to 0.31 inch (4.5 to 8.0 mm) long, narrowly lance shaped, and one to three nerved. The second glume is 0.24 to 0.39 inch (6 to 10 mm) long, lance shaped, and three to five nerved. Lemmas are 0.35 to 0.47 inches (9 to 12 mm) long, rounded on the back, smooth or rarely minutely hairy, and greenish to purplish tinged. The lemma apex is bidentate to slightly rounded. Awns, when present, are up to 0.08 inch (2 mm) long. Smooth brome flowers from June to August, and sometimes into early September.

Smooth brome hybridizes readily with native *B. pumpellianus*, a taxon that Elliott (1949) suggested might be reduced to a subspecies of *B. inermis* due to extensive introgression. Arnow (1987) stated that she had never seen material that could be identified as belonging to *B. pumpellianus*, which is distinguished from *B. inermis* by its pubescent culm nodes and lemmas.

Ecological Relationships and Distribution

Smooth brome is a European introduction that has been widely seeded for hay and pasture in irrigated and nonirrigated fields. In the Western United States it has been planted on overgrazed rangelands, roadways, ski areas, mined lands, burned areas, unstable watersheds, and other disturbances at mid to upper elevations (fig. 21). It is now distributed from Canada to Southern California and east to New Mexico and much of the North-Central and Northeastern United States (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Smooth brome is adapted to streambanks, valley bottoms, and upland sites (Hardy BBT Limited 1989) in exposed to partially shaded areas that receive 14 to 20 inches (356 to 508 mm) of annual precipitation (Jensen and others 2001; Plummer and others 1968) and sites that are subirrigated or intermittently wet. It grows on a variety of well-drained, medium-textured clay loam to sandy loam

Figure 21—A strongly rhizomatous introduced species, smooth brome receives wide use for watershed stabilization and postfire seedings on forested sites, but it does preclude recovery of native species (RMRS photo).

soils of at least moderate depth; it is less productive on fine or coarse soils and on shallow soils. Smooth brome is cold tolerant; tolerant of poorly drained soils, saline or acidic conditions, and drought; but it does not tolerate high alkalinity (Coulman 1987; Hafenrichter and others 1968; Wambolt 1976).

Smooth brome becomes dormant in winter, and initiates growth in early spring (Smoliak and others 1981). Plants are productive, developing abundant vegetative growth and large seedheads (Jensen and others 2001). They become dormant during dry periods, but initiate regrowth with adequate precipitation in fall.

Following wildfires, smooth brome regenerates by sprouting from rhizomes and tilllering. Productivity is increased by early- or late-season fires that remove litter, particularly in sodbound stands (Higgens and others 1989; Hughes 1985). Fires occurring in late spring are generally more damaging (Masters and Vogel 1989).

Plant Culture

Smooth brome is generally a cross-pollinating species (Knobloch 1944), but self-fertilization can occur between flowers in different spikelets (McKone 1985). Because of insect herbivory, seed set is lower for smooth brome than for many other brome species (McKone 1985; Nielson and Burks 1958). Seeds mature in early to midsummer. They are harvested by combining and cleaned with an air screen machine. There are 136,100 to 149,700 seeds per pound (300,000 to 330,000 per kg) (AOSA 1999). Smooth brome seed has remained viable for periods of 22 months to more than14 years in storage (Hafenrichter and others 1968; McAlister 1943; Rincker and Maguire 1979). The AOSA (1999) rule for testing germination of smooth brome stipulates an incubation temperature alternating between 68 and 86 °F (20 to 30 °C) (16 hrs/8 hrs). A moist prechill at 41 to 50 °F (5 or 10 °C) for 5 days is recommended for fresh or dormant seed.

Smooth brome should be planted in late fall or early spring at depths of 0.25 to 0.75 inch (0.6 to 1.9 cm), depending on soil texture, but seedlings do emerge from greater depths (Plummer 1943). Seeds may be drilled or broadcast and covered. The elongate seeds sometimes plug drills (Jensen and others 2001). Seedlings can germinate at low temperatures under snow (Bleak 1959) and develop rapidly as temperatures increase in spring. Smooth brome requires fertile soil. Fertilization or seeding with a nitrogen fixer may be required to maintain stands when natural soil fertility is inadequate (Jensen and others 2001). Seedlings are not strong, but once established they grow rapidly (Hardy BBT Limited 1989; Hassell and others 1983). Grasshoppers sometimes damage or destroy developing stands. Mature plants spread vegetatively, while spread from seed is moderate (Plummer 1977). Although stands may require 3 years to become fully established, they are aggressive and may dominate seedings or recovering native species. Because of its ability to spread vegetatively, smooth brome plants are long lived. Plantings have persisted for 60 years or more (Plummer and others 1968). Established stands of the species invade and dominate local disturbances (Boggs 1984; Boggs and Weaver 1992; D'Antonio and Vitousek 1992).

Uses and Management

Smooth brome is one of the most commonly seeded exotic grasses for pastures and wildlands in North America (Mitchell 1982, 1987b). Selected varieties can be used on a wide range of irrigated and nonirrigated sites with varying soil conditions.

A number of smooth brome varieties with differing areas of adaptation have been developed to provide erosion control on disturbed lands and nutritional forage or hay when planted alone or in combination with legumes. Smooth brome regrowth following cutting is slow. Sixteen to 18 inches (41 to 46 cm) of annual precipitation are generally required to maximize forage production. Pastures and fields that become sodbound require application of fertilizer and cultivation for renovation (Jensen and others 2001).

Smooth brome has been planted in a wide variety of plant communities to provide palatable forage for wildlife and livestock. Seeded stands, particularly those on fertile soils (Currie and Smith 1970), are palatable and tolerant of heavy use. The species has been seeded in saltgrass, pinyon-juniper, quaking aspen, and subalpine communities (McGinnies 1960a,b, 1975; Sampson and others 1951).

Wildlife use of smooth brome varies among animals and season. Deer browse the species (Stubbendieck and others 1992); elk take it primarily in winter (Hobbs and others 1981). Ducks and upland birds use it for nesting cover, while geese graze the new shoots. Rodents eat the forage and seeds.

The rhizomatous habit and aggressive growth of smooth brome make the species a valued erosion control plant (Hardy BBT Limited 1989). It is used for stabilization of degraded streambanks, mined lands, logged areas, and other disturbances (Elliott and others 1987; Ward and others 1986). Loss of native vegetation, however, may occur because of the aggressiveness of this species (Smoliak and others 1981).

Smooth brome has been widely used to hold surface soil and produce forage rapidly following wildfires (Clary 1988; Crane and Habeck 1982). Because recovering native grasses, forbs, and shrubs are often as effective in holding the soil and controlling erosion and because the aggressiveness of smooth brome may preclude recovery of native species, its value for postfire seedings has come under question (Clark and McLean 1979; Crane and Habeck 1982).

Varieties and Ecotypes

Smooth brome varieties are generally divided into three types: southern, intermediate, and northern. Southern varieties include 'Lincoln', 'Saratoga', 'Baylor', 'Beacon', 'Tempo', 'Signal', 'York', 'Radisson', 'Badger', 'Achenbach', and 'Southland'. Intermediate forms include Tempo, 'Magna', and Signal. 'Manchar', 'Carlton', 'Elsberry', 'Polar', 'Jubilee', 'Bravo', and 'Rebound' are northern forms (Alderson and Sharp 1994).

Southern varieties are strongly rhizomatous spreaders that are not compatible with natives. Their long, wide, and somewhat coarse leaves are primarily basal, but some occur along the culm. The panicles are somewhat contracted with green to light-red spikelets. Southern varieties generally exhibit good seedling vigor. They require less moisture than do the northern types, and they can be planted in areas receiving full sunlight or considerable shade. They green up early in spring and are good forage producers.

Northern varieties are also aggressive spreaders that are not compatible with natives. Their long leaves are intermediate in width, soft, smooth, more or less vertical, and occur well up the culms. Panicles are open with red to purple spikelets. Northern varieties exhibit good seedling vigor. They require more moisture than southern varieties, begin growth about 5 to 10 days later, and are generally less productive.

Lincoln and Manchar are two of the most commonly seeded smooth brome varieties in the Intermountain West. Lincoln, a southern variety, is derived from material thought to be of Hungarian origin (Alderson and Sharp 1994). It is seeded in aspen, mountain brush, ponderosa pine, upper pinyon-juniper, and big sagebrush communities that receive 13 or more inches (330 mm) of annual precipitation. It is also well adapted to semiwet meadows and streambanks. Lincoln establishes quickly from drilling or broadcasting and is a very aggressive spreader that eventually dominates mixed seedings.

Manchar, a northern variety from Manchuria, China (Alderson and Sharp 1994), is adapted to openings in aspen stands, conifer forests, mountain big sagebrush communities, semiwet meadows, and riparian areas. It is less well adapted to mountain brush communities. Manchar is aggressive and will dominate seeded areas, especially those that are heavily grazed.

Bromus riparius
Meadow Brome

Synonyms

Bromus erectus
Bromus biebersteinii
Bromus macounii

Description

Meadow brome, earlier described as *Bromus erectus* (Hitchcock 1950), is now recognized as *Bromus riparius* (Vogel and others 1996). Based on descriptions provided by Tsvelev (1984), Vogel and others (1996) concluded that most North American introductions and cultivars of *B. biebersteinii* are also *B. riparius*. Meadow brome is an introduced, long-lived, cool-season, perennial bunchgrass. Culms are tufted, 2 to 3 ft (6 to 9 dm) tall, erect, slender, and glabrous to silky haired. Leaf blades are narrow and sparsely hairy. Ligules are 0.06 inch (1.5 mm) long. Panicles are narrow and 4.0 to 7.8 inches (10 to 20 cm) long with ascending to erect branches. Spikelets are usually 5 to 10 flowered. Glumes are tapered to a point, the first is about 0.24 to 0.31 inch (6 to 8 mm) long, and the second about 0.31 to 0.39 inch (8 to 10 mm) long. Lemmas are 0.39 to 0.47 inch (10 to 12 mm) long and smooth or evenly rough hairy on the back. Awn length is 0.20 to 0.24 inch (5 to 6 mm) (Hitchcock 1950).

Meadow brome is somewhat similar in appearance to smooth brome (fig. 22). The main difference is the

Figure 22—Meadow brome can be distinguished from smooth brome by the pubescence on the awns and leaves. Its panicles rise well above the leaves (RMRS photo).

pubescence on the awns and leaves of meadow brome (Knowles and others 1993). In addition, its rhizomes are much shorter than those of smooth brome, and its stems and seeds are more pubescent (Vogel and others 1996).

Ecological Relationships and Distribution

Meadow brome is a European introduction (Weintraub 1953), and has been planted or has established in localities from Maine to New York, as well as in the Pacific Northwest and the South (Hitchcock 1950). In recent years it has been seeded on range and watershed sites in the West. Meadow brome has proven adapted to mountain brush, ponderosa pine, aspen, and subalpine communities in the Intermountain region. It is well-suited to acidic soils of the Idaho Batholith, including disturbances where subsoils have been exposed. This species is marginally adapted to drier regions occupied by pinyon-juniper and big sagebrush communities. In the Intermountain region, the plant has not persisted on sites receiving less than 12 to 14 inches (30 to 36 cm) of annual precipitation.

Plant Culture

Seeds of meadow brome are similar in size to those of smooth brome and other brome species. Knowles and others (1993) reported that compared to other bromes, the seeds of meadow brome shatter more easily and require more processing to remove the awns and pubescence to assure that seeds can be seeded uniformly. Meadow brome establishes quickly, and dense, uniform stands generally develop. Plants grown under cultivation produce reliable and abundant seed crops in most years. Successful stands have established on range and wildland sites in the West by drill seeding or broadcasting and harrowing to cover the seed. When drill seeded alone, planting rates of 8 to 10 pounds per acre (8.9 to 11.2 kg per ha) are sufficient. The rate should be decreased to 2 to 4 pounds per acre (2.2 to 4.4 kg per ha) when seeded in mixtures with other species. Rates should be increased slightly for seedings on severely disturbed and eroding sites to assure rapid development. Plants provide good ground cover in the first and second seasons. Like mountain brome, meadow brome is susceptible to head smut, and seeds should be treated prior to planting to reduce the chance of infestation.

Uses and Management

Meadow brome and smooth brome are the two species of brome cultivated for grazing and seed production in pastures in North America (Vogel and others 1996). Although there are native bromes in the West, few have been developed for restoration plantings. Instead, both smooth brome and meadow brome have been used to provide effective ground cover and furnish palatable forage. Use of meadow brome in the West began in 1966 with the release of ‘Regar’ for planting as a forage and conservation species on rangelands and to provide watershed stabilization (Casler and Carlson 1995; Knowles and others 1993).

Normally long lived, meadow brome is less winter hardy and drought tolerant than smooth brome (Knowles and others 1993). It has been widely and successfully planted in irrigated pastures for grazing and seed production. It is also well-suited to mountain brush, aspen, conifer forests, and mountain park communities, and it is recommended for planting in intermediate and high-elevation woodlands (Hansen 1972). In western Montana it has competed more successfully with cheatgrass than has crested wheatgrass. It is less well adapted to more arid regions occupied by big sagebrush and associated shrubs and bunchgrasses.

Meadow brome is not as productive as smooth brome, but it is still regarded as an important forage species. Spring greenup is rapid (Schwendiman and others 1946), and plants provide excellent early spring and summer herbage for game and livestock. Regrowth is more rapid for meadow brome than for smooth brome (Knowles and others 1993); consequently, pasture and rangeland stands supporting the species recover well from early-season grazing. When seeded on wet and semiwet sites in mountain communities this grass also provides excellent summer and fall herbage, and plants persist well. Herbage quality diminishes as plants mature, but the foliage remains quite palatable even though the leaves are quite pubescent (Hansen 1972). This species provides a valuable hay crop, even on soils with low fertility (Hansen 1972). Rangeland plantings have not diminished in productivity or become sodbound due to a decrease in available nitrogen, as is commonly experienced with smooth brome.

Vegetative spread is not so aggressive for meadow brome as for smooth brome. Plantings on high-elevation mountain herblands and in mountain brush communities have spread little from the original rows over a 25-year period. In addition, established stands have not seriously reduced the presence of associated native herbs. This grass is much less competitive with native species than smooth brome, and could be planted in areas where it is important to maintain the composition of native plants.

Varieties and Ecotypes

Regar is an early maturing bunchgrass that is adapted to areas in upper pinyon-juniper, mountain brush, and aspen communities that receive 14 inches (356 mm) or more of annual precipitation. It was developed from material collected at Zek, Turkey

(Alderson and Sharp 1994), and released by the Aberdeen Plant Materials Center in Aberdeen, ID (Foster and others 1966). This variety is characterized by good drought tolerance, excellent winter hardiness, and moderate spread. Plants greenup early in spring. They grow well in full sunlight and partial shade. They are leafy and exhibit good regrowth, particularly in midsummer. Cooper and others (1978) found that yields were greater for Regar than for smooth brome when seeded in grass-legume mixtures. Regar may be planted in fall or early spring when seeds germinate and establish readily. It does not spread as aggressively as smooth brome, and it is somewhat compatible with other recovering natives. It is seeded in the Intermountain West for forage and for stabilization of disturbed sites.

Subsequent meadow brome cultivar releases, ‘Fleet’ and ‘Paddock’, were developed by Agriculture Canada. Seed production of both cultivars generally exceeds that of Regar by more than 65 percent (Vogel and others 1996).

Dactylis glomerata
Orchardgrass

Synonyms

Bromus glomeratus
Festuca glomerata

Description

Attempts have been made to place orchardgrass in different generic complexes, but for the most part, taxonomists in the United States and Europe agree that it should remain in the monotypic genus *Dactylis*. The species is a tufted perennial that grows 1 to 4 ft (3 to 12 dm) tall and produces short rhizomes. Leaf sheaths are shorter than the internodes. Ligules are 0.16 to 0.31 inch (4 to 8 mm) long and oblong to ovate with irregularly lacerated margins. Leaf blades are 0.16 to 0.39 inch (4 to 10 mm) wide, lax or loosely arranged, and roughened on the surface. Panicles are 1.8 to 7.9 inches (4.5 to 20 cm) long, laterally compressed, and mostly interrupted. The primary panicle branches, one to three at each node of the rachis or axis of the panicle, measure about 1.2 to 4.7 inches (3 to 12 cm) long or longer, and are erect to widely spreading or reflexed. The branches are naked below, but with one to several dense clusters of subsessile to short-pedicillate spikelets borne near the branch tips and arranged on one side of the axis. Spikelets are 0.20 to 0.35 inch (5 to 9 mm) long, two to five flowered, and occasionally purple tinged. Glumes are subopposite, lance shaped, often asymmetrical, and keeled to rounded on the back. Their margins are straight, and they are acute to awn tipped apically. The keel is smooth to variously pubescent. The first glume is 0.20 to 0.25 inch (5 to 6.5 mm) long, keeled, and acute or tapered to an awnlike tip that is about 0.08 inch (2 mm) long. The second glume is 0.12 to 0.24 inch (3 to 6 mm) long and membranous. Florets disarticulate above the glumes, which remain attached to the spikelet. Flowering occurs from June through August (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; and Hitchcock and others 1969).

Ecological Relationships and Distribution

A European introduction, orchardgrass is widely distributed throughout North America. In the West it is found in sagebrush, mountain brush, ponderosa pine, aspen-fir, and occasionally in desert shrub communities. Orchardgrass was introduced as a hay and pasture grass, and in the West, it is commonly grown in irrigated areas or on sites receiving a minimum of 18 inches (457 mm) of annual rainfall. Although it generally occurs as a seeded species, orchardgrass volunteers on moist nonirrigated sites (Vallentine 1985). It requires well-drained, medium-textured, deep to moderately deep soils that are moderately acid to moderately alkaline. It will grow on shallow, gravelly, or stony soils (Vallentine 1961). Orchardgrass initiates growth in early spring, and it is highly productive during the cool season. Due to its deep rooting habit it is also capable of considerable summer growth under favorable conditions (USDA Natural Resources Conservation Service 2000). Orchardgrass produces palatable, nutritious forage, and it tolerates heavy grazing. It is reported to increase or remain stable after burning (Cocking and others 1979).

Plant Culture

Orchardgrass seed matures evenly and is ready for harvest in mid-August (USDA Natural Resources Conservation Service 2000). There are 480,000 to 650,000 seeds per pound (1,058,200 to 1,432,990 per kg). Orchardgrass can be spring seeded, but later dates can be successful with adequate irrigation. Fall seedings may be more appropriate on sites that are likely to dry early in the season. A clean, firm, weed-free seedbed is recommended. Seed should be planted about 0.5 inch (1.3 cm) deep. Seed increase fields should be planted with the rows at 28- to 40-inch (71- to 102-cm) spacings. Orchardgrass establishes well in mixtures with other competitive introductions where adequate precipitation, at least 12 inches (305 mm), is received annually (Hardy BBT Limited 1989).

Uses and Management

Orchardgrass is used in seed mixes with other grasses and forbs for revegetating overgrazed or otherwise disturbed lands (Hardison 1980) (fig. 23). Success of these seedings depends on the selection of appropriate cultivars. Orchardgrass has been planted in logged over or burned areas, and it provides cover and forage for livestock and wildlife (Clary 1975a). It has also been used for mine reclamation, ski slope stabilization, and suppression of annual weeds (Behan 1983; Hardy 1989). Orchardgrass is highly shade tolerant and has been seeded under aspen and open conifer stands.

Orchardgrass is recommended for moderate early-season grazing (Humphrey 1960). It provides excellent, highly digestible forage (Vallentine 1961). Rotational grazing practices are best for irrigated pastures. Orchardgrass is grown with alfalfa for hay crops because of its ability to recover from grazing or clipping. It responds well to nitrogen fertilizers and to being integrated with legumes (Shaw and Cooper 1973). In areas with dry, cold winters, a hardy variety of orchardgrass should be used to avoid losses from winterkill (Vallentine 1961).

Figure 23—Orchardgrass seedings provide forage, stabilize disturbances, and suppress the spread of invasive species, but it interferes with the recovery and establishment of natives (RMRS photo).

Vallentine (1961) reports that all classes of livestock readily use orchardgrass, and deer, elk, and bighorn sheep graze it. The basal rosette of the plant is green through fall and into the winter and provides a good source of forage for wildlife (Dalke 1941). Wildlife use of seedings on burns and other disturbances increases when orchardgrass is seeded (Evanko 1953; Leege and Godbolt 1985; Lowe and others 1978). Seedings also provide habitat for rodents (Reynolds and Johnson 1964) and nesting and brood rearing habitat for upland birds as well as escape and winter cover. It is used by rabbits and Canada geese (Crawford and others 1969).

Although orchardgrass is widely seeded following wildfires or other disturbances, it interferes with natural regeneration of conifer and native understory species and with establishment of planted conifers (Anderson and Brooks 1975; Elliott and White 1987; Lyon 1984; McLean and Clark 1980; Seidel and others 1990). It should not be included in seeding mixes with native species.

Varieties and Ecotypes

Varieties that have been developed and for which seed is available include: 'Able', 'Akaroa', 'Amba', 'Ambassador', 'Arctic', 'Benchmark', 'Cambria', 'Chinook', 'Comet', 'Dactus', 'Dart', 'Dawn', 'Hallmark', 'Haymate', 'Juno', 'Justus', 'Kay', 'Latar', 'Napier', 'Pomar', 'Potomac', 'Prairial', 'Rancho', 'Rapido', 'Sumas', and 'Summer Green' (Alderson and Sharp 1994). The only two rangeland varieties are 'Berber' and 'Paiute'.

Berber orchardgrass was developed for California rangelands from material obtained from South Australia (Alderson and Sharp 1994). It has not been seeded in the Intermountain West.

Paiute orchardgrass was introduced from Ankara, Turkey (Alderson and Sharp 1994). It is a drought-tolerant accession that is adapted to basin big sagebrush, pinyon-juniper, mountain brush, mountain big sagebrush, and ponderosa pine communities receiving 14 or more inches (355 mm) of annual precipitation. Paiute is characterized by an abundance of thick, succulent basal leaves that tend to remain green throughout the winter. It begins growth in spring as the snow melts. Plants are palatable and sought out by big game and livestock. Seed should be fall planted on a firm seedbed and covered. Germination is slow, but once established, Paiute forms strong bunches that are very persistent. Plants are shade tolerant and compatible with some seeded and indigenous species.

Latar, an introduction from Russia, and especially Potomac, developed from collections made in old pastures on the east-central coast of the United States

(Alderson and Sharp 1994), are used extensively in the Intermountain West for seeding streambanks and disturbed sites in mountain brush, aspen, ponderosa pine, and mountain big sagebrush communities. These two varieties produce an abundance of succulent leaves just after snowmelt in spring and remain green until late fall. Both varieties are long lived and exhibit considerable shade and grazing tolerance. They should generally be seeded in fall, and they can be planted with other rapidly developing species. Germination is generally slow.

Deschampsia caespitosa Tufted Hairgrass

Synonyms

Aira cespitosa
Deschampsia pungens
Deschampsia holciformis
Deschampsia beringenis

Description

Tufted hairgrass is a caespitose, mat forming perennial with culms 0.7 to 4.3 ft (2 to 13 dm) tall, and smooth, hairless leaf sheaths. Leaf blades are firm, flat, or folded, 0.04 to 0.20 inch (1 to 5 mm) wide, and often roughened ventrally. Ligules are 0.12 to 0.37 inch (3 to 9.5 mm) long, lacerate along the margins, and gradually tapering to a sharp point. Panicles are 1.6 to 11.8 inches (4 to 30 cm) long, loose, often nodding, and open to narrow, with slender, hairlike branches that are fine hairy. Spikelets are two or three flowered and usually shiny and purplish. Glumes are lance shaped, acute, and smooth or roughened. The first glume is single nerved and 0.08 to 0.20 inch (2 to 5 mm) long. The second glume is 0.10 to 0.20 inch (2.5 to 5.2 mm) long and one to three nerved. Lemmas are 0.10 to 0.18 inch (2.5 to 4.5 mm) long, often purplish basally, and five nerved with the four lateral nerves ending in apical teeth. The awns are 0.08 to 2.5 inches (2 to 6.5 cm) long and attach below midlength on the lemma. The callus is densely hairy. Paleas more or less equal the lemmas. Plants flower from late July to September (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; USDA Forest Service 1937).

Tufted hairgrass has been described as 30 or more different races, variants, or species. Recent western floras have included these in the highly variable species *D. caespitosa* (see Cronquist and others 1977) (fig. 24).

Figure 24—Tufted hairgrass exhibits considerable ecotypic variability; individual populations are adapted to a wide variety of soil types (Hitchcock 1950).

Ecological Relationships and Distribution

A circumboreal species, tufted hairgrass is distributed in the Western Hemisphere from Alaska to Newfoundland, south through the Western and Eastern States and into Northern Mexico. In the more southerly portions of its range it grows at higher elevations. Its distribution in the Great Plains is limited (Hitchcock 1950; Larson 1993; Stubbendieck and others 1992). Tufted hairgrass occurs in coastal prairies, bogs, marshes, wet to mesic meadows, forest openings, dry slopes, aspen stands, high-elevation valley bottoms, and open areas above timberline, particularly on sites where snow accumulates (Gould and Shaw 1983; Johnson and Billings 1962; Ward 1969). It is also found along ditches, streams, and lakeshores.

Tufted hairgrass is a long-lived, cool-season species that exhibits considerable ecotypic variation (Ward 1969). It occurs at elevations from sea level to over 14,000 ft (4,270 m) (Brown and others 1988) that receive 14 to 24 inches (356 to 609 mm) of annual precipitation (USDA Natural Resources Conservation Services 2002). It is more common on sites that receive at least 20 inches (508 mm) of annual precipitation (Brown and others 1988). Tufted hairgrass is adapted to fine- to medium-textured neutral to somewhat acidic soils that are of moderate depth and fertility. Some populations occur on coarser sandy or gravelly soils (Gates 1962; Johnson 1962; Lewis 1970). Plants are tolerant of anaerobic conditions (USDA Natural Resources Conservation Services 2002). They are not drought tolerant, but they exhibit good winter hardiness (USDA Natural Resources Conservation Service 2002). Individual populations tolerant of salinity, alkalinity, or specific heavy metals have been identified (Frenkel and Morlan 1991; Hardy BBT Limited 1989; Rabe and others 1999).

Tufted hairgrass occurs in a large number of late successional or climax communities (Walsh 1995), growing mixed with other species or as nearly pure stands on open sites, particularly at higher elevations. It rarely occurs as an understory species in shaded areas (Chambers 1987). Tufted hairgrass is also a common species on disturbed areas within its range, appearing in early- to midsuccessional communities (Brown and others 1988).

Plants begin growth in early spring when temperatures are near freezing. In moist areas the leaves remain green throughout the growing season (Bell 1974; Lewis 1970; Vallentine 1961). New leaf growth is initiated prior to the onset of dormancy, and immature leaves are protected over winter by dry leaves of the previous season.

Tufted hairgrass is fairly fire tolerant, as the leaves are generally green during the growing season and protect the root crown (Great Plains Flora Association 1986). Stands recover through resprouting from the root crown or through establishment of new seedlings from the soil seed bank (Chambers 1993; Gehring and Linhart 1992). Severe fires can kill the plants (DeBeneditti and Parsons 1979, 1984).

Plant Culture

Tufted hairgrass is self-sterile. Fruits ripen in summer. Wildland stands may be hand harvested in summer, but early shattering can reduce seed yields. Combining or swathing followed by combining are options for harvesting cultivated seed fields and extensive wildland stands on level terrain. Harvested seed is cleaned using air screen machines and a debearder or huller-scarifier. There are about 2,500,000 seeds per pound (5,500,000 seeds per kg). Fill and viability of wildland collections are highly variable (Chambers 1989). Germination requirements may vary among seed lots. Archibald and Feigner (1995) reported that seeds do not require moist prechilling for germination. Other investigators, however, found that exposure to light or transfer from a warm (68/50 °F) (20/10 °C) (16 hrs/8 hrs) environment to a cooler environment (59/41 °F) (15/5 °C) (16/8 hrs) after 6 weeks of incubation improved germination of their seed lots (Chambers and others 1987; Guerrant and Raven 1995; Sayers and Ward 1966).

Seed fields are planted at a rate of 1 pound per acre (1.1 kg per ha). Irrigated fields may be planted in spring or fall. Seeds are very small and should be drilled no more than 0.25 inch (0.6 cm) deep. Weeds must be controlled, as the early growth rate of tufted hairgrass seedlings is only moderate. Mature stands are quite competitive. Seed yields average 40 pounds per acre (44.8 kg per ha) (Smith and Smith 1997).

Wildland seedings are conducted in late fall (Brown and others 1988; Chambers and others 1987) or in spring at higher elevations. Seeds can be drilled or broadcast and covered at 0.8 to 1.6 pounds PLS per acre (0.9 to 1.8 kg per ha) or greater on highly disturbed sites (Pawnee Buttes Seed, Inc. 2002).

Plugs, sod, and container stock have also been used to establish tufted hairgrass on disturbances and provide soil stabilization more rapidly. Applications of fertilizers and soil amendments aid in hastening establishment on infertile soils (Brown and Chambers 1989, 1990; Brown and others 1988).

Tufted hairgrass is a valuable revegetation species, particularly for disturbances at high elevations (Vaartnou 1988). Because of the considerable ecotypic variability, local seed sources or sources known to be adapted to the planting site should be used. This is particularly true on sites with unusual soil characteristics. Populations have been identified that are tolerant of heavy metals such as copper, lead, and manganese; other populations will grow on peat, while still others have been found colonizing coal mine spoils (Hardy BBT Limited 1989; Russell 1985; Vitt and others 1990). Some populations are adapted to relatively dry sites (Arnow 1987).

Uses and Management

Tufted hairgrass provides an abundant source of forage from spring through summer. It provides good-quality summer range and is one of the most valuable forage species at high elevations. Tufted hairgrass meadows are sometimes cut for hay. Late summer and fall regrowth are moderate.

Although fairly tolerant of close grazing, the species does decrease with excessive grazing and associated trampling. It is considered an indicator species for grazing pressure in many high-elevation communities.

Stands should be allowed to set seed periodically to perpetuate the community. Management activities that alter the water table can also impact tufted hairgrass. Increased shading with development of woody species in later successional communities reduces tufted hairgrass populations.

Tufted hairgrass is used to seed mined lands, dredge spoils, coal mine overburden, burned forest lands, degraded livestock and game ranges, ski areas, and other disturbances at high elevations (McVay and others 1980; Pawnee Buttes Seed, Inc. 2002). Seed sources adapted to local soil conditions and with appropriate cold tolerance should be used for these projects.

Varieties and Ecotypes

'Norcoast' was selected from collections made in Cook Inlet, Alaska (Alderson and Sharp 1994), and released for revegetation of disturbances and to provide forage. It has been used on adapted sites from Alaska to California, but it has not seen use in the Intermountain West.

'Nortran' was developed from materials collected in Alaska and Iceland (Alderson and Sharp 1994; Mitchell 1988). It is used primarily for the revegetation of disturbed areas and for pasture seedings. It is hardy in alpine and boreal regions south of the Arctic. It has not been seeded in the Intermountain West.

'Peru Creek' was developed from mass collections made in subalpine meadows along Peru Creek, near Dillon, CO (Englert and others 2002), at an elevation of about 10,200 ft (3,120 m). It has been tested and seeded in the Intermountain West for reclamation of mined lands and other disturbed sites with acidic soils and for restoration of wet meadows at high elevations.

Distichlis spicata Inland Saltgrass

Synonyms

Uniola spicata
Uniola stricta
Distichlis maritima var. *laxa*
Distichlis dentata
Briza spicata

Description

Inland saltgrass is a native, dioecious, warm-season, strongly rhizomatous perennial halophyte (Ungar 1974) that is widely distributed across the Western United States and Canada (fig. 25) (Hitchcock 1950). It is a relatively short grass that grows to 16 inches (40 cm) in height. Inland saltgrass produces vigorous scaly rhizomes at shallow depths, generally in the upper 8 inches (20 cm) of the soil profile. The culms sometimes bear long, soft, straight hairs that are about 0.02 to 0.12 inch (0.5 to 3 mm) long at the collar and upper margins of the sheath. Leaf blades on the middle or upper portions of the culm are two ranked, loosely involute and 0.08 to 0.16 inch (2 to 4 mm) wide, with the upper surface sometimes roughened or long hairy. Ligules are 0.01 to 0.02 inch (0.2 to 0.6 mm) long with a fringe of cilia along the margins. Panicles are 1.2 to 4.0 inches (3 to 10 cm) long with a few somewhat congested and strongly compressed spikelets. The male panicle often extends above the leaves, while the female panicle is normally enclosed within them. Staminate spikelets are 6 to 14 flowered and yellowish, while the pistillate spikelets are 3 to 10 flowered. Glumes are lance shaped, hairless, and five to seven nerved. Lemmas are firmer than the glumes and seven to nine nerved. Glumes and lemmas of pistillate flowers are larger than those of the staminate flowers. The paleas of the pistillate florets are slightly shorter than the lemma, and their winged keels have irregular, shallowly serrate, and minutely ciliolate margins (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Figure 25—A strongly rhizomatous warm-season perennial, inland saltgrass can grow on sites with shallow water tables and on highly saline soils (photo courtesy of Marshall Haferkamp, USDA ARS, Miles City, MT).

Saltgrass is best adapted to medium- and fine-textured soils (Shaw and Cooper 1973), but it can also be found in sandy and gravelly soils. It often occurs in conjunction with a shallow water table and on sites that are periodically flooded. On highly saline soils, plants may be dwarfed, and the culms are generally reclining with the tips ascending, or they may be decumbent at the base and somewhat stoloniferous.

Saltgrass has a number of physiological adaptations that allow it to occupy saline soils. Vesicular-abuscular mycorrhizal fungi have been observed on inland saltgrass roots, and are thought to enhance salt tolerance (Ho 1987). Plants contain salt glands that are active in the extrusion of salt (Hansen and others 1976). The lacunae tissue of the roots is apparently continuous with the rhizome and leaf sheath. This allows for gas exchange under partial inundation and in heavy soils (Hansen and others 1976).

Ecological Relationships and Distribution

Inland saltgrass is distributed from the interior of British Columbia to Saskatchewan and southward to California, Texas, and Mexico. It also ranges eastward to Minnesota. Inland saltgrass is dominant or codominant in some communities and may be found in varying densities in a wide range of communities. Pure to nearly pure stands occur on sites where soils are saline and fine textured, and where the soil is wet at least part of the year (Shantz and Piemeisel 1940; Ungar 1974). In the Great Basin saltgrass is a dominant species in lower elevation desert shrub communities. It spreads rhizomatously and forms a sod under black greasewood and shadscale. Black greasewood and saltgrass occurring together indicate the presence of soil with a high moisture content. Where soil salinity becomes greater than 1 percent, black greasewood gives way to pure stands of saltgrass (Brotherson 1987).

Saltgrass does especially well on fine-textured soils in areas with high water tables that receive seasonal runoff. Salt flats, desert playas, valley bottoms, intermittent ponds, saline meadows, and borders of springs, streams, and lakes commonly support this species. Inland saltgrass forms a dense sod only on salt soils with fine texture and good soil moisture throughout most the year. It may also occur as a pioneering species. The spreading rhizomes allow saltgrass to colonize salt flats, playas, lakeshores, shale cliffs, and other barren saline sites (Cronquist and others 1977; Unger 1966) not tolerated by other grasses. Its pointed rhizomes are well adapted to heavy clays and shales (Hansen and others 1976).

Saltgrass has moderate to high drought tolerance and can remain dormant for long periods of time (Shantz and Piemeisel 1924). It exhibits exceptional tolerance of flooding (Platts and others 1987). Although flooded plants may show a loss of vigor, they generally recover within 30 days after the water has receded. Saltgrass tolerates burning, as the rhizomes are generally insulated from the heat of most fires.

Plant Culture

Inland saltgrass reproduction is mainly through vegetative spread from a well-developed system of deep underground rhizomes. It is well adapted to spreading into a wide variety of soils. The species is a poor seed producer. Seed production is generally restricted to better sites that support dense healthy stands (Cluff and Roundy 1988). Fill and viability of saltgrass seed is often quite high. Seed can remain dormant for at least 4 years (Shaw and Cooper 1973). This allows soil seed banking to occur and permits plants to establish in large numbers when favorable conditions exist for germination. Saltgrass seed requires relatively high temperatures, low salinities, and moist soil to germinate (Roundy 1987). Saltgrass has been successfully seeded with a Brillion seeder and with broadcast seeding. Seed must be planted about 0.5 inch (1.3 cm) deep.

Saltgrass has been established by planting rhizomes. Because rhizomes are sensitive to desiccation, they should be planted only in wet, saline areas, unless irrigation is being used during establishment. Planting rhizomes at depths of 1 to 2 inches (2.5 to 5 cm) has proven successful (Delzell 1972).

Uses and Management

Saltgrass is not greatly preferred by livestock and wildlife. Cattle generally avoid its harsh foliage. Because it usually remains green all summer long, it is most often grazed after other grasses have been consumed or have dried out (Humphrey 1970; Shaw and Cooper 1973). Saltgrass is low in nutritive value. For cattle, a pure saltgrass diet should be avoided because severe rumen compaction can occur (Stubbendeick and others 1985).

Small mammals and birds use saltgrass for cover, nesting, and feeding. It often forms a dense sod that provides good escape and security cover. Saltgrass stands can provide nesting cover for pheasants and many species of ducks and shore birds. Seeds of saltgrass are eaten by waterfowl and small mammals (Ohlenbusch and others 1983). Saltgrass sod around lakes often indicates alkaline conditions that are unfavorable for fish (Hansen and others 1988a,b).

Saltgrass is highly resistant to grazing and trampling, and it provides a resistant sod in areas where cattle concentrate, such as watering sites, corrals, and along trails. Attempts have been made to rehabilitate saltgrass meadows by killing the saltgrass and planting more palatable, salt-tolerant species (Bowman and others 1985; Ludwig and McGinnies 1978). Plowing, disking, and other mechanical treatments have proven ineffective because inland saltgrass reproduces profusely from rhizomes (McGinnies 1974, 1975).

Plant Culture

Reestablishment of saltgrass is often required to restore depleted wetlands. Seed, however, is not widely available. In addition, removal of weedy competition and preparation of a seedbed can be difficult on inland saltgrass sites. Seeding on sites with some surface litter is advised because the soils often crust, reducing seedling emergence. Inland saltgrass develops slowly, requiring 2 to 3 years to become fully established. Seeding pure stands is normally recommended.

Varieties and Ecotypes

There are no releases of inland saltgrass.

Elymus canadensis
Canada Wildrye

Synonyms

Hordeum patulum
Clinelymus canadensis
Sitanion brodiei
Elymus glaucifolius
Elymus robustus
Elymus brachystachys

Description

Canada wildrye is a highly variable, perennial, cool-season bunchgrass. Plants are coarse and open with erect to decumbent, tufted, hollow culms 2.6 to 6.5 ft (8 to 20 dm) tall. Rhizomes are short and usually absent. Leaves are mostly cauline. The blades are flat, 0.12 to 0.59 inch (3 to 15 mm) wide, and roughened above. Auricles are well developed, clasping, and about 0.04 to 0.08 inch (1 to 2 mm) long. Ligules are 0.01 to 0.08 inch (0.2 to 2 mm) long, truncate, and fringed with minutely ciliate hairs. Spikes are thick, bristly, and usually nodding or drooping (Asay and Jensen 1996b). Spikelets are 0.47 to 0.59 inch (12 to 15 mm) long excluding the awns, two to four flowered, and two to four per node. Flowers are widely separated, leaving the axis of the spikelet visible. Glumes are subequal, narrowly lanceolate, about 0.39 to 0.98 inch (10 to 25 mm) long, three to five nerved, broadest above the base, and tapering to a long awn. The nerves on the glumes are roughened to somewhat ciliate. Lemmas are about 0.33 to 0.55 inch (8.5 to 14 mm) long, strongly roughened, five to seven nerved, and gradually tapering into a long, rough, flexible, sharp awn that measures 0.63 to 1.18 inches (16 to 30 mm) in length. Flowering occurs from late June through August (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

E. canadensis has been found to hybridize with *Agropyron trachycaulum* and *E. interruptus* (Arnow 1987; Great Plains Flora Association 1986). It has formed synthetic hybrids with *Sitanion hystrix* and some *Agropyron* species (Dewey 1967).

Ecological Relationships and Distribution

Canada wildrye is distributed from Alaska south to California, and eastward across much of Canada and the United States except for the extreme Southeastern United States (Great Plains Flora Association 1986). It generally occurs in areas receiving 20 to 45 inches (508 to 1143 mm) of annual precipitation. The species occurs widely on tall-grass and mixed-grass prairies of the Great Plains and Midwestern States, particularly in sandy areas (Barker and others 1985). It also grows in riparian areas and wetlands, occurring with eastern cottonwood, green ash, redosier dogwood, and other riparian species in the Missouri River system of the Great Plains (Boggs 1984). Canada wildrye is tolerant of shade and occurs in oak savannas of Minnesota (Tolstead 1942), ponderosa pine communities in the Southwest (Lavin 1953), and mixed evergreen and hardwood forests of the Coast Range in California (Hickman 1993). It is less common in the Intermountain West, usually growing in low, moist valleys or along streams, irrigation ditches, and roadsides.

Canada wildrye is adapted to soils of low to moderate fertility. It can be found on soils ranging from gravelly to clayey and from neutral to slightly alkaline (Great Plains Flora Association 1986). Pure stands can be found on wet to moist, alkaline, or sometimes saline meadows (Arnow 1987).

Canada wildrye develops rapidly and is rather short lived. It is a good seed producer and depends upon seed for spread and persistence (Weaver and Zink 1946). The species is considered early to midseral and often occurs on riparian and upland disturbances. Canada wildrye begins growth in early spring, flowers in midsummer, and matures seed in late summer or early fall. Plants may enter dormancy in summer and resume growth in fall if moisture is received.

Fire may top-kill Canada wildrye. Its buds are located beneath the soil surface where they are somewhat protected from burning. The coarse leaves and stems are not highly flammable. Early spring fires are most harmful, while the best postburn response follows summer fires. Regeneration following fire occurs through recruitment from the seed bank (Howe 1994; Mowat 1990; Robocker and Miller 1955; Wright 1971; Wright and Bailey 1982).

Plant Culture

Canada wildrye may outcross or self-fertilize (Gabel 1984). It produces numerous reproductive stems and is generally a good seed producer. Seed maturation occurs from July in the southern portion of the species range to August in the northern portion (Smith and Smith 1997; Wheeler and Hill 1957). Seed production is generally good, and shatter during harvest is generally not problematic. However, threshing and cleaning are complicated by the presence of the long awns (Hafenrichter and others 1949). Swathing or windrowing during the hard-dough stage and combining are the recommended methods of harvest (Smith and Smith 1997). Seed is cleaned using a using a debearder, a four-screen fanning mill, and a two-disc indent cleaner (Smith and Smith 1997). Seeds average 115,000 seeds per pound (254,000 per kg). Seed yields from nonirrigated fields range from 150 to 300 pounds per acre (168 to 336 kg per ha), while yields from irrigated fields range from 400 to 1,100 pounds per acre (448 to 1,232 kg per ha) (Smith and Smith 1997).

Appropriate seed sources for proposed planting sites should be selected due to the considerable ecotypic variation within the species. Seed should be planted in late fall or early spring at a depth of about 1 inch (2.5 cm) by broadcasting and covering the seed or by drilling. Seeds germinate rapidly. Dry storage or a 2-month moist prechill improve germination (Blake 1935; Greene and Curtis 1950). Seedlings are vigorous and stands develop rapidly. Peak production occurs in 2 or 3 years (Wasser 1982). Stand life for seed fields is 7 or 8 years (Smith and Smith 1997). In native stands Canada wildrye may eventually be replaced by longer lived species. It is not competitive with aggressive exotic grasses. Canada wildrye is susceptible to infestation by ergot, which may cause illness or death if consumed by livestock (Vallentine 1961).

Uses and Management

Canada wildrye is used by wildlife and livestock. Forage value and palatability are greatest in early spring, but decrease as plants mature (Hoover and others 1948; Morris and others 1950; Stubbendieck and others 1986). Stands of Canada wildrye are harvested for hay in the boot stage, just as the seedheads emerge (Wheeler and Hill 1957). Plants tend to be avoided after this stage. Stands decrease with heavy grazing because the growing points are damaged (Ehrenreich and Aikman 1963).

Canada wildrye seedings provide cover, litter, and organic matter; control erosion; and provide habitat for birds and other wildlife (Barker and others 1985; Noyd and others 1995). It is tolerant of heavy metals, and can be used to revegetate abandoned mine tailings (Chambers and Sidle 1991; Hardell and Morrison 1983). It may also be used alone or in mixtures to seed disturbances in sand dunes, riparian areas or wetlands, or native prairie communities. Canada wildrye provides good cover for birds and many other small animals. Its foliage tends to be rather coarse and not highly palatable.

Varieties and Ecotypes

Mandan was released in 1946 by the Agricultural Research Station Northern Great Plains Research Center in Mandan, ND, the Natural Resources Conservation Service and the North Dakota Agricultural Experiment Station. It originated from material collected near Mandan, ND, and was selected for its rapid establishment, leafiness, productivity in young stands of mixed species, and soil stabilizing capabilities (Alderson and Sharp 1994; Baker and others 1985). It is shorter and more persistent than many Canada wildrye populations. Mandan currently receives little use, and seed is generally not available.

Elymus cinereus
Great Basin Wildrye

Synonyms

Leymus cinereus
Elymus condensatus var. *pubens*
Elymus piperi

Description

Great Basin wildrye is a coarse, robust, densely tufted perennial bunchgrass that often forms clumps up to 3.3 ft (1 m) across. It is the largest cool-season bunchgrass native to the Western United States (fig. 26) (Abbot and others 1991; Anderson and others 1995; Cash and others 1998). Plants sometimes produce short, stout rhizomes. Culms are usually more than 2.3 ft (7 dm) tall, often growing to heights of 6.6 ft (2 m). They are hairless, or more often minutely hairy, especially at the nodes. Leaf sheaths are hairless to soft hairy with appressed or spreading hairs. Auricles are well developed to lacking. Ligules are long and membranous or translucent, measuring about 0.08 to 0.28 inch (2 to 7 mm) in length. Leaf blades are flat, or nearly so, 0.17 to 0.59 inch (4.5 to 15 mm) wide, firm, and sometimes strongly nerved. Spikes are 2.8 to 9.0 inches (7 to 23 cm) long, 2.8 to 4.7 inches (7 to 12 cm) wide, stiff, erect, and sometimes compound and branching. Spikelets are 0.35 to 0.79 inch (9 to 20 mm) long and two to five flowered. There are usually three to six per node, but sometimes only two. Glumes are subequal, 0.28 to 0.63 inch (7 to 16 mm) long, narrow, somewhat awl shaped, tapered, and often as long as the spikelet.

Figure 26—Great Basin wildrye provides good winter cover for birds and small mammals (photo courtesy of John Kinney, USDA FS, Rocky Mountain Research Station, Boise, ID).

Lemmas are 0.28 to 0.47 inch (7 to 12 mm) long; pubescent with very short, stiff hairs or rarely hairless; and usually nerveless below and five to seven nerved above. The awn is short, usually less than 0.20 inch (5 mm) in length, or absent. Flowering occurs from June to early August (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Great Basin wildrye plants in the Western United States are generally tetraploid with $2n = 4x = 28$, while those in Canada are octoploid with $2n = 8x = 56$ (Asay and Jensen 1990b). Great Basin wildrye forms natural fertile hybrids with beardless wildrye and bottlebrush squirreltail in areas where the species overlap (Arnow 1987; Asay and Jensen 1996b).

Ecological Relationships and Distribution

Great Basin wildrye occurs throughout the Western United States and Canada and reportedly as far east as Minnesota (Arnow 1987; Asay and Jensen 1996b). In the Intermountain West it occurs in a wide range of community types from salt desert shrublands to ponderosa pine communities (Arnow 1987). In this area it commonly occurs with big sagebrush, rabbitbrush, junipers, and wheatgrasses. In the Great Plains it is associated with grama grass, buffalo grass, and mixed-grass prairie communities (Shiflet 1994). Great Basin wildrye may occur scattered among other species or it may form pure stands or stringers along riparian areas, dry washes, roadsides, and on floodplains or in other areas that receive runoff water or subirrigation, or that have high water tables (Jankovsky-Jones and others 1999; Wasser 1982). It also grows on upland prairies, hillslopes, and mountainous sites. Great Basin wildrye invades disturbed sites, and is an important colonizer of steep, eroded slopes and gullies where it is adapted.

Great Basin wildrye exhibits considerable ecotypic variation with populations growing at elevations ranging from 1,970 to 9,840 ft (600 to 3,000 m) on sites receiving 8 to 20 inches (200 to 500 mm) of annual precipitation. Some populations grow on sites receiving as little as 5 inches (130 mm) of annual precipitation (Cash and others 1998; Davenport Seed Corporation 1997; Hickman 1993). Great Basin wildrye commonly occurs on deep, silty to clayey soils, but it also occurs on soils that are sandy or gravelly or that have claypan layers or high potassium concentrations. Various ecotypes are moderately tolerant of acid, alkaline, or saline conditions (Asay 1987; Wasser 1982).

Great Basin wildrye plants begin growth in early spring (Hafenrichter and others 1968). Flowering occurs in early to midspring, and seeds ripen in late summer or early fall (Arnow 1987; Meyer and others 1995). Plants tolerate water stress; growth continues into summer and sometimes after seed ripening (Anderson and others 1987). Some ecotypes are moderately tolerant of intermittent high water tables, moderate soil drainage, and winter or spring flooding (Barkworth and Atkins 1984; Lesperance and others 1978; Morris and others 1950). Reproduction is from seed or by tillering or sprouting from rhizomes.

Plants are resistant to fires, particularly those occurring late in the growing season following the onset of dormancy (Range and others 1982; Zschaechner 1985). The bunching habit and the presence of coarse, dried leaves covering the growing points in late summer provide protection if burns are not severe (Range and others 1982; Zschaechner 1985). Damage is greater earlier in the season, particularly if soils are dry, limiting the potential for resprouting from the root crown or rhizomes (Bradley and others 1992a,b; Wasser 1982). If moisture conditions are favorable, production may increase and remain high for several years following fire (Klebenow and others 1976). In addition to resprouting following fire, stand increase may also occur from the seed bank, as smoke has been found to increase the growth of germinants (Blank and Young 1998).

Plant Culture

Wildland stands of Great Basin wildrye may be hand harvested. Extensive wildland stands and seed fields may be swathed and combined. Shattering is only moderate, but lodging may create problems. Seeds are cleaned by combining or by chopping and fanning (Plummer and others 1968). There are about 95,000 to 166,000 seeds per pound (210,000 to 366,000 per kg)

(Vallentine 1971). Seed fill and viability are variable and often low. Seeds may be marketed with 85 percent purity and 80 percent germination (Wasser 1982).

Great Basin wildrye is usually difficult to establish due to low or erratic germination, poor seedling survival, and slow establishment (Evans and Young 1983; Roundy and others 1983). It should be seeded in late fall in the drier portion of its range. Seeds should be drilled or broadcast and covered to a 1-inch (2.5-cm) depth (Wasser 1982). Seeds are nondormant and do not require afterripening, but they will germinate more readily in spring following exposure to cool, moist seedbeds in winter (Meyer 1994). This allows the seed to emerge more uniformly in spring and maximizes survival in the face of drying seedbeds. High-elevation and spring-flooded sites can be seeded in spring as soon as they become accessible.

Great Basin wildrye can be drill or broadcast seeded alone or with other nonagressive species in areas where it is most likely to establish. It should not be seeded in mixtures with more aggressive species or in areas where weeds have not been controlled. High soil salinity or soil crusting may reduce emergence. Stand establishment requires two or three growing seasons. New seedings of Great Basin wildrye should not be grazed or harvested until after the first two growing seasons.

Uses and Management

Great Basin wildrye is an important forage species for wildlife and domestic livestock. It is palatable and nutritious in spring and fall and receives considerable use during these seasons (Jarecki 1985). It is also valuable in winter because of its height and the accessibility of its forage (Cook and others 1954; Jarecki 1985). Palatability and nutrient content decrease in summer and winter as the leaves dry and become coarse (Cook and others 1954; Daubenmire 1970; Jarecki 1985; Krall and others 1971; Walker and Brotherson 1982; Wasser 1982).

Big game animals including mule deer, elk, and bighorn sheep graze Great Basin wildrye (Austin and others 1994; Keating and others 1985; Majerus 1992). It provides excellent cover for small mammals, waterfowl, and upland game birds, and bedding cover for big game (Batzli 1974; Sours 1983; Wasser 1982).

All classes of livestock use Great Basin wildrye. It provides valuable forage and thermal protection for livestock in winter. Native stands provide spring and fall grazing and may be cut for hay. Poor grazing practices, however, have degraded many native stands. The timing, frequency, and extent of grazing all have an impact on plant vigor and regrowth (Holzworth and Lacey 1991; Jarecki 1985). Forage is of high quality in early spring. Excessive grazing during this period depletes carbohydrates and is detrimental to the plants, especially when they are grazed during the boot stage (Tweit and Houston 1980). Plants should not be grazed until they reach heights of 12 to 15 inches (30 to 38 cm), and 20 percent of the production should be left to maximize regrowth (Hafenrichter and others 1968). Livestock should be removed before the soil dries out to permit regrowth and replacement of root reserves. This approach should also be followed for fall grazing. Great Basin wildrye is susceptible to infection by ergot, which may cause sickness or death of livestock that consume it (Cronquist and others 1977). Plants are also sometimes severely infested with leaf rusts.

Great Basin wildrye is seeded to provide forage and cover for livestock and wildlife. It is also planted in pastures, sometimes with tall wheatgrass, on saline and alkali soils that are subirrigated or that may flood intermittently to provide fall, winter, or spring livestock grazing and for calving. These seedings are also harvested for their hay and silage production.

Great Basin wildrye is valuable for erosion control plantings in areas where it is adapted because of its deep and spreading fibrous root system. It is useful for stabilization of drainage ditches, mine spoils, highway rights-of-way, burned sites, eroding slopes, and other disturbances (Barker and others 1985; Cronquist and others 1977; Walker and Brotherson 1982). Great Basin wildrye is also seeded as a component of windbreaks and conservation plantings. A major use of the species is for seeding disturbances on alkaline and saline sites that once supported the species. Monsen (1983) recommends that basin wildrye be included in seedings on disturbances in or adjacent to riparian areas including wet meadows, stream terraces, and mountain brush, big sagebrush, desert shrub, and saltgrass communities. Slow establishment, however, limits the value of Great Basin wildrye during the first two growing seasons following seeding.

Varieties and Ecotypes

‘Magnar’, an octoploid cultivar, originated in Saskatchewan, Canada (Alderson and Sharp 1994), and has been seeded extensively throughout the Intermountain West in upper pinyon-juniper, mountain brush, and mountain big sagebrush communities. It also establishes well in canyon bottoms, along road rights-of-way, and in depressions where extra moisture accumulates. It is adapted to soils ranging from loams to clays, and from slightly basic to alkaline. Magnar performs best on sites receiving 15 inches (380 mm) or more of annual precipitation, but stands establish in areas receiving as little as 13 inches (330 mm). It is not suited to lower, drier pinyon-juniper or sagebrush grass communities.

Magnar foliage is blue green. Plants grow to 7 ft (2.1 m) in height and produce wide, coarse leaves and large stems and seed heads. Seedlings are vigorous and establishment is generally rapid. Magnar is long lived, nonaggressive, and suitable for mixed seedings.

'Trailhead' was collected near Roundup, MT (Alderson and Sharp 1994). Plants are tetraploid and dark green with broad, somewhat lax leaves. Trailhead is considerably more drought tolerant and productive than Magnar. It has established successfully in areas receiving as little as 11 inches (280 mm) of annual precipitation. Trailhead is adapted to soils ranging from saline-alkaline to acidic. It can be seeded from valley bottoms up through the mountain brush zone. Trailhead is seeded to provide soil stabilization, early spring and winter forage, and wildlife habitat.

Elymus glaucus
Blue Wildrye

Synonyms

Elymus sibericus var. *glaucus*
Elymus villosus var. *glabriusculus*
Elymus nitidus

Description

Blue wildrye is a green to blue waxy cool-season native perennial bunchgrass that forms small loose to dense tufts with only a few culms. The root system is deep and fibrous. Plants sometimes produces short stolons. Culms grow from 1.9 to 4.6 ft (6 to 14 dm) in height. Leaves are scattered along the culms. Leaf sheaths may be glabrous or with downward pointing hairs; the collar is often purple. Leaf blades are flat to sometimes slightly involute, 0.16 to 0.47 inch (4 to 12 mm) wide, and mostly roughened to sparsely silky haired, or sometimes hairless below. Auricles are well developed, about 0.08 inch (2 mm) long, and clasping. Ligules are short, 0.01 to 0.04 inch (0.3 to 1 mm) long, squared at the apex, and irregularly lacerate and ciliate along the margins. Spikes are 2.4 to 6.3 inches (6 to 16 cm) long, excluding the awns, erect, interrupted below and overlapping above, or dense throughout and long exerted. Spikelets are mostly two per node, 0.39 to 0.63 inch (10 to 16 mm) long, and two to four flowered. Glumes are nearly parallel, concealing the base of the enclosed florets and tapering to a short awn. They are subequal, 0.25 to 0.75 inch (6.5 to 19 mm) long, three to five nerved, narrowly lance shaped, and broadest above the base. The glumes are hardened below and membranous above with glabrous, smooth to roughened surfaces. Lemmas are 0.33 to 0.55 inch (8.5 to 14 mm) long, five nerved, hairless to roughened along the nerves, and tapering to long, slender, mostly straight awns that are about 0.39 to 1.18 inches (10 to 30 mm) long. Plants flower from June to August (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Blue wildrye is often confused with *Agropyron trachycaulum* var. *unilaterale*. Blue wildrye, however, has the *Elymus* characteristics of two spikelets per node, narrow glumes, and a distorted rachilla. It is, however, extremely variable in its morphological and genotypic characters. Some biotypes cross readily with *Sitanion hystrix*, while others do not. These hybrids are referred to as X *elysitanion hansenii*. Some manuals recognize blue wildrye varieties such as *E. g.* var. *breviaristatus*, *E. g.* var. *glaucus*, and *E. g.* var. *jepsonii* (Cronquist and others 1977). The species is allotretraploid with 2n = 28 (Dewey 1982).

Ecological Relationships and Distribution

Blue wildrye is distributed from Alaska to California and into northern Arizona and New Mexico. It is found less commonly from Ontario to New York, and south to Arkansas (Arnow 1987, 1993; Cronquist and others 1977). Blue wildrye is most abundant in timbered areas from sea level to 10,000 ft (3,050 m) (Asay and Jensen 1996b). It occurs in shaded or open forests, grasslands, shrublands, and on moist soils of riparian areas and wetlands in mountain brush, aspen, ponderosa pine, spruce-fir, and lodgepole pine communities (Arnow 1987; Hitchcock 1950) (fig. 27).

Blue wildrye populations are adapted to well-drained soils with clay loam to sandy loam textures (Hassell and others 1982) that are moderately acid to neutral (pH 5.2 to 7). Populations are common on moist sites, but some are moderately drought tolerant. The species is adapted to soils of low fertility, but it does not tolerate shallow soils, and it is moderately sensitive to saline soils (Hassell and others 1983).

Plants are short lived, but stands reseed themselves readily (Asay and Jensen 1996b). The species is favored by disturbances and is often most abundant in early seral communities on open, disturbed sites where it may form dense stands (Cole 1982; Hitchcock and others 1969; USDA Forest Service 1937). Plants also grow in shaded areas (Plummer and others 1955).

Blue wildrye forms small bunches with coarse foliage that burn rapidly and can survive wildfires. Burned plants regenerate by resprouting from the root crown (Simmerman and others 1991). New plants establish from the seed bank, as burns appear to provide favorable microsite conditions for germination (Stickney 1989). Blue wildrye seedlings and cover develop rapidly, and stands of the species are common on burned over sites where competition is low. Stands may decline after the first few years (Brown and DeByle 1989; Hafenrichter and others 1949, 1968).

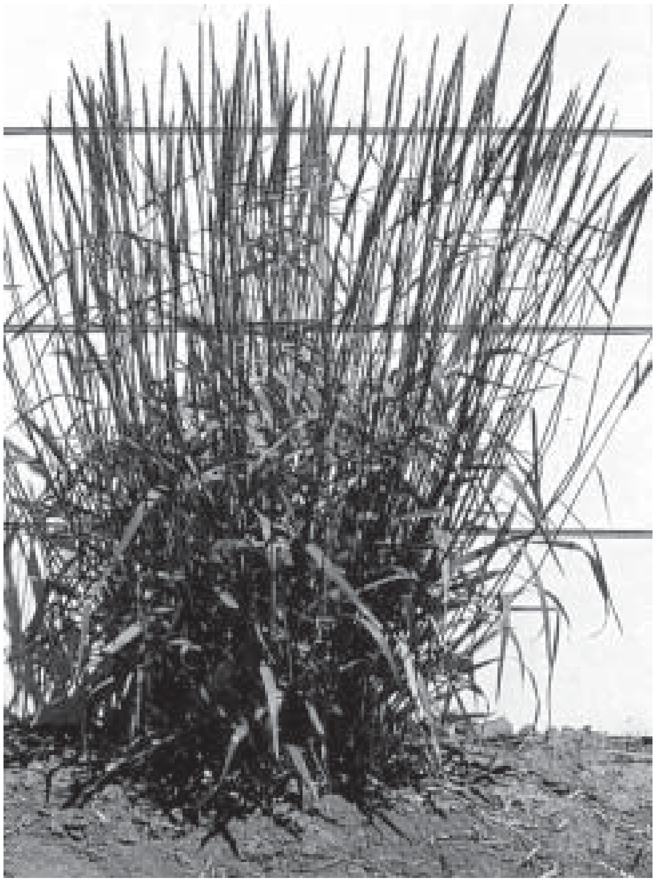

Figure 27—Blue wildrye is a native, shade-tolerant bunchgrass that can be seeded as an understory in tree and shrub plantings (photo courtesy of Kevin Jensen, USDA ARS, Logan, UT).

Plant Culture

Blue wildrye tends to be a good seed producer. Shattering can reduce yields, but seed can be safely harvested shortly before reaching maturity and allowed to ripen while drying (Link 1993). Seed must be dried before hammermilling to facilitate removal of the awns (Hafenrichter and others 1949, 1968; Link 1993). Awns of seeds in large lots may be detached with a debearder or brush machine. Debris is then removed using an air screen machine.

There are about 131,000 seeds per pound (288,800 per kg) (Hafenrichter and others 1968). Seeds maintain viability for 2 to 4 years. They do not require a pretreatment for germination (McLean 1967). Seeds should be incubated at 68/86 °F (20/30 °C) (16 hrs/8 hrs) for germination testing (Haferkamp and McSwain 1951).

Some seed is commercially available. Libby and Rodrigues (1992), however, suggested that use of commercial seed outside its area of origin could contaminate local populations. Hassell and others (1983) recommended use of local seed collected or produced from populations growing within 300 miles (483 km) and 1,640 ft (500 m) elevation from the planting site because of the high variability within the species.

Blue wildrye can be drill or broadcast seeded on a firm seedbed in fall or early spring. Seed should be covered to a depth of about 0.5 inch (1.3 cm) (Plummer 1943). Establishment and growth are rapid and seedings are persistent.

Uses and Management

Although blue wildrye provides fair to good forage for big game and livestock early in the growing season, the foliage is coarse and provides only poor protein content and good energy value (Dittberner and Olsen 1983). The species produces a fairly extensive root system, but plants are not tolerant of heavy grazing (Vallentine 1961). Blue wildrye recovers fairly rapidly when grazing is removed (Sampson 1944). A widespread species, it often provides considerable forage for wildlife. Early spring growth is most readily used; the awned seedheads are avoided (USDA Forest Service 1937).

Blue wildrye establishes rapidly and is a good seed producer (Plummer and others 1968). Consequently, it is used for postfire and postlogging seedings because it generally establishes well and can be planted in mixtures with other natives (Frishchknecht and Plummer 1955). It is a pioneering species and can be seeded to provide cover rapidly, spread from seed, and control erosion on steep slopes, roadsides, and other disturbances (Darris and others 1996; Hafenrichter and others 1949, 1968). Seedings of blue wildrye do not compete excessively with establishing tree seedlings, but the grass does restrict invasion of weedy species (Asay and Jensen 1996b). Blue wildrye has also been used to provide an understory cover in windbreak and conservation plantings.

Varieties and Ecotypes

Blue wildrye contains considerable intraspecific variability manifested by differing site requirements. Plants are highly self-fertile. Some ecotypes are cross-sterile, while others are compatible (Asay and Jensen 1996b; Snyder 1950). Seed transfer zones for the species have been identified for National Forests of north-central Oregon.

'Arlington' originated in Snohomish County, WA (Alderson and Sharp 1994). It has been seeded primarily for soil stabilization and to provide forage. It grows in shaded areas under the canopies of aspen groves and conifer forests, but it also does well on the forest edge and in openings, especially on moist sites and along stream edges. Arlington exhibits good seedling vigor, establishes readily, and provides cover for erosion control on burned and cutover forest areas. Plants are short lived, but the variety does spread from seed. Seed may be drilled shallowly or broadcast following a fire or on snow in winter. Seed is now rarely available.

Elymus junceus Russian Wildrye

Synonyms

Elymus cretaceus
Psathyrostachys juncea

Description

Russian wildrye is a densely tufted, perennial, cool-season bunchgrass with the leaves mostly basal. Culms are 1.3 to 3.6 ft (4 to 11 dm) tall. Leaf sheaths are hairless; the auricles and collars are well developed. Blades are flat, waxy, roughened, involute, and 0.06 to 0.16 inch (1.5 to 4 mm) wide. Ligules are very short, 0.01 to 0.04 inch (0.2 to 1 mm) long, squared at the apex, and ciliate along the margins. Spikes are erect, 1.6 to 5.1 inches (4 to 13 cm) long, and 0.16 to 0.47 inch (4 to 12 mm) wide with the rachis disarticulating between the spikelets. Spikelets are three or sometimes two per node. They are 0.31 to 0.39 inch (8 to 10 mm) long and two to three flowered. Glumes are subequal, short, 0.12 to 0.27 inch (3 to 7 mm) long, awl shaped, roughened or short haired, but often hairless and shiny at the base. Lemmas are small, 0.26 to 0.39 inch (6.7 to 10 mm) long, roughened to stiff haired, five to seven nerved, and tapering to an awn that is 0.02 to 0.12 inch (0.5 to 3 mm) long (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Russian wildrye is easily identified by the readily disarticulating axis of the rachis at maturity. This results in the accumulation of old leaf sheaths at the base of the plant that eventually separate into fibers. Plants flower from May to July (Arnow 1987, 1993; Cronquist and others 1977; Goodrich 1986; Hitchcock 1950; Hitchcock and others 1969).

Ecological Relationships and Distribution

Russian wildrye, a native of the steppes and deserts of Russia and China, was introduced to the United States in 1927. It has been seeded on the Northern Great Plains and the Intermountain and Rocky Mountain areas as a pasture grass and erosion control species since the 1950s (fig. 28). Russian wildrye provides nutritious and palatable forage nearly year long on arid and semiarid rangelands (Plummer and others 1968). It is now distributed from Canada south to Arizona, and eastward to Nebraska (Arnow 1987). Scattered naturalized plants have been found in Utah, Wyoming, Saskatchewan, and Manitoba (Cronquist and others 1977). In the Intermountain area the species is adapted to salt desert shrub, sagebrush, grasslands, pinyon-juniper, oak scrub, mountain brush, aspen, and ponderosa pine communities. It grows in openings and in the shade of shrubs, but it is not adapted as an understory species in the shade of Gambel oak and mountain brush (Plummer and others 1968). Russian wildrye is adapted to fertile loam and clay soils, but it will grow on a variety of soil types including moderately saline or alkaline soils. It can be seeded on soils that are too alkaline for crested wheatgrass. Russian wildrye is more heat tolerant than crested wheatgrass in areas receiving summer precipitation, and matures later, providing a longer period of grazing. It is best adapted to areas with winter and summer precipitation or a predominance of summer precipitation. The species is drought and cold tolerant. It does not tolerate spring flooding (Jensen and others 2001).

Figure 28—Russian wildrye is drought tolerant and produces palatable forage throughout the summer (RMRS photo).

Plant Culture

Russian wildrye seed matures in July to August. Seed production is generally low. Crops can be lost to wind or rainstorms occurring during the ripening period, and seeds tend to shatter shortly after reaching maturity. Fields are windrowed or direct combined. They can be grazed following harvest to remove litter (Jensen and others 2001). There are about 170,100 Russian wildrye seeds per pound (375,000 per kg) (Heady 1975). Fresh or dormant seed becomes more germinable following a 5-day prechill at 41 or 50 °F (5 or 10 °C) (AOSA 1999). Seed is incubated at an alternating temperature regime of 68/86 °F (20/30 °C) (16 hrs/8 hrs) for 14 days for germination testing.

Wildland seedings can be established in areas receiving as little as 8 inches (20 cm) of annual precipitation. Seed should be drill seeded or broadcast and covered in fall at a depth of about 0.75 inch (1.9 cm) (Ludwick 1976). Seeds are easily handled and planted. Seedling vigor is low to moderate, and slow establishment can preclude stand success when weedy competition is present and during dry periods because few seminal roots are produced (Jensen and others 2001). Stands are seeded at wide row spacings, as established plants are strongly competitive and self-thinning until widely spaced. The species is difficult to establish in mixes with species having more rapidly developing seedlings.

Uses and Management

Russian wildrye is seeded primarily to provide forage in dry areas because of its basal leaf production. Grazing of newly seeded stands should be delayed until plants are mature. Established stands are long lived and tolerant of grazing on fertile sites; stands decline more rapidly on sites of low fertility. The species begins growth early in the season, and the numerous basal leaves develop rapidly. Unlike many cool-season grasses of dry areas, it is palatable and nutritious from spring into fall and exhibits good regrowth following use (Jensen and others 2001). Seedings of the species provide good quality and quantities of fall and winter forage when other usable forage is often not available. Although seedlings of this species develop slowly, established stands are more competitive than associated native species.

Russian wildrye is seeded in pastures and maintained with fertilizer treatments in some areas (Jensen and others 2001). Legumes may be added to improve productivity. The species is not generally used for hay production. Wildlife use the species, and it can provide valuable forage in early spring and also in late summer when other grasses have dried out (Dittberner and Olson 1983; Plummer and others 1968). It provides some cover for small mammals and birds. Because plants tend to be widely spaced, it is not often used to control erosion; however, it has been used on roadside areas in southern Idaho to reduce blowing sand and dust.

Varieties and Ecotypes

'Bozoisky-select', an introduction from Russia (Alderson and Sharp 1994), was selected for its large seed size, good seedling vigor and establishment, and enhanced forage production. It is seeded throughout the Intermountain West in the same areas as 'Vinall', but exhibits better establishment and productivity.

'Cabree' was developed from Russian material for use on the Northern Great Plains and Canadian prairies (Alderson and Sharp 1994). It was selected for its seedling vigor, forage and seed production, and moderate drought tolerance. It has not been seeded extensively in the Intermountain West.

'Mankota', introduced from Alma-Ata in the former U.S.S.R. (Alderson and Sharp 1994), was developed for use on the Northern Great Plains and has received little use in the Intermountain West. It is similar to Vinall and Bozoisky-select.

'Mayak' was selected for use on the Northern Great Plains and Canadian prairies (Alderson and Sharp 1994), and has only infrequently been seeded in the Intermountain West. Mayak provides excellent forage throughout the grazing season and has good curing qualities that make it especially useful for late summer, fall, and early winter grazing. Its characteristics include good forage and seed yield and resistance to leaf spot disease.

'Swift', derived from 'Saki' and 'Mandan 1546' (Alderson and Sharp 1994), is adapted to areas of the Intermountain West, even though it was developed for the Northern Great Plains and Canadian prairies. It was selected for its seedling vigor, early spring growth, forage and seed production, and leafiness. It has not proven superior to Bozoisky-select.

'Tetracan' is a colchicine-induced tetraploid (Alderson and Sharp 1994) with large seedheads and seeds, wide leaves, and good seedling vigor. It has performed well on adapted sites, especially with regard to seedling vigor and establishment. Tetracan has seen little use in the Intermountain West.

Vinall was introduced from Russia (Alderson and Sharp 1994) and has been seeded widely throughout the Intermountain West, especially in pinyon-juniper, basin big sagebrush, Wyoming big sagebrush, black greasewood, and salt desert shrub communities. It is adapted to clay and clay-loam soils, and it is moderately tolerant of saline and sodic soils. A major drawback of this variety is its slow and erratic germination and establishment. It does not do well when seeded with species that establish and develop more rapidly. Mature stands can prevent the establishment of other species. This variety is long lived and drought tolerant.

Elymus salinus
Salina Wildrye

Synonyms

Elymus ambiguus var. *salina*
Elymus ambiguus var. *salmonis*
Leymus salinus
Elymus salina

Description

Salina wildrye is an erect, densely tufted perennial bunchgrass that occasionally produces short rhizomes. On some sites, particularly those with heavy clay soils, the plants form large tufts that give them the appearance of being nonrhizomatous. Plants are coarse stemmed with glabrous culms 1.1 to 3.3 ft (3.5 to 10 dm) tall. Leaves are glabrous to pubescent. Leaf blades are flat or more commonly involute, 0.08 to 0.16 inch (2 to 4 mm) wide, and often ciliate near the throat. Auricles are well developed and often clasping. Ligules are usually short, about 0.01 to 0.06 inch (0.2 to 1.5 mm) long, squared apically, and ciliate along the margins. Spikes are erect, slender, 1.9 to 5.9 inches (5 to 15 cm) long, and 0.10 to 0.31 inch (2.5 to 8 mm) wide. Spikelets are usually solitary at each node and slightly overlapping. They are 0.35 to 0.79 inch (9 to 20 mm) long and two to three or rarely six flowered. Glumes are subequal, awl shaped, three nerved, smooth to roughened, sometimes broader at the base, and 0.05 to 0.39 inch (1.2 to 10 mm) long. There is often an extra glume at nodes producing only one spikelet. Lemmas are five-nerved (at least above), smooth to slightly roughened on the surfaces, roughened on the awn and midnerve, and 0.28 to 0.41 inch (7 to 10.5 mm) long. Lemmas taper to a short awn that is 0.01 to 0.08 inch (0.2 to 2 mm) long. The species includes tetraploid ($2n = 28$) and octoploid ($2n = 56$) populations that do not differ morphologically. Plants flower in May to July (Arnow 1987, 1993; Cronquist and others 1977; Dittberner and Olsen 1983; Hitchcock 1950; Hitchcock and others 1969).

Ecological Relationships and Distribution

Salina wildrye is distributed from California and southern Nevada to southwestern Wyoming. It is found from salt desert shrublands through desert shrub, sagebrush-grass, mountain mahogany, aspen, and conifer communities. It may be a common to dominant species in Gambel oak and pinyon-juniper communities (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Salina wildrye is drought resistant and adapted to dry sites with loamy soils, but it also occurs on rocky to sandy sites and on clay soils. It is moderately tolerant of alkalinity (Cronquist and others 1977). The species grows on hillsides, alluvial fans, plateaus, bluffs, canyons, and mountainous areas (Baker and Kennedy 1985; Vallentine 1989) (fig. 29). Plants are generally scattered, and normally do not form pure stands. The species may be resistant to wildfire due to its rhizomatous nature and the widely spaced bunching habit (Baker and Kennedy 1985).

Salina wildrye spreads from seed and tillers. Rhizomes are more commonly produced under mesic conditions. On clay soils, rhizomes may be very short and inconspicuous.

Plant Culture

Seeds of salina wildrye mature in mid to late July. Fruits are cleaned with an air screen machine. There are about 130,000 seeds per pound (286,600 per kg) (Link 1993). Seeds are estimated to remain viable for 2 to 3 years. Germination is enhanced by a 30-day moist prechill (Link 1993).

Seedings of salina wildrye are often not successful due to low seed germination and poor seedling vigor. Established stands, however, are persistent and drought tolerant under a wide variety of conditions (Plummer and others 1968). The species has potential for increased use due to its wide range of adaptation, salt tolerance, drought resistance, and ability to stabilize disturbed slopes with clay soils (Goodrich and Neese 1986; Plummer 1977; Vallentine 1989).

Uses and Management

Salina wildrye is moderately productive. Quality and palatability of the coarse forage is only fair when green; it becomes unpalatable when cured (Vallentine

Figure 29—Salina wildrye grows in mountainous areas and on hillsides, alluvial fans, and canyons from California to southwestern Wyoming (RMRS photo).

1989). Excessive grazing has resulted in declines of the species in northwestern Colorado (Baker and Kennedy 1985).

Varieties and Ecotypes

The Upper Colorado Environmental Plant Center in Meeker, CO, is advancing 'Accession 9043501' from Colfax County, NM, toward release (UCEPC 2002). This accession has potential for revegetation of dry, moderately alkaline rangelands and other disturbed sites in the West. Its forage quality is moderate to fair for livestock and wildlife.

Elymus simplex
Alkali Wildrye or Low-Creeping Wildrye

Synonyms

Elymus triticoides var. *simplex*
Elymus simplex var. *luxurians*
Leymus simplex

Description

Alkali wildrye is a waxy perennial that develops from extensively creeping rhizomes. Culms are 1.3 to 2.3 ft (4 to 7 dm) tall and the rhizomes can be up to 16.4 ft (5 m) long. Leaves are mostly basal. Leaf sheaths are hairless. The blades are usually involute to more or less flat, 0.04 to 0.12 inch (1 to 3 mm) wide, rigid, and roughened or sparsely hairy on the upper surface. Auricles are poorly developed and usually less than 0.04 inch (1 mm) long. Ligules are very short, about 0.02 inch (0.5 mm) long, squared at the apex, and ciliate along the margins. Spikes are 2.4 to 6.3 inches (6 to 16 cm) long, erect, and usually rather slender (fig. 30). Spikelets are usually solitary, or sometimes two per node. When two per node, one is sessile and the other is short pedicellate. Spikelets are 0.43 to 0.80 inch (11 to 20 mm) long, three to ten flowered, sometimes well spaced and not overlapping, but usually slightly overlapping. Glumes are subequal, 0.22 to 0.63 inch (5.5 to 16 mm) long, awl shaped to only slightly broader at the base, hairless to roughened, nearly nerveless, or one to three nerved. There is sometimes an extra glume at a one-spikelet node. Lemmas are 0.30 to 0.37 inch (7.5 to 9.5 mm) long, usually hairless to minutely pubescent and shiny green or rarely with a purplish tinge. They are nerveless below and faintly five to seven nerved above. Glumes taper to a 0.10- to 0.31-inch (2.5- to 8-mm) awn. Plants flower from June to August.

Alkali wildrye is sometimes confused with small plants of creeping wildrye with solitary spikelets. It is also confused with salina wildrye plants that produce rhizomes. Location is the best way to distinguish between these two. Alkali wildrye is a grass of sandy bottomlands, whereas salina wildrye usually grows on mountainsides and in heavy clay soils (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Figure 30—Alkali wildrye spikes are elongate and slender with the spikelets generally solitary or sometimes two per node (Hitchcock 1950).

Ecological Relationships and Distribution

Alkali or low-creeping wildrye is found in moist, sandy soils along riverbanks, and sometimes in drifting sands along the Green River in Daggett County, UT. It also occurs in Wyoming and Colorado (Arnow 1987, 1993; Cronquist and others 1977).

Plant Culture, Uses, and Management

Alkali wildrye has received little use in revegetation efforts. The species could be used on native sites to provide cover, forage, soil stabilization, and diversity.

Varieties and Ecotypes

There are no releases.

Elymus triticoides
Creeping Wildrye or Beardless Wildrye

Synonyms

Elymus condensatus var. *triticoides*
Leymus triticoides
Elymus simplex var. *luxurians*
Elymus acicularis

Description

Creeping or beardless wildrye is a waxy blue or sometimes green perennial that produces extensive and aggressive creeping rhizomes. Culms are 0.5 to 3.9 ft (1.5 to 12 dm) tall. Leaf sheaths are glabrous, roughened, or sometimes minutely hairy. Leaf blades are flat or more commonly involute, and measure 0.10 to 0.28 inch (2.5 to 7 mm) in width. They are coarse, stiff, roughened, and sometimes glabrous below. Auricles are well developed and often clasping. Ligules are short, 0.01 to 0.28 inch (0.2 to 0.7 mm) long, squared, and irregularly lacerate and ciliate along the margins. Spikes are slender and about 1.4 to 3.5 inches (3.5 to 9 cm) long, erect, loose, open to rather dense, and sometimes compound. Spikelets are paired or sometimes solitary at the nodes, and 0.39 to 0.70 inch (10 to 18 mm) long. They are three to eight flowered and greenish, brownish, or purplish. Glumes are subequal, 0.16 to 0.43 inch (4 to 11 mm) long, narrow and awl shaped, firm, one to three nerved, and mostly roughened. Lemmas are small, 0.24 to 0.39 inch (6 to 10 mm) long, often shiny and smooth, hairless, minutely hairy, or sometimes minutely hairy only at the apices. They are faintly to prominently five to seven nerved, rounded on the back or keeled toward the tip, and awnless or with a short awn about 0.02 to 0.10 inch (0.5 to 2.5 mm) long. Plants flower from May through August.

Considerable ecotypic variation occurs within the species. Creeping or beardless wildrye can be confused with western wheatgrass when there is only one spikelet per node. Very narrow glumes and a twisted rachilla that cause the florets to be out of their normal position are characteristic of creeping wildrye (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969), and although of differing growth habits, creeping wildrye and Great Basin wildrye share similar genomes and hybridize in nature (Dewey 1984). Creeping wildrye also hybridizes with salina wildrye (Arnow 1987).

Ecological Relationships and Distribution

Creeping wildrye is distributed from Washington to Montana, and south from Baja California to Texas. It is especially common in the Humboldt River drainage of Nevada (Jensen and others 2001). It is a long-lived, salt-tolerant, sodforming perennial that grows in dry to moist places, valley bottoms, saline seeps and meadows, subirrigated sites including alkaline areas with high water tables, and sites exposed to spring flooding. It occurs on saline meadows and salt desert shrub lands receiving 8 to 12 inches (20 to 30.5 cm) of annual rainfall. The species is cross-pollinating and frequently does not set seed. Stands are generally not extensive; patches may represent single clones (fig. 31). Creeping wildrye often forms natural hybrids with Great Basin wildrye and salina wildrye (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; Knapp and Wiesner 1978).

Plant Culture

Creeping wildrye seeds mature between midsummer and early fall (Sampson 1924). Fields may be combined or swathed and windrowed. Seed retention at maturity is good, but lodging can interfere with harvest. Yields from seed fields average 100 to 200 pounds per acre (112 to 224 kg per ha) (Smith and Smith 1997). Stand life is about 5 years. Seeds are cleaned with a fanning mill. There are about 175,000 seeds per pound (385,000 per kg) (Smith and Smith 1997). Dormancy results from an impermeable outer seed coat. Germination is hastened by a 5-day prechill at 1.5 °C (Wagner and Chapman 1970) with incubation at 15/20 °C (Wagner and Chapman 1970) or 20/30 °C (16 hrs/8 hrs) (Haferkamp and McSwain 1951). Creeping wildrye is fall planted to provide overwinter exposure to cool, moist seedbed conditions. Seeds are drilled or broadcast and covered. Slow germination,

Figure 31—Patches of creeping wildrye often represent individual clones (photo courtesy of Tom Jones, USDA ARS, Logan, UT).

low seedling vigor, and resulting poor establishment have limited use of this species. Although young stands are not competitive, established stands are highly persistent.

Uses and Management

Creeping wildrye is seeded to provide soil stabilization on highly erodible sites and can be used for reseeding disturbances along waterways and on mined lands, roadways, and disturbed rangelands. It is one of the few species that can be seeded to provide forage on wet, alkaline sites in low-precipitation areas, and it is useful in saline areas and areas that are flooded in spring. It can be used in native species restoration efforts in salt desert shrub and pinyon-juniper communities. Native stands provide cover and forage for wildlife and are sometimes cut for hay (Jensen and others 2001).

Varieties and Ecotypes

'Rio' was released by the Lockford Plant Material Center in 1991. It was selected for its vigorous spreading habit. 'Shoshone', released in 1980 by the Bridger Plant Materials Center, is a productive and rhizomatous cultivar.

Festuca arundinacea
Tall Fescue, Reed Fescue, or Alta Fescue

Synonyms

Bromus arundinaceus
Festuca elatior var. *arundinacea*

Description

Tall fescue is a stout, often strongly tufted perennial with an extensive coarse, fibrous root system. Rhizomes are generally short and vary considerably in their sodforming ability. Culms are 1.6 to 6.6 ft (0.5 to 2 m) tall and ascending or erect with smooth or roughened leaf sheaths. Leaf blades are stiff, flat or somewhat involute, 0.12 to 0.47 inch (3 to 12 mm) wide, and roughened above. Auricles are prominent and usually ciliate. Ligules are about 0.01 inch (0.2 mm) long. Panicles are narrow, 5.9 to 13.8 inches (15 to 35 cm) long, and often somewhat nodding. Spikelets measure 0.4 to 0.6 inch (10 to 15 mm) in length and are five to nine flowered. Glumes are lance shaped. The first is 0.16 to 0.24 inch (4 to 6 mm) long and one to three nerved; the second is 0.16 to 0.28 inch (4 to 7 mm) long and three to five nerved with translucent margins. Lemmas are 0.3 to 0.4 inch (7 to 10 mm) long with five to seven faint nerves. Awns, when present, are up to 0.08 inch (2 mm) long. Plants flower from late May through July (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). The species is allohexaploid with 2n = 6n = 42 (Sleper and West 1996).

Ecological Relationships and Distribution

Tall fescue, native to Europe, is seeded as hay, pasture, or turf grass in the Western Hemisphere. The species contains considerable variability, and many cultivars are available. Leaves of the forage varieties are generally soft and lax compared to those of the turf varieties (Jensen and others 2001). Tall fescue is cultivated from Alaska and southern Canada throughout much of the United States (fig. 32). It is also present in South America. The species has escaped and become widely established in areas where it has been seeded. Tall fescue can now be found in seeded fields, moderately moist areas along irrigation ditches and roadsides, and in fallow fields and seeded mountain meadows. Its best growth is on deep, moderately fertile, fine silty to clay soils, but it will grow well on a wide range of soil textures when moisture is adequate (Wasser 1982). It can also be seeded on moderately saline and alkaline soils (Jensen and others 2001). Growth is good in areas that are irrigated, subirrigated, or that receive at least 18 inches (460 mm) of annual precipitation (Jensen and others 2001; Wasser 1982). Tall fescue is a relatively drought- and heat-tolerant

Figure 32—Reed fescue grows on moist soils and tolerates saline and alkaline conditions. Grown for pasture and hay production, it has escaped and become widely distributed in North America (RMRS photo).

pasture grass, but it does not survive long dry periods. This species tolerates cold, winter flooding, high water tables, and poorly drained soils, and it is moderately shade tolerant. Plants are resistant to burning when dormant, but the species does not commonly occur in areas susceptible to wildfire.

An endophytic fungus, *Acremonium coenophialum*, frequently infects tall fescue (Sleper and West 1996). When infected forage is consumed in large quantities, susceptible livestock may develop lameness and sometimes gangrene (Kingsbury 1964). Endophyte-free cultivars should be used for forage production, but these often require more fertile soils or fertilizer applications. Tall fescue is also an invader of lawns (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Plant Culture

Seeds are harvested by direct combining or by swathing and combining. Some seed loss normally results from shattering. Seeds are cleaned using an air-screen machine. There are 181,000 to 230,000 seeds per pound (399,000 to 507,100 per kg). Minimum purity for seed purchases is 98 percent, and germination is 85 percent (Wasser 1982). Seeds are drilled or broadcasted seeded and covered to 0.25 to 0.5 inch (0.6 to 1.3 cm) deep depending on soil conditions. Germination and initial seedling establishment and growth are moderate to good (Hassell and others 1983; Plummer and others 1968). Seedlings usually become established after one growing season (Jensen and others 2001). Plants are persistent, good seed producers, and spread well from seed. Seed production is centered in the Northwest, and yields of 2,510 pounds per acre (2,240 kg per ha) are obtained in western Oregon (Sleper and West 1996).

Irrigated tall fescue fields are planted in late summer. Weed infestations must be controlled until plants are established. When legumes are added to improve forage palatability and quality, seeding may be done in early spring (Jensen and others 2001). The legumes are often planted in alternate rows with the grass. Ladino clover, alfalfa, white clover, and birdsfoot trefoil are used for this purpose (Sleper and West 1996; Wasser 1982). Annual nitrogen applications are required when tall fescue is seeded without legumes.

Wildland sites in mountainous areas are seeded in late fall or early summer. The resulting stands are competitive and persistent when established, but they may be somewhat slow to develop. New seedings should not be grazed until plants are well established

Uses and Management

Tall fescue seedings provide pasture or hay in irrigated fields in valleys of the Intermountain region. They are particularly useful on saline and heavy alkaline soils where few other grasses can be seeded (Arnow 1987). The species is persistent, palatable, moderately to highly productive, and compatible with a variety of management programs (Hanson 1979). Tall fescue can be grown with selected legumes if managed carefully (Wasser 1982). When grown alone, it requires added nitrogen and irrigation to maximize productivity (Thornburg 1982). Tall fescue is tolerant of periodic or continuous grazing and can be grazed or mown to a 2- to 4-inch (5 to 10 cm) stubble height (Plummer and others 1968; Wasser 1982). Grazing should be applied evenly to maintain a uniform stand. Frequent grazing improves palatability, induces new tiller production, and maintains a dense sod (Wasser 1982). Stands are more resistant to trampling than most pasture grasses.

Tall fescue provides a long grazing season. It receives greatest use in spring and early summer when leaves are young. Its productivity and palatability are greatly reduced in late summer when the leaves become coarse (Hassell and others 1983). Summer and fall growth retain digestibility and crude protein content better than many cool-season grasses (Matches 1979). Leaves remain green and provide good-quality fall and winter forage for livestock. Tall fescue provides excellent quality hay (Jensen and others 2001). Tall fescue increases over time when planted with other pasture grasses due to its lower palatability (Jensen and others 2001). Cutworms, slugs, and grasshoppers can reduce yields.

Tall fescue has been seeded to provide forage in mountain meadows and in openings in aspen and conifer forests (Vallentine 1971). It is used by elk and deer, but its palatability to big game is generally low. Seeds are consumed by songbirds, and the seeds and foliage are used by small mammals. Sodforming cultivars are used to stabilize soils on road cuts and fills, and disturbances in riparian areas and recreational areas, and to provide cover crops. Fertilizer applications may be required when using the species on infertile soils (Vallentine 1967).

Varieties and Ecotypes

‘Alta’ and ‘Fawn’ were developed from European material (Alderson and Sharp 1994) and are adapted to valley bottoms where they are seeded as pasture grasses and for the renovation of saltgrass sites. Both varieties are also used for soil stabilization and forage production in semiwet meadows of upper elevation areas and in openings in aspen and conifer forests. They require at least 16 inches (410 mm) of annual precipitation. Both green up early in spring. They are compatible with other species and can be included in mixtures.

Several tall fescue varieties have been developed for hay and pasture forage production. These include 'Barcel', 'Barvetia', 'Cajun', 'Courtenay', 'Dovey', 'Festorina', 'Fuego', 'Georgia No. 5', 'Goar', 'Kentucky 31', 'Martin', 'Maximize', 'Mozark', 'Penngrazer', 'Phyter', 'Southern Cross', 'Stargrazer', and 'Stef' (Alderson and Sharp 1994). None of these varieties have proven adapted to mountain rangeland conditions. There are a number of other varieties that have been bred for use as turf grasses.

Festuca idahoensis
Idaho Fescue or Bluebunch Fescue

Synonyms

Festuca ovina var. *ingrata*
Festuca ingrata
Festuca occidentalis var. *ingrata*
Festuca ovina var. *oregona*
Festuca ingrata var. *nudata*
Festuca ovina var. *nudata*

Description

Idaho fescue is one of the most common bunchgrasses in the West. It is a densely tufted nonrhizomatous, long-lived perennial bunchgrass with hairless to roughened culms that grow 1 to 3.3 ft (3 to 10 dm) tall (fig. 33). Leaves are numerous, fine, and mostly basal, forming a tuft 6 to 12 inches (15 to 30 cm) tall that is usually more than half the length of the culms. Leaf blades are firm, involute, less than 0.04 inch (1 mm) wide, and without auricles. Ligules are mostly 0.01 to 0.02 inch (0.3 to 0.6 mm) long, finely ciliate, and longer on the sides than at the center. Panicles are 1.9 to 5.9 inches (5 to 15 cm) long, loosely compressed, and extending mostly from one side of the rachis. Spikelets are 0.31 to 0.51 inch (8 to 13 mm) long and four to seven flowered with visible joints on the axis of the spikelet. Glumes are narrowly lanceolate and taper to a pointed or rounded apex. The first glume is 0.10 to 0.18 inch (2.5 to 4.5 mm) long, the second is 0.16 to 0.22 inch (4 to 5.5 mm) long. Lemmas are 0.20 to 0.28 inch (5 to 7 mm) long, rounded, and glabrous to roughened distally. Awns are 0.08 to 0.24 inch (2 to 6 mm) long. Plants flower from May to August (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Idaho fescue is very closely related to *Festuca ovina*. Some authors regard it as the native, low-elevation phase of that species and apply the name *F. ovina* var. *ingrata*.

Figure 33—Idaho fescue is one of the most important cool-season bunchgrasses in the West (RMRS photo).

Ecological Relationships and Distribution

Idaho fescue ranges from Southwestern Canada south to northern California and east from central Montana to northern New Mexico (Tisdale 1959). It occurs at elevations ranging from 800 to 12,000 ft (244 to 3,659 m) on sites receiving 15 to 30 inches (380 to 760 mm) of annual precipitation (Daubenmire 1966). On north slopes and cool areas receiving added moisture it may grow where annual precipitation is as low as 10 inches (254 mm). Idaho fescue occurs over a wide environmental gradient and is associated with a range of soil conditions and plant communities. It grows on dry, well-drained, fertile, moderately deep soils ranging from clayey or silty to sandy and gravelly loams that are slightly acidic to slightly alkaline (USDA Forest Service 1937; Wasser 1982; Vallentine 1971). It also occurs on shallow, rocky soils and on weakly saline soils where its productivity is lower. Plants are cold tolerant and moderately drought tolerant, but they are not tolerant of high water tables or flooding. Idaho fescue is a common or codominant species in grasslands, sagebrush-grass, mountain mahogany, oakbrush, mountain brush, pinyon-juniper, antelope bitterbrush, mountain meadow, conifer, riparian, and alpine communities (Zouhar 2000). It occurs on meadows, plains, foothills, ridgetops, mountain brush communities, and open conifer forests. The species occurs in open areas, but it is also moderately shade tolerant. Associated species are big sagebrush, Sandberg bluegrass, bluebunch wheatgrass, and many native forbs. In lower elevation and drier communities, the distribution of Idaho fescue is restricted to areas with better availability of water (Johnson 1994). Many Idaho fescue sites have been invaded by cheatgrass (Wasser 1982).

Seedlings may emerge in fall and develop during favorable periods in winter and spring to the point that the plants can become dormant and survive summer drought (Daubenmire 1975b). Idaho fescue begins growth in March or April, and seeds mature in mid to late summer depending on location and altitude. Plants become dormant during summer, but resume growth in fall if adequate moisture is received (Wasser 1982). Reproduction is by seed and tillers (Stubbendieck 1992). Plants produce shallow, fibrous root systems. Goodwin and others (1996) found that about 40 percent of the root biomass occurs in the upper 4 inches (10 cm) of soil. Roots are associated with vesicular-arbuscular mycorrhizae (Goodwin 1992; Ho 1987).

Idaho fescue can be damaged by wildfires at any season (Smith and Busby 1981; Wright and others 1979). Cool fires burning through stands with little litter buildup may cause minimal damage. However, the fine leaves and accumulation of litter can result in prolonged high-temperature burning that may kill or damage the root crown (Agee 1996), with the extent of damage dependent upon fire conditions, fire history of the site, extent of grazing, and other factors (Bunting 1984; Wright and others 1979). Rate of postfire recovery varies considerably among burns and depends on the degree of plant damage and environmental factors (Beardall and Sylvester 1976; Harniss and Murray 1973), with response to season of burn variable. Surviving plants recover through tillering if soil moisture permits. Both protein content and digestibility of Idaho fescue increase temporarily following burning (Beardall and Sylvester 1976; Singer and Harter 1996). Fires near the margins of the species range are damaging at any season (Blaisdell 1953; Wright and others 1979); fires in dry environments tend to reduce productivity for longer periods because the shallow root systems are heavily damaged. Seedling establishment is reduced following burns, likely due to reduction of the seed bank when temperatures exceed 257 °F (125 °C) for more than 5 minutes (Warg 1938). It is not clear whether early- or late-season burning best protects Idaho fescue plants, but Wright (1974) recommended burning when species of concern are dormant and not stressed by drought. Bunting and others (1998) found that deferring grazing for at least 1 year following burning improved recovery of Idaho fescue.

Plant Culture

Variable and often low seed production and viability in wildland stands has limited the use of Idaho fescue in wildland seedings (Ensign and others 1984; Wasser 1982). Overcoming this problem has been a major emphasis in plant selection work with the species; two cultivars are now available. Lodging is not normally a problem in seed fields. Harvesting is accomplished by swathing before seed shattering occurs in early to midsummer. Seed can be combined when in the hard-dough stage. Yields are about 300 pounds per acre (336 kg per ha) from irrigated fields and 100 pounds per acre (112 kg per ha) from nonirrigated fields. A debearder will remove awns; seeds are cleaned using a fanning mill (Smith and Smith 1997). There are about 425,000 to 460,000 seeds per pound (937,000 to 1,014,100 per kg) (Ensign and others 1984). Recommended quality standards are 90 percent purity and 80 percent germination (Wasser 1982). Seeds undergo afterripening over a period of at least 6 months (Goodwin and others 1996), thus germination is delayed until seeds have gone through at least one winter. Idaho fescue can be germinated by incubating the seeds at 50/68 °F or 68/86 °F (10/20 °C or 20/30 °C) (16/8 hrs) (Haferkamp and McSwain 1951). Exposure to light improves germination (Haferkamp and McSwain 1951).

Idaho fescue is fall seeded on drier sites by broadcasting or drilling on a firm seedbed. Seed should be planted about 0.5 inch (1.3 cm) deep. In irrigated seed fields or on low-elevation wildland sites that receive reliable moisture it can be spring seeded. Dry sites are fall seeded. At high elevations it can be spring or early summer seeded as soon as the site is open.

In seed fields, drilling into stubble or planting in alternate rows with annual grains may establish seed fields. Fallowing also reduces weed populations. Row spacings of 30 to 36 inches (76 to 92 cm) are recommended for seed fields (Wasser 1982). Expected stand life is about 5 years (Smith and Smith 1997).

Vigor of seedlings is poor to fair (Shaw and Cooper 1973; Vallentine 1971), and they are not competitive with seedlings of more aggressive species (Hafenrichter and others 1968). Stands require 2 to 3 years to establish (Hafenrichter and others 1968; Plummer and others 1968), and weeds must be controlled in seed fields. Grazing should be restricted until stands are established (Ensign and others 1984); grazing pressure must be carefully controlled to maintain stands. Resting during the season or grazing on a rotational basis may be required (Hormay and Talbot 1961). Seedlings are susceptible to attacks by damping off and other seedling diseases, grasshoppers, and rodents (Wasser 1982). Competitive ability increases considerably as Idaho fescue stands mature. When seeded on erosive sites, addition of mulch may be required to stabilize the surface soil until plants become established (Hafenrichter and others 1968).

Uses and Management

Idaho fescue is very palatable and heavily used by livestock and wildlife. It is a particularly valuable species at mid to higher elevations in sagebrush grasslands, open conifer forests, and alpine areas.

Greatest use is received in spring when the forage is succulent and palatable, but use, particularly by sheep, declines later in the season as the forage becomes coarse and dry. Animals will continue to use it if other forage is not available. Plants cure well and provide good fall and winter forage where accessible (Shaw and Cooper 1973). The species withstands some use, but stands are weakened or lost with excessive grazing and trampling, particularly in early spring. Stands maintained in healthy condition will reseed themselves. Deer use Idaho fescue in spring (Johnson 1994), and elk use it throughout the year (Dragt and Havstad 1987; Kufeld 1973; Shaw and Cooper 1973).

Idaho fescue can be planted alone or in mixtures with other native grasses to provide diversity. Although not deep rooted, it produces an extensive, fibrous root system that provides soil stabilization and ground cover on disturbances resulting from logging, road construction, mining, and recreation (Ensign and others 1984; Hafenrichter and others 1968). It can be seeded in areas where tree seedlings have been planted if the seeding rate is low to moderate (Ensign and others 1984). Mature stands withstand or slow the spread of invasive species (Borman and others 1990; Hafenrichter and others 1968; Lilley and Benson 1979).

Varieties and Ecotypes

The varieties ‘Joseph’ and ‘Nezpurs’ were developed from material collected in the Northwestern United States and Southwestern Canada (Ensign and others 1984). They are adapted to elevations ranging from 1,000 to 9,000 ft (305 to 2,745 m) and communities ranging from sagebrush grass to subalpine that receive 14 to 30 inches (355 to 760 mm) of annual precipitation. Both varieties are cold and drought hardy and moderately shade tolerant. They are best adapted to silty to sandy loam soils that are slightly alkaline to slightly acidic. They do especially well in ponderosa pine and mountain big sagebrush communities on gravelly to well-drained loamy soils. Joseph and Nespurs are seeded on summer ranges to provide forage for livestock and wildlife and soil stabilization on road cuts and fills, skid trails, cutover forest areas, and recreational sites. These varieties perform well as components of seeding mixes because they are not overly competitive.

Joseph was selected for its greater leaf and culm height (28 to 31 inches [72 to 80 cm]), basal leaf growth, and good germination (Ensign and others 1984). Nezpurs was selected for its shorter stature, 20 to 28 inches (50 to 70 cm), large seed size, productivity, basal leaf growth, and olive-green color. Both varieties have been seeded in the Intermountain West, especially in Idaho, Wyoming, eastern Oregon, and western Colorado. Nezpurs has received more use than Joseph.

Festuca ovina Sheep Fescue or Alpine Fescue

Synonyms

Festuca brevifolia
Festuca minutiflora
Festuca saximontana

Description

Sheep fescue is a short, matforming perennial with dense tufts of basal leaves. Culms are 0.3 to 1.6 ft (0.8 to 5 dm) tall. The tufts are 2.0 to 5.9 inches (5 to 15 cm) tall and generally about half the height of the culms. Sheaths are glabrous to minutely hairy. Leaf blades are stiff, involute, and without auricles. Ligules are scarcely 0.02 inch (0.4 mm) long, finely ciliate, and longer on the sides than at the center. Panicles are 0.6 to 3.95 inches (1.5 to 10 cm) long, mostly strongly compressed, but somewhat open in *F. o.* var. *ovina*. Spikelets are 0.16 to 0.35 inch (4 to 9 mm) long and two to five flowered. Glumes are narrowly to broadly lanceolate. The first glume is 0.08 to 0.14 inch (2 to 3.5 mm) long and one nerved. The second is 0.12 to 0.18 inch (3 to 4.5 mm) long and three nerved. Lemmas are 0.14 to 0.24 inch (3.5 to 6 mm) long, glabrous or minutely hairy toward the tip. Awns are 0.04 to 0.20 inch (1 to 5 mm) long. Sheep fescue flowers in July through August and disperses its seed from August to October. Reproduction is solely by seed due to the absence of rhizomes (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Ecological Relationships and Distribution

Sheep fescue is a widespread, polymorphic circumboreal species with many varieties, some of which have been treated on the specific level. In North America, sheep fescue is distributed southward from the arctic region through mountainous areas to California, and east to northern New Mexico, Kansas, and North Carolina. The species also occurs in Mexico and South America. Plants of the two native varieties are small and occur in rocky areas and on shallow, gravelly soils, and dry exposed sites on slopes and ridges. They require annual precipitation of 8 to 14 inches (20 to 36 cm) or more (Arnow 1987), and may be abundant in communities from sagebrush to pinyon-juniper, mountain brush, aspen, conifer, and mountain grassland communities. *F. o.* var *rydbergii* is distributed from foothill to subalpine areas and *F. o.* var. *brevifolia* occurs in subalpine and alpine habitats (Cronquist and others 1977).

The three varieties commonly seeded are all European in origin: sheep fescue, hard sheep fescue) (fig. 34), and sulcate sheep fescue (fig. 35). Sheep fescue is distinguished by its open and spreading panicle. Hard sheep fescue has leaf blades that are smoother, wider, and firmer than those of sulcate sheep fescue.

Sheep fescue is a long-lived, drought-hardy variety. It grows on coarse, dry, infertile soils on sites receiving 10 to 18 inches (25 to 46 cm) of annual precipitation (Jensen and others 2001). Sheep fescue is cold tolerant and provides stability to surface soils. It is somewhat tolerant of finer soils and shading. Hard sheep fescue is seeded on sites receiving 15 inches (38 cm) or more of annual precipitation (Wasser 1982) to stabilize soils and revegetate disturbances. It is used for roadway plantings, airports, and other sites where a competitive, low-growing ground cover is required. Although seedlings are slow to establish, plants are long lived and become competitive as they develop through the growth of abundant fibrous roots. Forage production is low, but of fair to good quality (Hassell and others 1983). Sheep fescue is adapted to shallow, moderately to well-drained soils with pH 5.5 to 7.5. Plants are heat tolerant.

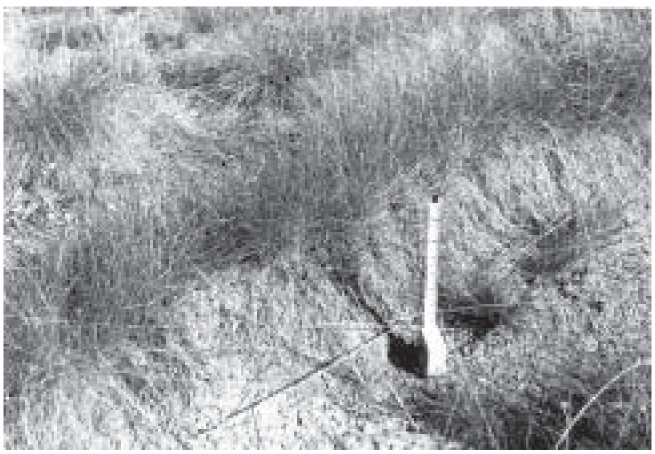

Figure 34—Hard sheep fescue plants are upright, leafy, and slightly taller than those of sulcate sheep fescue (RMRS photo).

Figure 35—Sulcate sheep fescue grows as distinct fine-leaved clumps (RMRS photo).

Plant Culture

Sheep fescue seeds ripen in early fall (Sampson 1924). They can be combined directly or first windrowed and dried for 5 to 7 days (Smith and Smith 1997; Wheeler and Hill 1957). Lodging is generally not a problem, but seeds begin shattering after reaching the hard-dough stage (Smith and Smith 1997). Seed is cleaned using a debearder and fanning mill. An indent cylinder may be used to increase purity. Seeds are not generally harvested during the establishment year. Stand life is 4 to 5 years. There are about 500,000 seeds per pound (1,100,000 per kg) (Smith and Smith 1997).

Seed fields can be planted in fall or spring (Jensen and others 2001; Plummer and others 1968). Seeds are easily handled. They should be planted about 0.25 to 0.5 inch (0.6 to 1.5 cm) deep (Horton 1989; Plummer 1943) on a firm seedbed. Rows should be 12 or 24 inches (30 to 60 cm) apart in irrigated fields and 36 inches (90 cm) apart on drylands (Smith and Smith 1997). Wildland sites are drill seeded or broadcast. Dry sites are best seeded in fall. More mesic areas can be spring seeded. Seedlings are not highly vigorous, and establishment occurs over a 2- to 3-year period as plants develop extensive fibrous root systems. On wildland sites, sulcate sheep fescue is more compatible with other species than hard fescue and can be included in mixtures. Plants are not tolerant of highly saline or alkaline soils (Jensen and others 2001); they are useful on dry, sandy, or rocky sites (USDA Forest Service 1937) where other components of the mixture may not establish well. Mature plants are persistent due to development of an extensive fibrous root system. Plantings reduce the spread of weeds and are tolerant of grazing if properly managed. Excessive grazing can damage the stands; recovery is slow (Jensen and others 2001).

Uses and Management

Sheep fescue has been seeded successfully throughout the Intermountain West in mountain big sagebrush and mountain brush communities and in openings in aspen and subalpine communities that receive 14 inches (355 mm) or more of annual precipitation. Its seedlings are slow to establish, but tenacious. The extensive root system of mature plants makes them competitive and fairly resistant to drought and trampling. Sheep fescue greens up early in spring and receives some use by livestock, particularly sheep. Grazing should be regulated to leave a 2- to 4-inch (5 to 10 cm) stubble (Jensen and others 2001).

Sheep fescue is used for postfire seedings, mined land reseedings, recreation areas, ditchbanks, and other disturbances in mountainous areas to reduce soil erosion. Baron (1962) found conifer seedling survival was not decreased on areas planted with sheep fescue relative to controls. Sheep fescue is used in lawn seed mixtures and is particularly useful on infertile or sandy soils.

Varieties and Ecotypes

'Covar' sheep fescue originated near Konya, Turkey (Alderson and Sharp 1994). A fine-leaved fescue, it was selected for erosion control and revegetation of disturbed sites and depleted communities. It is adapted to shallow, gravelly, and well-drained soils that receive at least 8 inches (203 mm) of annual precipitation (Wasser 1982). Covar has been seeded successfully in mountain big sagebrush, upper mountain brush, ponderosa pine forests, and aspen openings. It requires fall seeding, and it is slow to establish. Mature plants are persistent, competitive, winter hardy, and drought tolerant. The variety is competitive and will spread to dominate a community.

'Durar' hard fescue, a larger plant of European origin (Alderson and Sharp 1994), is adapted to well-drained, basic to moderately acidic soils of pinyon-juniper, mountain brush, ponderosa pine, aspen, and conifer forests receiving 14 to 28 inches (300 to 700 mm) of annual precipitation. The variety was developed for soil stabilization and forage production. Durar is somewhat slow to establish, but mature stands spread aggressively and outcompete most native and some introduced grasses, forbs, and shrubs.

Hilaria jamesii
Galleta or Curly Grass

Synonyms

Hilaria sericea

Description

Galleta is a strongly rhizomatous or stoloniferous perennial warm-season grass with a dense, fibrous root system. Rooting depth is about 12 inches (30 cm). Culms are 0.5 to 2.1 ft (1.5 to 6.5 dm) tall and grow horizontally along the ground before turning upward (fig. 36). Nodes of the culms are often finely hairy. Leaves are mostly basal with hairless to minutely roughened sheaths, and a few shaggy hairs at the throat. Leaf blades are short and curly, flat to folded, 0.06 to 0.12 inch (1.5 to 3 mm) wide, 0.8 to 2 inches (2 to 5 cm) long, and involute toward the tip. They are rigid, hairless to roughened, often waxy, and sometimes covered with small stiff hairs. Ligules are 0.04 to 0.10 inch (1 to 2.5 mm) long with lacerate, long-ciliate margins. Spikes are 0.08 to 0.28 inch (2 to 7 mm) in length with long, shaggy hairs at the base of the spikelet clusters. Glumes of the lateral spikelets are subequal, roughened, and 0.20 to 0.33 inch (5 to 8.5 mm) long with an irregularly lacerated apex. The first glume is asymmetrical with the midnerve displaced to one side; awn length is 0.12 to 0.22 inch (3 to 5.5 mm). The second glume is awnless, or very short awned. Glumes of the central spikelet are subequal and 0.16 to 0.26 inch (4 to 6.6 mm) long with stiff hairs. The nerves in the glumes extend into an irregular awn that measures 0.06 to 0.28 inch (1.5 to 7 mm) in length. Lemmas of the lateral and central spikelets are 0.18 to 0.35 inch (4.5 to 9 mm) long, lanceolate, and blunt tipped. They are hairless basally, roughened apically, and three nerved. The single lemma of the central spikelet is narrowly lanceolate and bears a dorsal awn from below the notched apex (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Galleta is sometimes referred to in older literature as black grama. This common name is misleading, giving the impression that it belongs to the genus *Bouteloua*. Galleta flowers from May to August. Chromosome number is 2n = 2x = 36 or 38 (Arnow 1987).

Figure 36—A strongly rhizomatous or stoloniferous species, galleta stems grow along the ground before bending upward (RMRS photo).

Ecological Relationships and Distribution

Galleta is the most northerly distributed species of its genus (Heizer and Hassell 1985). Its range extends from southeastern California and southern Nevada across Arizona and southern Utah to Wyoming, New Mexico, Kansas, Texas, and the Oklahoma Panhandle (Heizer and Hassell 1985). It grows from dry desert scrublands of lower valleys to mesas, plains, and pinyon-juniper woodlands of foothills. Galleta often grows in association with blue grama in sagebrush areas, often as the dominant species. It occurs from the valleys to the lower ponderosa pine zone at elevations from 4,000 to 8,000 ft (1,220 to 2,439 m) (USDA Forest Service 1937; Wasser 1982). It is particularly common and frequently dominant on the plains of New Mexico. It grows with shadscale on salt desert shrub sites in the Great Basin and on sandy and rocky sites in the Colorado Plateau. It also occurs in creosote bush and desert shrub communities in the Southwest.

Galleta grows on sites receiving 6 to 18 inches (150 to 460 mm) of annual precipitation with soils ranging from coarse to fine and pH of 6.6 to 8.4 (Bridges 1942; Horton 1989; USDA Natural Resources Conservation Service 2003; Stefferud 1948). Plants have a low requirement for soil fertility (USDA Natural Resources Conservation Services 2003); tolerance of salinity and alkalinity varies among populations. Plants are drought and cold tolerant, but not shade tolerant. Galleta is moderately fire tolerant and usually recovers by the second year following burning (Arnold and others 1964).

Plant Culture

Galleta initiates growth in spring if adequate moisture is received (Wasser 1982). If summer rains occur, it may mature two seed crops. The first crop can be harvested in June and the second in August to October. Many florets in wildland stands do not produce seed, thus costs of wildland collections are high. The release, 'Viva', was selected for its high percentage of seed-bearing florets (Heizer and Hassell 1985). Native and domestic seed fields can be harvested by combining (Wasser 1982). Seed is cleaned by hammermilling and fanning. Recommended purity is 20 to 40 percent and germination 80 to 98 percent for seed sales. There are about 170,000 seeds per pound (374,780 per kg). Seeds do not require prechilling. They can be incubated at 68/86 °F (20/30°C) (16/8 hrs) to test germination (Haferkamp and McSwain 1951). Exposure to light is required. Seeds are nondormant and will germinate under a range of constant and alternating temperatures (Knipe 1967).

Seed should be planted during the most reliable period of rainfall, usually early summer (Link 1993). Seed is planted about 0.5 to 1 inch (1.3 to 2.5 cm) deep using drills designed to plant chaffy seed. Seed may be broadcast, but it must be covered. Light irrigation helps to increase germination and establishment in seed fields.

Wildland stands may be established using water catchment techniques such as deep furrow drilling to aid stand establishment on dry sites. Rate of seedling development is slow to moderate and stand establishment may require 2 years or more. Seedlings are drought and cold tolerant, but they are susceptible to attacks by rodents and grasshoppers (Wasser 1982). Galleta is adapted to fine, sometimes saline soils that limit seedling establishment of many species. It can be seeded in mixtures with other species adapted to such sites. Grazing should be avoided during one or more growing seasons to permit stand establishment (Merkel and Herbel 1973).

Uses and Management

Galleta produces considerable nutritious forage and withstands heavy grazing and drought. It is palatable in pure stands, but receives less use when mixed with more palatable grama grasses. When grazed heavily, such mixtures gradually shift toward a dominance of galleta. Galleta provides good, moderately palatable forage for livestock and wild ungulates during the summer growing season. Regrowth is good following summer rainfall, but regrowth following fall rains or frost is more limited. Dormant plants are dry, tough, and unpalatable (Heizer and Hassell 1985; Vallentine 1971; West 1972). Plants receive little use in late fall or winter. Although galleta is resistant to grazing, excessive use results in reduced forage and rhizome production (Heizer and Hassell 1985).

Galleta is seeded to provide forage, soil stabilization, and watershed protection (Wasser 1982). Spread from seed is slow, but the woody rootstocks that sometimes grow to 6 or 7 ft (1.8 to 2.1 m) in length permit vegetative spread. They also protect plants from trampling damage and hold soils in erodible areas. Plants are bunchy and do not form a continuous sod. Galleta is extremely drought resistant and provides a persistent vegetative cover in adapted areas.

Varieties and Ecotypes

Viva was collected from a population near New Kirk, NM, on a site at 5,740 ft (1,750 m) elevation that receives an average of 9 inches (230 mm) of annual precipitation (Alderson and Sharp 1994). It exhibits good seedling vigor and drought and cold tolerance. Viva provides forage for livestock and big game. It is also used to revegetate mined lands and other disturbances. It is seeded in extreme southern Utah and Colorado, northern Arizona, and northwestern New Mexico. It has done well when seeded with other warm-season grasses on the Great Plains from Mexico to the Canadian border. It has not established or persisted well in the Great Basin.

Koeleria macrantha
Prairie Junegrass

Synonyms

Koeleria cristata
Poa cristata
Aira cristata
Koeleria gracilis
Koeleria nitida

Description

Prairie junegrass was originally and erroneously named and described as *K. cristata*, based on a specimen of *Poa cristata*. The oldest valid name is believed to be *K. macrantha*; however, Cronquist and others (1977) prefer to use the oldest New World name, *K. nitida*. Junegrass can be distinguished from *Poa fendleriana* and *Trisetum wolfii* by its hairy panicle axis and generally smaller spikelets. It is often found in association with these grasses.

Prairie junegrass is a cespitose perennial bunchgrass with culms 0.6 to 2.2 ft (2 to 6.5 dm) tall. Most leaves are basal, but a few small leaves are produced on the culms. Sheaths are stiff haired or rarely hairless. Leaf blades are usually folded or involute, 0.04 to 0.10 inch (1 to 2.5 mm) wide, and stiff haired to hairless. Ligules are 0.02 to 0.08 inch (0.5 to 2 mm) long, irregularly lacerate to subentire, minutely ciliate, and sometimes sparsely short hairy. Panicles are 1.0 to 5.9 inches (2.5 to 15 cm) long, contracted, and spikelike with short, appressed branches (fig. 37). The spike axis is densely short hairy. Spikelets are 0.16 to 0.20 inch (4 to 5 mm) long and two to four flowered. Spikelet axes are silky haired. Glumes are subequal and roughened on the keel and sometimes throughout. The first glume is 0.11 to 0.20 inch (2.8 to 5 mm) long, lanceolate to narrowly lanceolate, and one nerved. The second glume is 0.13 to 0.22 inch (3.2 to 5.5 mm) long, lanceolate, and one to three nerved with the lateral nerves barely visible. Lemmas are about as long as the second glume, lanceolate, and five nerved with the lateral nerves obscure. They are roughened and sometimes bear a short awn near the tip. Flowering occurs in June and July (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Ecological Relationships and Distribution

Prairie Junegrass is the only species of *Koeleria* native to Western North America. It ranges from southern Ontario to British Columbia and southward to Texas, California, and Washington. It is one of the most common and widely distributed of the western grasses, extending over a wide range of altitudes and growing on a variety of dry to moist clay loam to sandy or sometimes rocky soils with pH 6.5 to 8.0 (Hassell and others 1983). Junegrass is an important mid- to late-seral forage species of the sagebrush, mixed grass, and open timber types (Coupland 1950). It requires 16 to 21 inches (41 to 53 cm) of annual precipitation, and is usually found at elevations of 5,000 to 8,000 ft (1,524 to 2,438 m) (Parker 1975). The species does not yield a great deal of forage, as it is low growing with abundant but short and mostly basal leaves. Prairie junegrass begins growth from seed or established plants very early in the season (Simonin 2000). Seed is dispersed from July to September. The generally low seed viability is counterbalanced by abundant production (Arnow

Figure 37—Prairie Junegrass panicles are spikelike with short-appressed branches (photo courtesy of John Kinney, USDA FS, Rocky Mountain Research Station, Boise, ID).

1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Plants are cold, heat, and drought tolerant (USDA Natural Resources Conservation Service 2003).

Prairie junegrass production is improved by spring or fall burns when adequate soil moisture is available, and effects may be long lasting (Blaisdell 1953). Late spring burns are most damaging (Towne and Owensby 1984). Plants are small and clumped with the growing points near the soil surface; thus, they burn rapidly with little heat transfer (Young 1983). Recovery is from the crown or from seed.

Plant Culture

Native stands of prairie junegrass are collected by hand stripping, while cultivated fields can be combined or swathed and combined (Smith and Smith 1997). Lodging and shattering are not generally problems with this species. The seeds are small, but readily cleaned using an air-screen machine. Seed yields on irrigated land average 150 pounds per acre (168 kg per ha) and 75 pounds per acre (84 kg per ha) on nonirrigated land (Smith and Smith 1997). There are about 2,315,000 seeds per pound (5,090,000 per kg) (Smith and Smith 1997). Blake (1935) found viability of seed kept in dry storage decreased from 21 percent after 3 years to 7 percent after 6 years (Blake 1935).

Prairie junegrass should be planted about 0.25 to 0.50 inch (0.6 to 1.3 cm) deep on a firm seedbed in fall. Seed fields and upper elevation sites are planted in early spring. Seed may be planted by drilling or broadcasting. Seed fields should be planted at 1 pound per acre (1.1 kg per ha) in 24-inch (60-cm) rows, 2 pounds per acre (2.2 kg per ha) in 12-inch (30-cm) rows, and 0.75 pound per acre (0.82 kg per ha) for 36-inch (90 cm) rows (Smith and Smith 1997). Direct seeding and seedling transplanting has produced poor results in seed fields; however, transplanting 1-year-old plants has been more successful (Nuzzo 1978). Commercial growers do not grow junegrass often because they are unable to acquire large amounts of native seed (Hassell and others 1983). Available native seed is frequently of poor quality, as it is generally harvested from wildland sites. Use of locally adapted material may be essential for reestablishment of healthy stands (Simonin 2000). Some European material is now being marketed in the United States.

Junegrass may be useful for reestablishing vegetation resistant to annual weed encroachment and invasion, largely due to the early spring emergence of its seedlings. This species does well in colonizing disturbed soils, and seedling emergence and survival are not affected by competition with Japanese brome (Romo and Eddleman 1987; Simonin 2000). However, plugs of prairie Junegrass were unable to compete with medusahead, dogtail, bulbous bluegrass, ripgut brome, or yellow starthistle (Borman and others 1991). In irrigated seed fields the plants grow relatively slowly compared to weeds (Smith and Smith 1997). Established plants are long lived (Hassell and others 1983).

Uses and Management

All classes of wildlife and livestock utilize prairie junegrass with greatest use early in the season (Rose and others 1998). It provides good-quality early spring forage due to its rapid development, but palatability decreases during seed production (Vallentine 1961). Prairie junegrass is a key winter food source for animals of the British Columbian prairies (Blower 1982). Although utilized by whitetail and mule deer, prairie junegrass is not a primary source of forage because of its scattered distribution.

Prairie junegrass can be used to revegetate highly disturbed areas (Redmann and Schwarz 1986). Studies of succession in the Piceance Basin of northwestern Colorado (Biondini and others 1985) and Wood Buffalo National Park, Alberta (Redman and Schwarz 1986), showed that prairie junegrass increased following soil disturbances. The species has been included in seed mixes designed to restore disturbed fescue communities in Glacier National Park (Laycock 1967).

Varieties and Ecotypes

There are no releases.

Oryzopsis hymenoides Indian Ricegrass

Synonyms

Achnatherum hymenoides
Stipa membranacea
Stipa hymenoides
Oryzopsis membranacea

Description

Indian ricegrass is a densely tufted perennial bunchgrass with a deep, fibrous root system. Culms are hollow, thick walled, and 0.7 to 2.8 ft (2 to 8.5 dm) tall. Leaf sheaths are persistent and glabrous to minutely hairy. Old sheaths are fibrous and papery, sometimes becoming partly buried on sandy sites. Ligules are 0.10 to 0.30 inch (2.5 to 7.5 mm) long, entire to lacerate along the margins, and abruptly tapering at the apex. Leaf blades are smooth, strongly involute, about 0.04 inch (1 mm) wide, and nearly as long as the culms. Panicles are 2 to 7.5 inches (5 to 19 cm) long with the branches and hairlike branchlets paired, lacey, and spreading widely at maturity. Glumes are ovate, fine hairy to nearly hairless, translucent along the margins, and tapering to a point or short awn up to 0.08 inch (2 mm) long. The three or sometimes five nerves are prominent near the base, but become indistinct toward the apex. Length of the first glume is 0.18 to 0.31 inch (4.5 to 8 mm), and the second is 0.17 to 0.30 inch (4.2 to 7.5 mm). Lemmas are 0.10 to 0.20 inch (2.5 to 5 mm) long, subglobose to fusiform, hard, thickened, shiny, and dark brown or nearly black when mature. They are densely silky haired with the hairs nearly exceeding the glumes. Awns are 0.12 to 0.22 inch (3 to 5.5 mm) long, straight, and readily deciduous. Paleas resemble the lemmas (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Plants flower from May through August. Indian ricegrass is largely self-fertile, particularly in hot weather. Its chromosome number is 2n = 2x = 48 (Johnson and Rogler 1943). Indian ricegrass is the state grass of Utah and Nevada (USDA Natural Resources Conservation Services 2002). It was named for its large, high protein seeds that were used by Native Americans to make flour.

Arnow (1987) transferred Indian ricegrass from *Oryzopsis* to *Stipa* based on similarities in embryological characteristics and floral structures and natural hybridization between the two genera. More recently, Barkworth placed the species in *Achnatherum* (Barkworth and Everett 1987; Hickman 1993).

Ecological Relationships and Distribution

Indian ricegrass is one of the most common grasses on semiarid and arid lands of the West. It is distributed across Western North America from British Columbia to southern California and Mexico and eastward to Manitoba, the Dakotas, and Texas (Arnow 1987; Stubbendieck and Jones 1996). It is one of the most drought-tolerant native range grasses (USDA Forest Service 1937), occurring on sand dunes and dry, sandy soils of valley bottoms where it often forms dense stands. Indian ricegrass is a dominant or associated species in creosote bush, salt desert, big sagebrush, black sagebrush, pinyon-juniper, ponderosa pine, and mixed-grass prairie communities (Jensen and others 2001; Plummer and Frischknecht 1952; Young and Evans 1984). It also grows scattered among other vegetation on high grassy plains, foothills, exposed ridges, and dry, sandy or rocky mountain slopes.

Indian ricegrass can be found at elevations ranging from 2,000 to 10,000 ft (600 to 3,000 m) (Booth and others 1980; Wasser 1982) on sites receiving 6 to 16 inches (15 to 40 cm) of annual precipitation (Natural Resources Conservation Service 2002). Although it generally occurs on sandy soils on drier sites, it is found on soils ranging from sandy to heavy clays where precipitation is greater (Jones 1990; Platou and others 1986).

The growth cycle of Indian ricegrass is keyed to survival in dry and uncertain environments. Growth of mature plants is initiated at low temperatures in early spring (Pearson 1979). Leaves and flowers develop rapidly, and good seed crops mature prior to summer drought. Flowering may continue into summer in favorable precipitation years (Jones and Nielson 1989; Stoddart and Wilkinson 1938). Plants adapt to unstable sandy soils by developing adventitious roots from elongating basal internodes (Stoddart and Wilkinson 1938). Fungal hyphae are associated with the root system (Robertson 1976), and the rhizosheaths fix nitrogen (Wullstein 1980).

Indian ricegrass is fire tolerant when dormant. Spring and early summer burns may be more damaging, but the effects of fire on the plant and its response to fire are not well documented. Recovery occurs through resprouting, tillering, or germination of seeds remaining in the soil seed bank or arriving from offsite (Everett 1987; West 1994; Wright 1985; Wright and others 1979).

Plant Culture

Rodent caching and burial of seeds by blowing sand provide appropriate microsites for natural regeneration (McAdoo and others 1983; Smigelski 1968). Long afterripening requirements may be met as seeds endure drought periods, permitting development of stands during wet periods (Jones and Nielson 1989).

Seed production of native stands varies by year and is dependent upon local weather conditions. In addition, flowering and seed ripening are indeterminate and seed dispersal is rapid (Robertson 1977). Consequently, only a portion of the seed crop may be harvested on any collection date. Narrow glume angle has been used as a factor for selecting genotypes that might disperse seeds more slowly (Whalley and others 1990). Much of the seed produced under arid conditions fails to fill, but remains on the plant; thus, production may be considerably less than anticipated (Stoddart and Wilkinson 1938; Stubbendieck and Jones 1996). In cultivated fields with irrigation, good seed yields are expected annually.

Seed may be harvested by hand collection from wildland stands or by swathing and combining (Wasser 1982). Planted seed fields are combined. Harvesting equipment such as brush harvesters for species with indeterminate flowering and fruit ripening may permit multiple harvests, thus increasing the total annual yield (Stubbendieck and Jones 1996).

Seed is cleaned using a barley debearder or hammermill. Air-screen machines remove the chaff. Seed is marketed at about 95 percent purity and 11 percent germination (Wasser 1982). A high percentage of the seed is usually dormant. There are about 159,000 seeds per pound (350,000 per kg) (Smith and

Smith 1997). Seed can be stored in a warehouse for 5 years (Plummer and others 1968).

Emergence and establishment of seeded stands of Indian ricegrass is slowed by complex seed dormancy (Jones 1990). Mechanical restraint imposed by the indurate lemma and palea restricts oxygen uptake. Physiological dormancy is strongest in newly harvested seed and decreases over time. Acid treatments and mechanical scarification have been applied to relieve mechanical dormancy, while use of old seed and moist prechilling treatments can reduce physiological dormancy. These treatments and combinations of these treatments, however, have not proven satisfactory for ensuring stand establishment (Jones 1990), and they are not easily applied on a large scale.

Seed dormancy in this species is further complicated by the presence of seed polymorphism (Jones 1990). The presence of two or more likely heritable seed types with differing germination requirements within a population serves as a natural survival mechanism. Seed polymorphism, however, also increases the difficulty of establishing uniform seeded stands.

Seeds should be fall planted in areas receiving primarily winter precipitation to provide exposure to cool, moist winter conditions that serve to reduce physiological dormancy (Smith and Smith 1997). Seed should be drilled 1 to 3 inches (2.5 to 7.6 cm) deep, or broadcast and covered to this depth. Seed may be planted up to 4 inches (10.2 cm) deep in very sandy soils (Wasser 1982). If pure stands are drill seeded, 5 to 10 pounds of pure live seed per acre (5.6 to 11.2 kg PLS per ha) should be applied (Allison 1988; Pawnee Buttes Seed, Inc. 2002). The rate should be increased for broadcasting. Natural variation in dormancy among seeds and seed types within a population often translates to erratic stand development.

Early growth is slow, and good weed control is required in agricultural fields to permit establishment of a good stand. Wildland seedings should not be conducted in areas where dense stands of cheatgrass or other weeds are likely to create considerable competition. Indian ricegrass should not be drill seeded with highly competitive species. Stands should be protected from grazing until they are well established because younger plants are easily uprooted. Stands develop slowly, but they are persistent once established (Wasser 1982). Wildland seedings spread well from seed if not grazed excessively (Plummer and others 1968).

Uses and Management

Indian ricegrass is highly palatable to wildlife and livestock (Beale and Smith 1970; Kufeld 1973; Lauer and Peek 1976). Plants are productive and the herbage cures well, providing a good energy source in winter (Cook and others 1954; Stubbendieck and others 1985; Young 1989) (fig. 38). Protein content of dry material is low during this period (Welch 1981), but some material near the base of the plants may remain green and more nutritious. The species is extremely important on winter ranges, such as salt desert shrublands where extensive stands occur (Young 1989). It is also valuable in late winter and early spring because it initiates new growth sooner than many associated species (Green and others 1951; Hutchings and Stewart 1953; Quinones 1981). Indian ricegrass is moderately resistant to grazing, but stands have been lost as a result of excessive use (Rogler 1960; Stubbendieck and others 1985). Deferment of livestock use in early spring may be required in some years to permit recovery of plants that have been grazed excessively and to permit seed production and dispersal. Summer dormant plants are more tolerant of use (Stubbendieck and others 1985).

Seeds of Indian ricegrass are large and high in protein. Big game, livestock, rodents, rabbits, birds, and other small animals seek them out (McAdoo and others 1989). Rodent gathering and caching of the seeds aids in dispersal and establishment of the species.

Because it is an early successional species, Indian ricegrass is frequently used to revegetate disturbed sites such as mine sites on sandy soils. It may be used alone or in mixtures. Although initial growth is slow,

Figure 38—Indian ricegrass is an extremely important forage species that remains nutritious through the winter (photo courtesy of John Kinney, USDA FS, Rocky Mountain Research Station, Boise, ID).

established plants provide canopy cover and develop extensive root systems that bind surface soils in areas where few other species may be adapted. Indian ricegrass is used for low-maintenance landscaping in recreational areas, on roadsides, and in parks and gardens. It is often used as an ornamental and in dried bouquets because of its attractive growth habit and seed heads.

Varieties and Ecotypes

Seed production, seed germination, and establishment traits vary considerably among populations of Indian ricegrass. Specific ecotypes have been selected to provide cultivars that can be successfully cultured (Jones 1990; Jones and Nielsen 1989). The cultivars released to date are all nonbred, native-site populations.

'Nezpar' originated near White Bird, ID (Alderson and Sharp 1994), and has been seeded extensively in the West. It is best adapted to the Snake River Plain and Columbia River Basin.

'Paloma' originated from a site near Pueblo, CO (Alderson and Sharp 1994), at an elevation of 5,000 ft (1,530 m) that receives 10 to 12 inches (250 to 300 mm) of annual precipitation. Paloma is adapted to sandy to sandy loam soils where it exhibits good stand establishment, vigor, drought tolerance, and forage production. It is seeded to provide soil stabilization on mined lands and other disturbed rangelands. Paloma is adapted to basin and Wyoming big sagebrush; black, Bigelow, and sand sage; and pinyon-juniper communities. It has performed well in Arizona, New Mexico, and the southern portions of Utah, Nevada, and Colorado.

'Ribstone' was collected near Taber, Alberta (Jones and Larsen, in press; Jones and others 2002e, 2004c), and selected for its good seed yield, germination, and acute glume pair angle. The latter trait has been associated with seed retention. Ribstone is adapted to the dry mixed grass ecoregion characterized by brown chernozem soils in southeastern Alberta and surrounding areas. The Utah Agriculture Experiment Station recommended it for release as a Selected Germplasm in 2002.

'Rimrock' originated at 3,600 ft (1,100 m) near Billings, MT (Alderson and Sharp 1994; Jones and Larson, in press; Jones and others 2002e, 2004a), on a site with fine sandy loam soil that receives 10 to 14 inches (250 to 350 mm) of annual precipitation. It is adapted to sandy soil, but it is more persistent in medium- and heavy-textured soils than are Nezpar or Paloma. Rimrock is adapted to the Northern Great Plains, Rocky Mountains, Great Basin, Snake River Plain, Columbia River Plateau, and prairies of southern Alberta and Saskatchewan. Its intended uses are for revegetation of disturbed rangelands and as a forage for livestock, big game, birds, and other wildlife species.

Phalaris arundinacea
Reed Canarygrass

Synonyms

Arundo colorata
Calamagrostis variegata

Description

A perennial sodformer, reed canarygrass was first introduced into the United States in about 1880. By the 1930s the first selections were released for use in the Western States. The plant is now widespread and regarded as a widely naturalized species. Reed canarygrass grows to 9 ft (2.7 m) in height, and it is strongly rhizomatous. Leaf blades are flat and 0.24 to 0.70 inch (6 to18 mm) wide. Ligules are 0.12 to 0.40 inch (3 to 10 mm) long, blunt or rounded at the apex, sometimes hairy, and usually lacerate along the margins. Panicles are 2.8 to 7.9 inches (7 to 20 cm) long, compact, and sometimes lobed at the base. Spikelets are ovate and three flowered with the first two florets sterile and the third perfect. Glumes are subequal, 0.16 to 3.0 inches (4 to 7.5 mm) long, and strongly compressed, especially toward the tip. They are keeled and three nerved, with the lateral nerves most prominent. The keel of the glume is roughened, tapering to a point, and usually wingless. Lemmas are shiny, appressed hairy, and faintly three to five nerved. The fertile lemma is 0.12 to 0.16 inch (3 to 4 mm) long, ovate, and brownish at maturity. The two sterile lemmas subtending the floret are subequal, 0.04 to 0.08 inch (1 to 2 mm) long, awl shaped, and hairy (Arnow 1987; Cronquist and others 1977).

Ecological Relationships and Distribution

Reed canarygrass is a common riparian species in wet places along ditches, streambanks, marshes, and meadows (fig. 39). It ranges from Alaska through Canada and the Western States to California, Nevada, northern Arizona, northern New Mexico, and Oklahoma. It occurs in the Great Lakes area of the Central States and eastward to North Carolina. It is also found in Mexico and South America. Reed canarygrass tolerates frequent and prolonged flooding and submergence, but it can also withstand periods of drought. It is best adapted to fine-textured and poorly drained soils, and it is moderately tolerant of saline or alkaline soils (Marquis and others 1984; Wasser 1982). It has little shade tolerance.

Reed canarygrass has become a weedy species in many wetland areas. It is highly productive and persistent once established. It spreads vegetatively and from seed. It is highly competitive with timothy, Kentucky bluegrass, and redtop, often invading areas

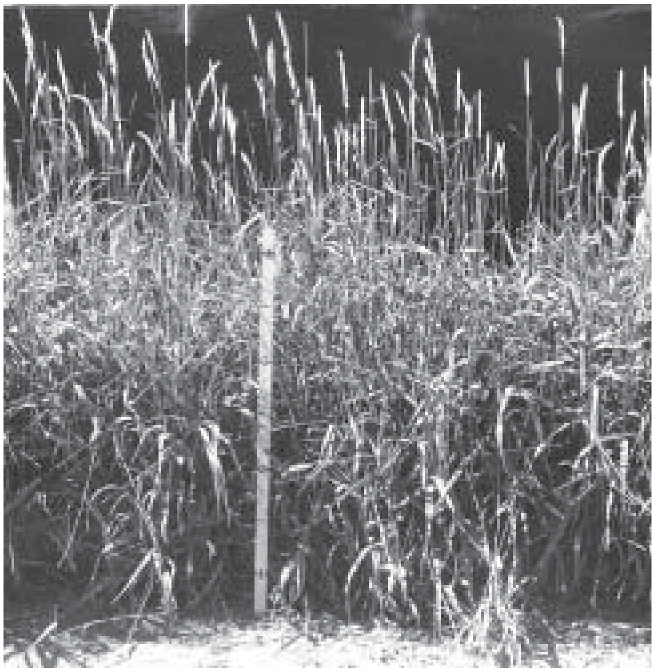

Figure 39—Reed canarygrass, invasive in many North American wetland areas, forms monotypic stands that displace native species (RMRS photo).

dominated by these species and developing persistent, monotypic stands (Apfelbaum and Sams 1987).

Plant Culture

Reed canarygrass is highly productive and has been successfully used to plant meadows, wetlands, and other sites with poorly drained soils. It can be seeded in fall or early spring when there is sufficient moisture for establishment. Seeds of reed canarygrass germinate readily, but produce weak seedlings. Consequently, satisfactory stands often fail to develop. Problems arise due to the difficulty of preparing seedbeds on wetland or wet meadow sites. Planting sites must be allowed to drain or dry out prior to cultivation or seeding. Soil crusting is common on these sites and contributes to poor seedbed conditions and planting failures. Reed canarygrass should be seeded alone, as it is not compatible with most other grasses. Once established, it reproduces mainly by rhizomes that grow into dense mats within 1 year. Up to 74 percent of new shoots in established stands arise from rhizomes; new tillers bud within 2 inches (5 cm) of the soil surface (Apfelbaum and Sams 1987).

Uses and Management

Reed canarygrass has been used to seed wetlands, meadows, riparian sites, and aspen and conifer stands with degraded understories, and disturbed sites with poorly drained soils. It is a useful soil stabilizer and provides an abundance of forage for cattle and big game. Waterfowl, upland game birds, riparian mammals, and fish all use reed canarygrass for cover and food. Reed canarygrass hay fields have been planted to provide goose grazing areas (Burgess 1969). Prairie chickens use reed canarygrass for hiding and thermal cover in winter (Tester and Marshall 1962). Reed canarygrass has been rated as good forage for cattle, sheep, and horses in Utah, Colorado, Wyoming, and Montana (Dittberner and Olsen 1983). It is most palatable when it is growing, becoming more coarse and increasing in alkaloids in autumn (Boggs and others 1990).

Reed canarygrass can be a desirable forage crop for cattle. Grazing should begin when the grass is 12 inches (30 cm) tall and when soils are dry to minimize trampling (Boggs and others 1990). Intense stocking rates with a short rotation period are recommended. Stands should not be grazed to less than 5 to 8 inches (13 to 20 cm) in height. Reed canarygrass is often cut for hay, providing an acceptable winter feed for cattle.

This grass has been successfully established as an understory with aspen and conifers. Although it has little shade tolerance, it can still dominate these communities. It has been seeded with other perennial grasses in aspen parks and mountain herblands, meadows, and on wet sites, but it generally dominates the stand. Reed canarygrass has been widely seeded to control erosion and stabilize streambanks, as it produces a spreading ground cover that provides excellent soil protection. Reed canarygrass has been seeded in the Intermountain West on areas with a high water table, including sites that are inundated with water for up to 4 months. It has been planted within waterways and riparian areas from the valley floor up to and including the conifer forest. This grass will grow in neutral to very basic salty soils. It has not proven useful on most wildland plantings, and is now most widely planted as a pasture species at lower elevations. It has often been seeded in riparian communities because seeds of native species were not available, but it gains dominance to the exclusion of other species. It should not be planted where native recovery is desired and wildlife habitat is important.

Varieties and Ecotypes

'Ioreed' reed canarygrass has been seeded in the Intermountain West on areas with high water tables, sites that are inundated for up to 4 months each year, and along waterways and riparian areas from the valley floor up through conifer forests. This grass will grow in neutral to very basic, salty soils. Ioreed was selected for its high forage productivity and its adaptation to wet sites. It is seeded to stabilize disturbed sites, waterways, and severely eroding areas, and to provide forage. Ioreed can be very aggressive and exclude other species. Other, less used, varieties include 'Castor' and 'Vantage' (Alderson and Sharp 1994). Seed of other unknown sources has been planted widely in the Intermountain West.

Phleum alpinum Alpine Timothy, Mountain Timothy

Synonyms

Phleum pratense var. *alpinum*

Description

Alpine timothy is a densely tufted perennial with culms 0.7 to 1.5 ft (2 to 4.5 dm) tall that are often prostrate at the base. Leaf sheaths are glabrous. Leaf blades are flat, about 0.10 to 0.28 inch (2.5 to 7 mm) wide, roughened along the margins and sometimes on the surfaces. Auricles, when present, are blunt to rounded. Ligules are 0.02 to 0.18 inch (0.5 to 4.5 mm) long, truncate, and subentire. Panicles are small and ovoid to cylindric when fresh. When pressed flat they are 0.4 to 2 inches (1 to 5 cm) long and 0.28 to 0.47 inch (7 to 12 mm) wide (fig. 40). Spikelets are one flowered and elliptic. Glumes are subequal, 0.10 to 0.14 inch (2.5 to 3.5 mm) long, abruptly truncate, and tapering to stout awns that are 0.05 to 0.13 inch (1.2 to 3.2 mm) long. Margins of the glumes are roughened; the margin of the first glume is sometimes ciliate. Lemmas are 0.07 to 0.10 inch (1.7 to 2.5 mm) long, lanceolate to ovate, truncate at the apex, glabrous, and shiny or sometimes fine hairy. Alpine timothy is distinguished from timothy by the sheath of the uppermost leaf being typically inflated. Its panicles rarely exceed 2 inches (5 cm) in length, the awns are generally greater than 0.06 inch (1.5 mm) long, and the culms are not bulblike at the base (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Ecological Relationships and Distribution

Alpine timothy is the only species of *Phleum* native to North America. It is widely distributed throughout the cooler portions of North America and ranges from Alaska south to New Hampshire, northern Michigan, South Dakota, New Mexico, and southern California. It is also found in Mexico, Chile, Patagonia, Northern Europe, and Asia. Alpine timothy grows mainly in alpine and subalpine areas, and it also extends down through the spruce-fir zone and into the aspen zone. It can be found in moist or wet mountain meadows, parks, on streambanks, around springs, and in the mud of bogs and marshes. It can also appear on relatively well-drained soils on grassy slopes, dry meadows, and occasionally in moist sagebrush areas. In Alaska and along the northwest coast it grows at sea level. Alpine timothy may develop dense, monotypic stands, but in many areas, it occurs mixed with other species, forming only a minor portion of the vegetation.

Alpine timothy grows on deep clay loam to sandy loam soils of pH 5.0 to 7.5 that are poorly to well drained (Hassell and others 1983), but it sometimes occurs on shallow soils in areas receiving 16 to 60 inches (410 to 1,520 mm) of annual precipitation. Plants grow slowly and are moderately long lived (USDA Natural Resources Conservation Service 2003). They reproduce from shoots developing from the base of the plants as well as from seed. The species is cold

Figure 40—Alpine timothy is the only *Phleum* species native to North America. Panicles generally less than 2 inches (5 cm) in length aid in distinguishing it from timothy (Hitchcock 1950).

and fire tolerant, fairly shade tolerant, but not drought tolerant (USDA Natural Resources Conservation Service 2003).

Plant Culture

Supplies of alpine timothy seed are limited, as seed is generally harvested from wildland stands. Seed matures in August or September (USDA Forest Service 1937) and is hand harvested (Rose and others 1998). Seeds remain on the plants for a short period before dispersal (USDA Natural Resources Conservation Service 2003). Fruits are cleaned using a hammermill and air-screen machine. Seeds are small at 1,680,000 seeds per pound (3,703,730 per kg) (Hassell and others 1983) and should be planted shallowly on a firm seedbed in fall or spring by cultipacking or by broadcasting. Seeds can be planted on or near the surface if the soil is moist. Germination and emergence are good if moisture is available, but seedling growth is slow to moderate (Hassell and others 1983; Rose and others 1998).

Uses and Management

Alpine timothy produces a fair amount of nutritious foliage that usually remains green throughout the summer, making it especially valuable as a late-season feed for livestock and big game (Hitchcock 1950; Stubbendieck and others 1992). Regrowth following use is slow (Natural Resource Conservation Service 2003).

Alpine timothy spreads slowly from seed (Natural Resources Conservation Service 2003). The species naturally revegetates disturbances and openings in mountainous areas (Brown and Johnston 1978a,b). It has performed well when tested on alpine mine wastes in Montana. Alpine timothy has potential for use in improving wildlife habitat, forage for livestock, roadway plantings, and in seeding mixes for disturbed areas within its range.

Varieties and Ecotypes

There are no releases.

Phleum pratense
Timothy

Synonyms

Phleum nodosum var. *pratense*

Description

Timothy is a tufted perennial with a usually bulbous base, hairless leaf sheaths, and culms 0.7 to 4.9 ft (2 to 15 dm) tall. Leaf blades are flat and 0.12 to 0.31 inch (3 to 8 mm) wide with roughened margins and sometimes with small auricles. Ligules are 0.06 to 0.20 inch (1.5 to 5 mm) long, subentire, rounded at the apex and sometimes lacerate along the margins. Panicles are 0.12 to 0.63 inch (3 to 16 mm) long, 0.20 to 0.40 inch (5 to 10 mm) wide when pressed flat, and compressed-cylindrical when fresh. Spikelets are one flowered and elliptical. Glumes are subequal, 0.08 to 0.13 inch (2 to 3.2 mm) long, abruptly truncate, and awned. Keels of the glumes are strongly and evenly ciliate. Glumes are three nerved, with the lateral nerves close to the keel. The first glume is slightly narrower and sometimes hairy along the margins. Awns of the glumes are 0.02 to 0.06 inch (0.6 to 1.6 mm) long. Lemmas are 0.05 to 0.08 inch (1.2 to 2 mm) long, ovate, faintly five nerved, minutely hairy, truncate, lacerate, and sometimes with a small awn at the apex (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Ecological Relationships and Distribution

Timothy is widely distributed in Europe and Asia in cool, humid habitats. Introduced to North America, it is now widespread in the northern half of the United States and southward in mountainous areas. It is found on moist meadows, weedy or grassy parks, streambanks, moist canyon bottoms, open grassy slopes, woodlands, forest openings, and roadsides and trails from sea level to 10,500 ft (3,200 m). Timothy is widely adapted, but grows best on deep, fertile, well-drained, moist clay, silt, or loam soils (Wasser 1982) that are weakly basic to weakly acidic. It also grows in sandy, gravelly, or rocky areas if the soil is moist. It withstands winter and early spring flooding, but it is intolerant of flooding during the growing season (Jensen and others 2001). Timothy is not drought tolerant, but it is cold and frost tolerant (USDA Natural Resources Conservation Service 2003). Timothy is moderately fire tolerant, particularly when dormant. It occurs on many wet sites and high-elevation locations that rarely burn (Wasser 1982).

Plant Culture

Timothy blooms in late spring and produces large numbers of seeds that mature in mid to late summer. Seeds are small and dispersed by livestock, wildlife, wind, and other forces (USDA Forest Service 1937). Seed are harvested by combining, and are cleaned with an air-screen machine. There are about 1,300,000 seeds per pound (2,865,980 per kg) (Wheeler and Hill 1957). Seeds remain viable for 4 to 5 years in dry storage (Wheeler and Hill 1957). They become highly germinable in about 1 month following harvest, and germination remains high for 1 to 2 years. A potassium nitrate pretreatment and a 5-day prechill with incubation at 59/77 °F (15/25 °C) or 68/86 °F (20/30 °C) (16 hrs/8 hrs) and exposure to light during the high temperature periods are recommended for maximizing germination (AOSA 1999). Germination occurs rapidly. Seed lots may be purchased with 99 percent purity and 90 percent germination (Wasser 1982).

Timothy is seeded in fall where early spring drying of the soil is likely to occur. Higher elevation sites are planted in mid to late summer, while irrigated fields are planted in late summer (Wasser 1982). Seed should be planted about 0.25 to 0.50 inch (0.6 to 1.1 cm) deep, or slightly deeper in coarser or drier soils (Jensen and others 2001; Wasser 1982). Seed can be surface planted or barely covered on fine, moist soils. The small seeds may require addition of a diluent to permit regulation of the seeding rate. Seeding is accomplished by broadcasting, cultipacking, or use of a drill that will place the seeds near the soil surface.

Timothy seedlings develop rapidly when adequate moisture is available (Cornelius and Talbot 1955; Hassell and others 1983; Jensen and others 2001; USDA Natural Resources Conservation Service 2003). They are susceptible to competition and soil drying because of their shallow root systems. Plants are generally fully established by the second growing season, or sometimes by the end of the first growing season (Wasser 1982). Transplants with well-developed root systems are sometimes more successfully used in areas where frost heaving or drying are problems (Brown and Johnston 1978a,b; Brown and others 1976).

Uses and Management

Timothy is known best for its widespread use as hay, primarily for horses, but it is also a forage plant where seeded on Western ranges. It is frequently grown in combination with other cool-season grasses and with red clover, alfalfa, and other legumes (Berg and others 1996; Wasser 1982). Timothy hay can be harvested two to four times per season, but regrowth is slow. The seed is used by birds. It provides cover for small mammals, waterfowl, and other birds. It is used as a forage by big game animals.

Livestock use timothy in spring and fall, and it persists well if properly grazed (Wasser 1982). Timothy should not be grazed prior to emergence of the heads. Forage quality, quantity, and palatability are greatest in spring. Plants recover slowly following grazing, and forage quality declines rapidly as plants mature. Plants can spread by tillering, but they are not resistant to heavy grazing or trampling because the sod and bulbous bases of the plants are easily damaged (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Stands are short lived if not permitted to reseed naturally. Established seedings are long lived when managed properly (USDA Natural Resources Conservation Service 2003).

Timothy can be seeded where soils are moist and the growing season is adequate for seed production. It has been used for reseeding irrigated mountain meadows and to provide ground cover and forage on burned, logged, or excessively grazed mountain rangelands where annual precipitation exceeds 40 inches (102 cm) per year (Jensen and others 2001; USDA Forest Service 1937). An early to midseral species, timothy will encroach and dominate on disturbed sites. It is used in seeding mixes to stabilize roadsides, mined lands, recreational areas, and other disturbed sites (fig. 41). Timothy establishes by the second year after seeding. Adapted seed sources should be used (Wasser 1982).

Timothy can be invasive and limit the regeneration and establishment of native species. It has reduced native grass colonization in fescue grasslands of Glacier National Park and invaded natural vegetation there (Tyser 1992). It competes strongly with seeded and transplanted conifers where seeded following wildfires (Baron 1962).

Varieties and Ecotypes

'Climax' is the most commonly seeded timothy on rangelands and wildlands in the Intermountain West. It is adapted to aspen, ponderosa pine, conifer, and subalpine communities. Climax is seeded to provide forage and soil stabilization. It can be seeded in fall or early spring. Germination occurs quickly, and seedling establishment and vigor are good. Climax is

Figure 41—Seeded on mountainous sites to provide forage or soil stabilization, timothy limits establishment of naturally recovering or seeded species (RMRS photo).

compatible with natives, providing rapid soil stabilization as slower developing species establish and mature. Stands weaken with time; their longevity is normally 5 to 9 years. Climax will reseed itself in weak communities and on open, disturbed sites if seed is allowed to mature.

The variety, 'Clair', has been seeded recently. It appears to perform as well as Climax on Western rangelands. Additional varieties developed for hay and pasture production for which seed is available are: 'Alexander', 'Alma', 'Argus', 'Basho', 'Bottnia II', 'Bounty', 'Carola', 'Champ', 'Drummond', 'Dynasty', 'Farol', 'Glenmor', 'Hokuo', 'Itasca', 'Korpa', 'Mariposa', 'Mohawk', 'Nike', 'Richmond', 'Salvo', 'Tiiti', 'Tiller', 'Toro', and 'Winmor' (Alderson and Sharp 1994).

Poa ampla
Big Bluegrass

Synonyms

Poa secunda
Poa confusa

Description

Big bluegrass is a robust, long-lived, densely tufted, hairless to minutely hairy, green or blue-waxy perennial. Mature plants develop strong, fibrous root systems. Culms are 1.3 to 5.9 ft (4 to 18 dm) tall with a basal cluster of leaves 8 to 16 inches (20 to 40 cm) long that generally wither early. Leaf sheaths are smooth to roughened, generally shorter than the internodes, and open less than one-fourth their length. Auricles of culm leaves are often hard and conspicuous. Leaf blades are roughened along the margins, faintly blue-waxy, 0.06 to 0.14 inch (1.5 to 3.5 mm) wide, and usually flat, but become involute as they dry. Ligules are short, thick, 0.04 to 0.08 inch (1 to 2 mm) long, and truncate or more often rounded. Panicles are narrow and elongate, 0.31 to 0.87 inch (8 to 22 mm) long, densely flowered, and usually pale green, but sometimes tinged with purple. Spikelets are 0.22 to 0.43 inch (5.5 to 11 mm) long, three to five flowered, and relatively narrow to somewhat cylindrical. The glumes taper to a point, the first glume is 0.12 to 0.18 inch (3 to 4.5 mm) long and the second 0.14 to 0.22 inch (3.5 to 5.5 mm) long and about as long as the first floret. Lemmas are 0.17 to 0.24 inch (4.2 to 6 mm) long, rounded at the apex, and usually rounded on the back toward the base, becoming somewhat keeled towards the tip. Lemmas are yellowish green with translucent margins or sometimes brownish. They are usually hairless, but sometimes slightly hairy below. Flowering occurs from May through July. Big bluegrass often hybridizes with rhizome-producing *Poa* species such as Canada bluegrass and Kentucky bluegrass. As a result, some specimens may have short rhizomes. (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Arnow (1987) placed *Poa ampla* in the *P. secunda* complex.

Ecological Relationships and Distribution

Big bluegrass is found on moderately moist to dry sagebrush slopes, aspen and forest openings, and midelevations and, less frequently, subalpine meadows (Wasser 1982). It ranges from Alaska to North Dakota and south from northeastern California to New Mexico (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Big bluegrass begins growth in early spring. At low elevations it matures in late spring or early summer, while at higher elevations or on sites with greater moisture availability, growth may continue later into the summer or throughout the season (Cronquist and others 1977; Shaw and Cooper 1973; Wasser 1982). Big bluegrass grows in areas receiving 15 to 21 inches (381 to 533 mm) of annual precipitation, but it also occurs in areas receiving as little as 10 inches (254 mm) (Hassell and others 1983).

Big bluegrass is adapted to a wide range of soil textures, but it is generally found on clay loam to sandy loam soils that may be shallow and of low fertility. It grows on soils with pH ranging from 6 to 8 (Hassell and others 1983), and it is moderately sensitive to salinity. Plants are only weakly tolerant of early spring flooding, high water tables, and poor drainage (Hassell and others 1983). Local ecotypes are tolerant of cold or heat. The species is only moderately shade tolerant and not particularly drought tolerant. Plants are fairly fire tolerant when dormant (Hassell and others 1983)

Plant Culture

Seed fields are harvested using a combine or stripper or by first windrowing (Archer and Bunch 1953). Seeds are cleaned in a fanning mill. Acceptable purity is 90 percent and germination 70 percent (Wasser 1982). There are about 917,000 seeds per pound (2,022,000 per kg) (Heady 1975). Seed requires a prechill treatment of 7 days at 41 °F (5 °C) for germination (Currie 1967; Haferkamp and McSwain 1951). Seed can be stored for 5 years (Plummer and others 1943). Seed should be planted 0.25 to 0.50 inch (0.6 to 1.3 cm) deep on medium-textured soils. It can also be broadcast and covered. Seedings should be conducted in fall in drier areas. Spring or early summer seedings may be successful on sites receiving greater annual precipitation or in irrigated seed fields (Archer and Bunch 1953; Currie 1967; Wheeler and Hill 1957).

Seedling vigor is low to moderate and stands mature slowly. Seedlings are easily pulled up, particularly on wet or loose soils; thus, grazing should be avoided for two growing seasons or until the roots are securely anchored.

Uses and Management

Big bluegrass is seeded on disturbed mountain big sagebrush sites and high mountain meadows (Jensen and others 2001). It is used for postfire seedings in forested areas. It is also seeded in hay fields and pastures with alfalfa and other grasses in both irrigated and nonirrigated fields. Such seedings may require weed control during the first season. Big bluegrass may be seeded in mixtures with other native grasses, forbs, and shrubs to provide diverse native vegetation and wildlife habitat. Established stands of big bluegrass are persistent and competitive with cheatgrass and other weeds.

Big bluegrass greens up early in spring. It can be grazed in spring or fall, and it is highly palatable during these periods. Palatability declines in early summer when moisture is inadequate. Fall rather than spring grazing and dense seedings that favor vegetative development are approaches for minimizing pull-up problems resulting from grazing (Hyder and Sneva 1963). Grazing in spring should be delayed until plants reach a height of at least 8 inches (20 cm). Plants are tolerant of grazing, but excessive use as plants are heading out can reduce growth during the subsequent year (Wasser 1982). Excessive grazing and trampling can lead to loss of big bluegrass.

Big bluegrass provides forage for wildlife and is used by ungulates in spring and fall. Elk use it throughout the year. At higher elevations it provides summer forage, remaining green throughout the season if adequate moisture is available and producing good fall regrowth. Small animals use big bluegrass as escape and thermal cover. Birds use it for nesting cover and consume the seeds and foliage.

Varieties and Ecotypes

‘Sherman’, collected near Moro, Sherman County, OR (Alderson and Sharp 1994), is a large, long-lived bluegrass that greens up very early as the snow melts. In the Intermountain West this variety is adapted to mountain brush communities and openings in aspen and conifer forests. Sherman is used for soil stabilization, forage production, revegetation of disturbed lands, and postfire seedings (fig. 42). Big game and livestock seek it out. It is nonaggressive and compatible with other native species.

Figure 42—Sherman big bluegrass can be seeded with other natives to provide wildlife forage and increase species diversity (photo courtesy of Scott Lambert, USDI BLM, Boise, ID).

Poa compressa
Canada Bluegrass

Synonyms

Paneion compressum

Description

Canada bluegrass is an introduced, perennial, cool-season, rhizomatous sodformer that has naturalized throughout much of the United States and Canada. Plants are wiry, erect, and bluish green throughout. Culms are 8 to 31 inches (2 to 8 dm) tall, strongly flattened, prostrate at the base, and often bent at the nodes. Stems and leaf sheaths are characteristically flattened. Leaf sheaths are open near the base, and so strongly compressed as to appear winged. Leaf blades are flat to folded, and 0.06 to 0.14 inch (1.5 to 3.5 mm) broad with short, boat-shaped tips. Ligules are to 0.02 to 0.08 inch (0.5 to 2 mm) long, fairly stiff, more or less entire, and rounded to nearly squared at the apex. Panicles are 1.2 to 3.5 inches (3 to 9 cm) long, compact, dense, and usually narrow, but occasionally somewhat open (fig. 43). Spikelets are 0.12 to 0.30 inch (3 to 7.5 mm) long, crowded, and usually three to seven flowered. Glumes are subequal and 0.07 to 0.13 inch (1.8 to 3.2 mm) long, the first one to three nerved, the second broader and three nerved. Lemmas are 0.08 to 0.12 inch (2 to 3 mm) long, firm, sometimes leathery, strongly keeled, more or less rounded, and often purplish at the tip. There are fine hairs on the keel and along the marginal nerves, especially toward the base.

Figure 43—Canada bluegrass panicles are compact, dense, and usually narrow, but sometimes open (photo courtesy of Kevin Jensen, USDA ARS, Logan, UT).

The web is lacking, or if present, it is very scant (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Ecological Relationships and Distribution

Canada bluegrass was introduced into North America from England. It is now widely distributed throughout the cooler regions of North America from British Columbia southward to California and east to Georgia. In the United States, it is most common from New England to Ohio and West Virginia. It occurs sparsely throughout Intermountain ranges in mountain meadows and along dry streambanks, and it is occasionally abundant on sites where it has been seeded. In the Southwest it occurs on higher mountain ranges. It has spread to occupy extensive disturbances throughout its present range (Van Dyne 1958), and also grows in irrigated lawns and pastures.

Canada bluegrass grows on soils ranging from clay to sand and gravel. It grows well on soils with low fertility or poor drainage (Hardy 1989; Sampson and others 1951). Plants exhibit moderate drought and salinity tolerance, but they are not shade tolerant (Van Dyne 1958). Canada bluegrass and Kentucky bluegrass occur on similar sites. Canada bluegrass tends to dominate only on soils that are too acid, droughty, or nutrient deficient for Kentucky bluegrass (Johnson and Nichols 1970).

Plant Culture

Canada bluegrass reproduces from seed and rhizomes. Seeding is best accomplished in fall. There are more than 2.5 million seeds per pound (5.5 million per kg). Seed may be drilled or broadcast, but it should not be planted more than 0.12 inch (0.3 mm) deep, as light is required for germination (Fulbright and others 1982). Seedlings may emerge, but they do not persist with more competitive species on highly fertile soils. Seedlings do, however, compete exceptionally well on soil with low fertility (Sampson and others 1951), but they develop slowly, requiring 2 to 4 years to reach maturity. Once established, Canada bluegrass can increase its area of occurrence by natural spread, even amid considerable competition. In the Intermountain West, Canada bluegrass has been seeded in big sagebrush, mountain brush, aspen, conifer forests, mountain meadow parks, and riparian sites. It requires at least 14 inches (356 mm) of annual precipitation to establish and persist. Because seedlings develop slowly, Canada bluegrass can be seeded with tree and shrub species on roadways and other disturbances.

Uses and Management

Canada bluegrass has been used extensively as a turf grass, especially in mixtures with other turf species. It is often used to provide cover and erosion control on roadsides, road cuts and fills, borrow pits, dam sites, and recreational areas. It is frequently seeded in mixtures with legumes for revegetation of mined areas (Hardy BBT Limited 1989). It is generally slow to establish, but mature stands provide good cover and remain green over a long period.

Canada bluegrass is used by cattle, horses, sheep, deer, and elk (Crawford and others 1969; Hardy BBT Limited 1989; Kufeld 1973; Kufeld and others 1973; Sampson and others 1951). It greens up early in spring, and growth continues in summer and fall. Consequently, it is palatable to livestock during this period (Hardy BBT Limited 1989). Because it matures later than Kentucky bluegrass and is more drought tolerant, Canada bluegrass tends to be more palatable in summer. It provides fair to good cover for birds and small mammals (Dittberner and Olson 1983). This species is resistant to heavy use and trampling and shows good fire tolerance.

Canada bluegrass is classed as an invader on overgrazed rangelands (Van Dyne and Payne 1964). It is generally not recommended for seeding as a pasture grass because of its low productivity. On poor soils, mine wastes, and roadway disturbances it may be seeded to provide useful forage (Stubbendieck and others 1985; Welsh and others 1987) and ground cover. Although slow to establish, this species competes well with annual weeds. It is not recommended in seedings where native species are desired. It can be planted to furnish cover on harsh sites, but it usually does not support establishment of herbaceous species. Native trees and shrubs are able to establish into existing stands of the grass, particularly in areas receiving over 20 inches (508 mm) of annual precipitation.

Varieties and Ecotypes

'Foothills' Selected Germplasm, a composite of eight Canada bluegrass accessions (Englert and others 2002), is adapted to the Northern Rocky Mountains of the United States and Southern Canada. It was selected for its forage production, seed production, and ability to spread. Recommended uses include erosion control, critical area plantings, grazing, and low maintenance landscaping.

'Reubens' originated near Reubens, ID (Alderson and Sharp 1994). It was selected for stabilization of low-fertility soils with an irregular moisture supply. In the Intermountain West it is seeded extensively in mountain brush, mountain big sagebrush, three-tip sagebrush, and ponderosa pine communities. Reubens establishes well on sterile, coarse-textured soils ranging from slightly acidic to slightly basic. It is seeded on mined lands, road cuts and fills, and other disturbances to stabilize the soil. Plants are low growing and not highly productive. Reubens is compatible with other species, and can be seeded as a component of mixtures.

Poa fendleriana
Mutton Bluegrass

Synonyms

Eragrostis fendleriana
Poa eatoni
Poa montana
Poa longiligula

Description

Mutton bluegrass is a perennial bunchgrass that forms large tufts 0.7 to 2.5 ft (2 to 7.5 dm) tall. Stems tend to stool at the edge of the tufts, and there are occasionally a few short rhizomes. Leaves are basal, erect, numerous, and strongly blue waxy. Basal leaf sheaths are papery, persistent, somewhat roughened, and open nearly their entire length. Leaf blades are firm, stiff, usually roughened, 0.06 to 0.16 inch (1.5 to 4 mm) wide, sometimes flat, but more often folded or involute with keeled tips. Culm blades are reduced or lacking, revealing only the ligule on the bladeless sheath. Ligules are highly variable, often truncate, and range from 0.02 to 0.47 inch (0.5 to 12 mm) in length to much elongate and tapering, sometimes exceeding 0.4 inch (1 cm) in length. Most are about 0.12 to 0.31 inch (3 to 8 mm) long. Panicles are pale to deep purple or sometimes tawny, 0.12 to 0.6 inch (3 to 15 mm) long, and 0.4 to 0.8 inch (1 to 2 cm) wide, oblong, contracted, and usually situated well above the basal leaves. Spikelets are 0.20 to 0.41 inch (5 to 10.5 mm) long and tightly three to six flowered. They are strongly compressed, keeled throughout, and often appear papery. The first glume is 0.11 to 0.18 inch (2.8 to 4.5 mm) long; the second is 0.14 to 0.22 inch (3.5 to 5.5 mm) long. Lemmas are 0.16 to 0.28 inch (4 to 7 mm) long, blunt on the usually irregularly lacerated apex, and with long, silky hairs on the prominently nerved keel and marginal nerves. Specimens of mutton bluegrass from the Intermountain area are generally pistillate, posing doubt that fertilization actually takes place. Some plants produce a few staminate or perfect florets (Arnow 1987) (fig. 44). Plants flower from May

Figure 44—Mutton bluegrass flowers from May to August. Flowers are generally pistillate, but some plants produce a few staminate florets (RMRS photo).

to August (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Muttongrass forms a highly polymorphic complex extending across a broad elevational range and occupying diverse habitats (Arnow 1987). Soreng (1985) described the species as including three subspecies differing in production of rhizomes, ligule characteristics, and reproductive biology. Goodrich and Neese (1986) consider the species highly variable, but suggested the subspecies be reduced to varieties. Although most plants are pistillate, they found a limited number of staminate plants that produced long rhizomes.

Ecological Relationships and Distribution

Mutton bluegrass is one of the most widely distributed native bluegrass species in the West (Wedin and Huff 1996). It is distributed from southeastern British Columbia to Manitoba and south to California, Northern Mexico, western Texas, Colorado, and western South Dakota. In the southern part of its range it occurs from the pinyon-juniper zone through oakbrush, mountain brush, ponderosa pine, and aspen communities to elevations of 7,000 to 12,000 ft (2,134 to 3,658 m) on sites receiving 10 to 22 inches (254 to 559 mm) of annual precipitation (Link 1993; USDA Natural Resources Conservation Service 2003). It appears mainly on mesas, ridges, and slopes, and in open timbered areas, as well as in well-drained parks and meadows. In the northern portion of its range it occurs at lower elevations in the sagebrush zone where it grows with other cool-season grasses and forbs. It occasionally occurs in desert shrub communities (Arnow 1987), but it may have been lost from drier areas as a result of overgrazing.

Mutton bluegrass is best adapted to clay loam soils, but will grow on well-drained, medium- to coarse-textured soils that are fairly neutral (USDA Forest Service 1937). In oakbrush, mountain brush, and aspen communities it grows as an understory species on deep soils and tolerates some shade. In sagebrush and pinyon-juniper communities it may occur on shallow and gravelly soils in addition to soils with moderately well-developed surface horizons (USDA Forest Service 1937; Dittberner and Olsen 1983).

Mutton bluegrass is an important late successional species in many shrub-dominated communities (Koniak 1985). It is generally tolerant of fires (Arnold 1950). Although Koniak (1985) found some stands were damaged by wildfires, Gartner and others (1978) determined that growth of rhizomatous population was actually stimulated by fire. Plants have responded well following fire in sagebrush, pinyon-juniper, and mountain brush woodlands in central and eastern Utah.

Plant Culture

Muttongrass seed matures between late May and mid-August (Sampson 1924; Smith and Smith 1997). Seeds can shatter rapidly at maturity (Smith and Smith 1997). Seed stocks remain erect at maturity and extend well above the leaves. Fields can be direct combined as lodging is generally not a problem. Yields in irrigated seed fields vary considerably from year to year, averaging about 35 pounds per acre (39 kg per ha) and ranging from 25 to 75 pounds per acre (28 to 84 kg per ha) (Smith and Smith 1997).

Seeds can be cleaned to some extent during combining. Further processing using a debearder may be required to complete separation of seed from the debris. Trash is removed with an air-screen machine. There are about 890,000 seeds per pound (1,958,000 per kg). Germination tests can be conducted by incubating seeds at an alternating temperature regime of 68/86 °F (20/30 °C) (16 hrs/8 hrs) with exposure to light during the high-temperature alternation (Haferkamp and McSwain 1951). Seed can be kept in dry, cold storage for up to 5 years (Smith and Smith 1997).

Mutton bluegrass seed fields can be planted in early spring. Establishment may require 2 years, and weeds must be controlled to reduce competition. Stand life is about 8 years (Smith and Smith 1997).

Wildland seedings should be conducted in fall. Spring plantings may be attempted, as emergence can occur rather rapidly. However, spring plantings can be lost when soil surfaces dry quickly in spring. Seed can be planted by drilling if seeds are placed near the soil surface. Seed may also be broadcast and covered or seeded with a cultipacker. Mutton bluegrass seedlings are generally quite small when they enter dormancy during the first growing season, but they begin growth early in the second growing season. Growth rate and lifespan are both moderate (USDA Natural Resources Conservation Service 2003). Established stands spread slowly from seed, and generally do not interfere with the establishment of other native species.

Uses and Management

Mutton bluegrass begins growth in early spring and is grazed by livestock and wildlife. Palatability decreases as the plants mature, but they retain some green leaves and are grazed late in the season when other forage is not available. Plants normally green up in the fall and offer good-quality forage at this period. Mutton bluegrass persists well in openings and in the understory with oak and other shrubs, furnishing green forage over a long period. It is also an important species within the sagebrush zone. Mutton bluegrass is considered an excellent species for all classes of domestic livestock. It provides forage for deer and elk in spring, and is also used in winter when the foliage is dry (Judd 1962). Pronghorns use the seedheads in winter (Ferrel and Leach 1950). Mule deer and elk use stands of this species in areas where pinyon and juniper trees have been cleared. These stands can draw game animals from nearby cultivated fields, thus reducing crop damage. Stands can, however, be reduced by excessive grazing. The seeds and foliage are used by birds (Christensen 1958; Harper and others 1958; Martin and others 1951).

Mutton bluegrass produces a fibrous root system about 10 inches (25.4 cm) deep that provides good surface erosion control. Like Sandberg bluegrass, this species is drought tolerant. Its growth rate and lifespan are both moderate (USDA Natural Resources Conservation Service 2003). Seed crops vary among years, and natural spread can be slow. Good recovery has been observed on sites protected from grazing.

Mutton bluegrass has not been widely used to restore disturbed areas, but it could be useful in efforts to reestablish native diversity. The species could be used in many areas where introduced grasses are now planted. It is key in areas where pinyon and juniper encroachment has depleted the understory and seasonal habitat for big game has been lost. It is also an important species to develop for use in seeding big sagebrush communities where the native understory has been lost and annual weeds have become a major problem.

Varieties and Ecotypes

There are no releases.

Poa pratensis
Kentucky Bluegrass

Synonyms

Paneion pratense
Poa peckii
Poa agassizensis

Description

Kentucky bluegrass is considered a European introduction by many botanists, but its occurrence in remote areas throughout the Intermountain region suggests that there may be native populations. Some publications treat *Poa agassizensis* as the native counterpart of Kentucky bluegrass. They are differentiated as follows: *Poa agassizensis* has waxy-blue leaves with blades 0.03 to 0.08 inch (0.8 to 2 mm) wide, spikelets mostly two flowered, and lemmas only slightly webbed as opposed to highly webbed at the base. Kentucky bluegrass has bright green leaves, blades 0.08 to 0.12 inch (2 to 3 mm) wide, spikelets mostly three flowered, and lemmas heavily webbed at the base.

Kentucky bluegrass is a leafy, long-lived perennial that spreads by seed and especially by rhizomes. It can form a dense sod, especially on moist, fertile soils, even when grazed or clipped. Most roots are within 3 inches (7.5 cm) of the soil surface. Leaf sheaths are smooth, occasionally somewhat roughened, and closed for about half their length. Blades are soft, usually green or sometimes slightly bluish, flat or more commonly folded, and about 0.04 to 0.18 inch (1 to 4.5 mm) wide with roughened margins and boat-shaped tips. Ligules are shorter than wide, squared, and mostly entire. The inflorescence is an open, pyramidal panicle, 2 to 8 inches (5 to 20 cm) long. Panicle branches are spreading or ascending and whorled in groups of three to five. Spikelets are 0.12 to 0.24 inch (3 to 6 mm) long, ovate, congested, and two to four flowered. They are green to purplish in color and strongly compressed. Glumes are roughened on the keel; the first glume is one nerved and the second is three nerved. Lemmas are three to five nerved, with weak lateral nerves. They are rounded or tapered to a point apically and there are cobweb-like hairs at the base (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; USDA Forest Service 1937).

Ecological Relationships and Distribution

Kentucky bluegrass was one of the earliest grass introductions to arrive in the United States. Plantings in North America were reported as early as 1685 (USDA Forest Service 1937). Kentucky bluegrass is now widely distributed throughout most of North America, growing in every State and Canadian Province. It is adapted for growth in cool, humid climates, and is most prevalent in the Northern United States and Southern Canada. It is not common in the Gulf States nor in the desert regions of the Southwest (Wheeler and Hill 1957). Kentucky bluegrass is not widely adapted to arid regions receiving less than16 inches (40 cm) of annual precipitation. The grass, however, has spread into many wildland communities. Kentucky bluegrass can be found on prairies and in cultivated fields, mountain grasslands, mountain brush communities, mountain meadows, riparian drainages, and open forests. It is common along roadsides and in waste places.

Kentucky bluegrass has proven well adapted to many mountain brush, aspen and conifer communities, and wet or semiwet meadows in aspen and subalpine communities. It dominates riparian areas over a wide range of elevations. Considerable variability has been noted among collections of this species. Although Kentucky bluegrass is generally best suited to areas receiving more than 16 inches (40 cm) of annual precipitation, it has sometimes persisted when seeded in more arid sites. Vallentine (1961) noted that the species is not shade tolerant, but numerous plantings in forested communities have survived. Although Kentucky bluegrass grows best in full sunlight, it will tolerate light shading if moisture and nutrient conditions are favorable (Hardy BBT Limited 1989; Smoliak and others 1981).

Kentucky bluegrass does not produce vigorous seedlings. Plants persist once established, but stands are often slow to develop. Once established, however, the species can be aggressive, spreading by development of strong rhizomes. It often invades and suppresses populations of other useful species. Kentucky bluegrass produces abundant seed that establishes in openings within the community. It often dominates in heavily grazed meadows, pastures, riparian sites, and other disturbances.

Kentucky bluegrass grows on a wide variety of soils, but thrives on well-drained loams or clay loams rich in humus (USDA Forest Service 1937), including soils derived from limestone (Hardy BBT Limited 1989; Smoliak and others 1981; USDA Forest Service 1937). Optimal soil pH is between 5.8 and 8.2 (Smoliak and others 1981). This species requires fertile soils and exhibits a high nitrogen requirement at all stages of growth.

Plant Culture

There are 2.1 to 2.2 million seeds per pound (4.6 to 4.8 million per kg). Germination is generally high, ranging from 75 to 94 percent. Seed has been drilled or broadcast seeded in fall, but it should not be planted more than 0.20 inch (5 mm) deep because exposure to light is required for germination (Fulbright and others 1982). If used, this species should be seeded in limited amounts in mixtures with other species due to its competitive ability. Kentucky bluegrass establishes well from broadcast seedings on exposed soils. It has been widely seeded by aerial application on rangelands and over mountainous terrain. It is also broadcast seeded on loose soils, including mine spoils and roadway disturbances. Mine wastes and other exposed substrata must be fertilized to assure seedling establishment. Seeded stands are slow to develop. Once established, however, Kentucky bluegrass is highly persistent and spreads from seed and rhizomes.

Uses and Management

Because of its sodforming ability, Kentucky bluegrass has been widely used as a ground cover. It is one of the first grasses to resume growth in late winter and to green up in early spring. It is highly palatable in the early stages of growth and provides nutritious forage for all classes of livestock and wildlife. In the West, it is often abundant in mountain grasslands, moist and dry mountain meadows, aspen parklands, open ponderosa pine forests, and in riparian areas where it receives heavy use by domestic sheep and cattle (Bowns and Bagley 1986; Clary 1975a; Kauffman and others 1983). Mountain meadows dominated by Kentucky bluegrass may be relatively limited in extent, but they are highly productive and provide substantial amounts of summer forage (McInnis and Vavra 1986). Plants are highly resistant to grazing because their growing points remain below ground throughout the growing season, and they produce a low ratio of reproductive to vegetative stems (Ehrenreich and Aikman 1963). Few grasses withstand heavy grazing as well as Kentucky bluegrass. It increases rapidly on overgrazed pastures and ranges, and its presence is usually an indication of poor grazing management. For livestock use, these sites are best managed under a grazing system other than season long.

Kentucky bluegrass is highly palatable to most large ungulates in spring when it is green and succulent. In moist mountain meadows, palatability remains moderately high during summer (Bellrose 1980). In drier areas it becomes semidormant in summer and its palatability is much reduced. Regionally, Kentucky bluegrass is important in the diets of elk, mule deer, and bighorn sheep (Dittberner and Olson 1983). Grasslands dominated by this grass provide habitat for numerous small mammals (George and others 1978; Medin and Clary 1989). Kentucky bluegrass meadows found along mountain streams are often preferred foraging areas for wild ungulates and grouse. Mueggler and Campbell (1986), however, suggested that the aspen/Kentucky bluegrass community type in Utah is one of the poorest aspen types for wildlife habitat due to its low diversity of plant species.

Kentucky bluegrass leaves and seeds are eaten by small mammals and songbirds (Martin and others 1951). Prairie chickens eat small amounts of its seeds (Crawford and others 1969). It is also an important food for cottontail rabbits and wild turkeys (Crawford and others 1969; George and others 1978). Sage-grouse use Kentucky bluegrass-dominated areas for strutting and chick rearing.

The use of Kentucky bluegrass for revegetation on rangelands is limited because of its slow establishment, lack of drought tolerance, and its high soil fertility requirements (Vogel 1981; Wasser 1982). When planted in seed mixtures, it often takes 2 to 3 years to become established (fig. 45).

The value of Kentucky bluegrass on rangeland is also limited because of its low productivity, summer dormancy, and propensity to invade native grasslands. In the Intermountain West, Kentucky bluegrass is well adapted to meadows with seasonally high water tables and midsummer drought (Volland 1985a). It has become naturalized and dominates many

Figure 45—Two-year-old Kentucky bluegrass plants spread rhizomatously and develop a dense ground cover (RMRS photo).

meadows once occupied by tufted hairgrass and sedges. Reestablishment of the original natives is impractical because of the competive ability of Kentucky bluegrass.

Because of its shallow root system, Kentucky bluegrass is not recommended as a soil stabilizer. It is less effective than the native grasses and forbs it has replaced, and it is not capable of stabilizing streambanks. Erosion and channel downcutting may occur when it dominates, especially in heavily grazed areas (Hansen and others 1988a,b; Kovalchik 1987). Kentucky bluegrass is intolerant of prolonged flooding, high water tables, and poor drainage (Wasser 1982).

Kentucky bluegrass is one of America's most popular lawn grasses. It withstands considerable abuse and it is often used as a sod grass on golf courses, campgrounds, and ski slopes (Shaw and Cooper 1973). It fails to control weed invasion and spread, particularly in riparian sites and meadows. Serious weed problems occur where this species has displaced native grasslike species.

Varieties and Ecotypes

Many varieties of Kentucky bluegrass have been selected and released for turf purposes. Most are not adapted for rangeland use. The most popular variety for wildland seeding is 'Newport', obtained from a coastal site in Lincoln County, OR (Alderson and Sharp 1994). Newport is seeded in the Intermountain West to provide soil stabilization. It is adapted to well-drained alluvial soils derived from limestone. Newport is rhizomatous, moderately drought tolerant, and exhibits good growth compared to other Kentucky bluegrass accessions. Newport is less competitive than some Kentucky bluegrass varieties, and it can be seeded in mixtures with some species.

Poa secunda
Sandberg Bluegrass

Synonyms

Paneion sandbergii
Poa canbyi
Poa confusa
Poa nevadensis
Poa sandbergii
Poa scabrella

Description

The *Poa secunda* complex occupies a wide range of habitats, and its members exhibit many forms, several having been given species status over the years. Sandberg bluegrass is one of the more common early-season desert bunchgrasses in the Intermountain area. It is a small, densely tufted perennial that often produces extensive tufts of basal leaves that wither and disappear early (fig. 46). Plants are often more or less purple tinged throughout. Culms are 0.7 to 1.5 ft (2 to 4.5 dm) tall and wiry. Sheaths are smooth to roughened and open for three-quarters or more of

Figure 46—A small, tufted cool-season perennial, Sandberg bluegrass is one of the most common bunchgrasses of the Intermountain area (photo courtesy of Loren St. John, USDA NRCS, Aberdeen Plant Materials Center, Aberdeen, ID).

their length. Leaf blades are soft, folded or involute, rarely flat, 0.02 to 0.06 inch (0.5 to 1.5 mm) wide, and 1.2 to 1.95 inches (3 to 5 cm) long. The basal cluster of leaves is 1.2 to 5.5 inches (3 to 14 cm) tall. The leaves are roughened and their tips are prow shaped. Ligules are tapered to a point and rather prominent. Those of the basal leaves are mostly less than 0.06 inch (1.5 mm) long, and those of the culm leaves are usually more than 0.10 inch (2.5 mm) long. Panicles are 0.8 to 7.9 inches (2 to 20 cm) long, narrow to rather open, but usually not dense. Panicle branches are short and usually ascending. Spikelets are 0.16 to 0.37 inch (4 to 9.5 mm) long, two to six flowered, slightly compressed and rather cylindrical, narrow, and pointed. They are usually strongly purple tinged. Glumes are roughened, translucent along the margins, and tapered to a point. The first glume is 0.09 to 0.20 inch (2.2 to 5 mm) long and one nerved; the second is 0.12 to 0.20 inch (3 to 5 mm) long and three nerved. Lemmas are 0.12 to 0.22 inch (3 to 5.5 mm) long, rounded below and only slightly keeled above. They become increasingly curly haired below, and are not at all webbed at the base (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969).

Ecological Relationships and Distribution

Sandberg bluegrass ranges from Alaska through much of Canada and south into the Western United States, Mexico, Nebraska, and Michigan. The species is also found in South America. It grows at elevations from 980 to 12,000 ft (300 to 3,660 m) on sites receiving 10 to 22 inches (254 to 559 mm) of annual precipitation (Hitchcock 1950; Stubbendieck and others 1992; USDA Forest Service 1937; USDA Natural Resources Conservation Service 2003). Sandberg bluegrass occurs on dry to mesic plains, foothills, and ridgetops of salt desert shrub, sagebrush, pinyon-juniper, oakbrush, mountain brush, grassland, aspen, conifer, and meadow communities (Arnow 1987).

Sandberg bluegrass occurs on soils of a wide range of textures, but it is most productive on deep, well-drained sandy clay, silt, and sandy loam soils that range from slightly acidic to basic. It is often a dominant species on dry, rocky sites and on shallow soils of scablands. The species is tolerant of salinity and of sites that are flooded in spring, but it does not tolerate soils that are saturated for prolonged periods (Arnow 1987; Hafenrichter and others 1968; Plummer and others 1968).

Sandberg bluegrass begins growth in early spring prior to most other native bunchgrasses and sets seed in late spring or early summer, depending upon elevation. Plants evade summer drought by entering dormancy. Growth may resume in fall if adequate precipitation occurs. The dense tufts of leaves and the fibrous rooting system provide stabilization of surface soils (Jensen and others 2001).

Sandberg bluegrass is generally not damaged by wildfires. The small clumps, low amounts of litter, and prolonged summer dormancy preclude extensive damage to the buds. Early fires during dry years may be more damaging (Kearney and others 1960). Cover provided by the species may increase for a time following fire if other species are lost or reduced (Blackburn and others 1971). Reestablishment of sagebrush or other taller species may eventually reduce the cover provided by Sandberg bluegrass, as it is not shade tolerant (Acker 1992; Tueller 1962).

Plant Culture

Regeneration of Sandberg bluegrass is by seed and tillering with occasional production of a small number of rhizomes (Arnow 1987). The species is self-fertile or wind pollinated and facultatively apomictic (Daubenmire 1970; Hitchcock and others 1969; Kellogg 1985a,b). Plants produce considerable seed in early summer. Native stands are harvested by hand or with mechanical strippers. Little seed is normally harvested from wildlands, and such seed is often of low viability. Seed fields of the released varieties are harvested by swathing (Smith and Smith 1997) or by direct combining (Rose and others 1998). Some seed may be lost through shattering. Seed is cleaned using a hammermill and air-screen machine.

There are about 925,000 seeds per pound (2,039,255 per kg) (Hafenrichter and others 1968). Yields from seed fields of the Canby bluegrass type average 150 pounds per acre (168 kg per ha) (Smith and Smith 1997). Wasser (1982) recommended 90 percent purity and 65 percent germination as purchasing standards. AOSA (1999) recommendations for germination are pretreatment with 0.2 percent potassium nitrate followed by incubation at alternating temperatures of 68 and 86 °F (20 and 30 °C) (16 hrs/8 hrs) with exposure to light during the high-temperature periods.

Seed fields and wildland seedings of Sandberg bluegrass should be planted on firm seedbeds in clay loam to sandy loam soils at a 0.25 to 0.5 inch (0.6 to 1.3 cm) depth in fall (Fulbright and others 1982). Germination is slow and seedling vigor is low. Stands establish slowly and there is little production during the first season (Smith and Smith 1997; Wasser 1982). Stand life for seed fields is 7 or 8 years. Use of local seed sources is recommended for wildland plantings because of the wide distribution of the species.

Uses and Management

Sandberg bluegrass has been successfully seeded in areas receiving as little as 12 inches (300 mm) of annual precipitation (Arnow 1987). Seedlings are not highly competitive. New seedings must be protected from grazing and weed invasion. Established plants are more competitive, but also compatible with other native species. Plants are short lived; management should permit periodic seed production and natural seeding to perpetuate stands and reduce the risk of cheatgrass invasion. Seedling establishment and stand productivity fluctuate widely with weather conditions (Daubenmire 1975b).

Sandberg bluegrass is one of the earliest grasses to be grazed in spring. It provides high-quality and palatable, but coarse, forage for livestock and wildlife from spring to early summer. Both forage quality and palatability decline rapidly as the plant matures, but the species receives some use in summer and fall. Summer regrowth is limited; fall regrowth may be moderate, depending upon precipitation (Thornburg 1982). Plants are highly resistant to grazing and trampling.

Sandberg bluegrass is an important component of the Townsend ground squirrel’s diet (Johnson 1977). It provides some cover for small mammals, songbirds and waterfowl, and other small animals. Elk, deer, and other wildlife species browse it (Vallentine 1967). Sandberg bluegrass provides some surface soil stabilization, particularly on shallow soils where it may be the dominant species.

Varieties and Ecotypes

‘Canbar’ originated in the Blue Mountains of Columbia County, WA (Alderson and Sharp 1994). It is adapted to basin and Wyoming big sagebrush and mountain brush communities. Although it establishes slowly when seeded, it eventually fills the interspaces between larger bunchgrasses, thus inhibiting the invasion of cheatgrass. Once established, Canbar is a vigorous understory species with an abundance of basal leaves. It makes excellent early spring growth, and it spreads well from seed. When planted with other native species it is compatible and not overly competitive.

‘High Plains’ Selected Germplasm is a composite of materials from Montana and Wyoming (Englert and others 2002). The variety grows to 2 ft (0.6 m) in height. It was selected for use in native seedings to provide wildlife habitat and restore native communities. It is recommended for use on adapted sites in Montana and Wyoming.

‘Service’ originated near Whitehorse, Yukon Territory, Canada (Alderson and Sharp 1994). It has not been seeded in the Intermountain West. It has, however, performed well in Alaska when seeded for erosion control and revegetation of disturbances on dry, gravelly, and rocky soils.

Sitanion hystrix
Squirreltail, bottlebrush

Synonyms

Elymus elymoides
Aegilops hystrix
Sitanion elymoides
Sitanion californicum
Sitanion rigidum
Sitanion glabrum
Sitanion cinereum
Sitanion montanum
Sitanion brevifolium
Sitanion longifolium
Sitanion hordeoides

Description

Squirreltail is a short-lived, loosely to densely caespitose perennial that is nearly hairless to white hairy throughout. Culms are erect to spreading and 0.3 to 2.1 ft (1 to 6.5 dm) tall, with hairless to silky haired leaf sheaths. Leaf blades are flat to folded or involute, 0.4 to 0.24 inch (1 to 6 mm) wide, stiff haired to soft hairy above, and sometimes hairless below. Auricles are inconspicuous, up to 0.04 inch (1 mm) long, and often purplish. Ligules are short, less than 0.2 inch (5 mm) long, and squared at the margins. Spikes are compact to loose and open, and 1.2 to 5.9 inches (3 to 15 cm) long, excluding the awns. They are often included in the upper leaf sheaths, or sometimes entirely exerted in robust specimens. The rachis disarticulates as the spikelets mature. Spikelets are mostly in pairs, sometimes in threes, or solitary when in the upper portion of the spike. They are mostly one to six flowered, sometimes all fertile, but more commonly with the lowermost flower sterile and glumelike. Awns of the glumes and lemmas are 0.8 to 4.7 inches (20 to 120 mm) long, varying from green to red or often purplish. Glumes are 1.4 to 3.4 inches (35 to 85 mm) long, subulate, and extend into slender, spreading, roughened awns. Lemmas are 0.3 to 0.4 inch (8 to 10 mm) long, hairless to strongly short haired, and faintly three to five nerved. The main nerve extends into a slender to stout, flexuous awn that may be straight or divergent, while two of the lateral nerves extend into bristles that are about 0.4 inch (10 mm) long (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). Plants are self-pollinating and allotetraploid (2n = 28).

Squirrreltail is a member of the Tribe Triticeae, and hybridizes with members of the *Elymus*, *Hordeum*, and *Pseudoroegneria* complexes. It also produces sterile hybrids with Great Basin wildrye (Jones 1998). Barkworth and others (1983) included the species in

Elymus elymoides. Wilson (1963) and Jones and Larson (in press) describe squirreltail as a complex of five taxa. Most widespread is *E. e.* var. *elymoides*. *E. e.* var. *californicus* is native to the eastern Sierra Nevadas. *E. e.* var. *brevifolius* are larger plants, while *E. e.* var. *hordeoides* are small and less common. Big squirreltail occurs in the Northwest and southward into California and parts of Nevada. The taxa exhibit considerable differences in morphological and phenological characteristics (Hironaka and Tisdale 1972; Jones and Larson, in press) and occupy differing habitats.

Ecological Relationships and Distribution

Squirreltail ranges from British Columbia to Saskatchewan and south throughout the Western and Central United States and into Mexico. It grows in plant communities ranging from salt desert shrub to alpine meadows on sites receiving 8 inches (20 mm)or more of annual precipitation (Horton 1989) at elevations ranging from 2,000 to 11,500 ft (610 to 3,500 m) (Kearney and others 1960). It is a common understory species in sagebrush steppe communities (Jones 1998). Squirreltail commonly grows on dry, gravelly soils that may be saline or alkaline, but some populations also grow on fine-textured soils (Jensen and others 1990; Morris and others 1950). Squirreltail may be an early successional species in overgrazed or otherwise disturbed sites. It is also a mid to late successional species (Young and others 1972). Jones (1998) suggests its seral status may be related to both genotype and site conditions.

Bottlebrush squirreltail is competitive with the annual grasses cheatgrass and medusahead and has been observed to persist on ranges invaded by these weeds (Arredondo and others 1998; Beckstead 1994; Hironaka 1994) (fig. 47). The ability to germinate and produce roots at low temperatures permits it to establish in annual grass-infested areas (Hironaka 1994; Hironaka and Sindelar 1975; Young and Evans 1977). Facultative fall or spring germination, early spring growth, extensive root development, and early seed development contribute to the competitive ability of the species (Reynolds and Fraley 1989). Plants are drought tolerant and winter hardy.

Squirreltail is fairly tolerant of burning (Britton and others 1990) due to its small size, limited leafy material, and coarse, solid stems. The low herbage volume generally limits fire damage to the root crown (Wright 1971; Wright and Klemmedson 1965). Plants are more susceptible to damage when surrounded by accumulations of litter and dead material or when fire frequencies increase (Wright and Klemmedson 1965). Damaged plants regenerate from surviving portions of the root crown and from on- and offsite seed sources (Bradley and others 1992a,b). Squirreltail's ability to compete with cheatgrass may be favored by fire.

Figure 47—Squirreltail is competitive with invasive annual grasses, including cheatgrass and medusahead (RMRS photo).

Plant Culture

Squirreltail seeds mature from June to September depending on site conditions (Link 1993). Mature seeds are dispersed following disarticulation of the rachis, thus timing of harvest is critical. Doescher (2001) found seed could be harvested when awns are divergent and straw colored or about 1 week prior to disarticulation of the rachis. Most viable seed falls near the plant, but fruit morphology, particularly the long awns, permits wind dispersal, and some seeds can be carried as much as 130 ft (40 m) (Beckstead 1994; Hironaka and Tisdale 1963; Marlett and Anderson 1986). The long awns, short seedstalks, and large amounts of chaffy material make seed collection difficult. Seed fields and extensive wildland stands in accessible areas are harvested by combining or by first windrowing. Wildland stands are also hand harvested. Awns may be removed with a brush machine, and trash can be removed with an air-screen machine. There are about 191,555 seeds per pound (422,302 per kg) (Plummer and others 1968). Seed can be stored for 3 or 4 years (Link 1993).

Seed can be germinated at constant or alternating temperatures of 59, 50/59, or 50/68 °F (15, 10/15, or 10/20 °C) without prechilling (Young and Evans 1977). A requirement for afterripening may vary among seed lots and range from 0 to 4 months (Allen and others 1994; Beckstead and others 1993; Young and Evans 1977).

Squirreltail seed may be direct seeded alone or in mixtures at depths of 0.25 to 0.5 inch (0.6 to 1.2 cm). Seed fields are short lived. Weed control is difficult and plants are subject to rust. However, seed can be harvested the first year (Archibald and Feigner 1995), and production is generally good (Hironaka and Tisdale 1963; Young and Evans 1977).

Because of the great variability within this species complex, seed sources for revegetation efforts must be selected carefully. Seed should be planted in fall in the Intermountain and Rocky Mountain areas and in late winter to early spring in the Southern Great Plains. Plummer and others (1968) ranked germination of squirreltail seedings high, but they considered initial establishment, growth rate, final establishment, and persistence of squirreltail seedings only moderate.

Squirreltail has long been considered one of the more competitive native grasses on cheatgrass rangelands. Its ability to germinate rapidly across a wide temperature range is considered a factor in its ability to establish on disturbed sites (Young and Evans 1977). Allen and others (1994) found that squirreltail from a low-elevation site (4,100 ft [1,250 m]) was more likely to germinate in fall than cheatgrass. In Nevada, Tipton (1994) found that mature squirreltail plants usually initiated growth before cheatgrass. Jones (1998) described squirreltail as a potential species for "assisted succession," a species capable of replacing invasive species following wildfire. He listed squirreltail attributes suited to this role, including facultative fall germination, rapid growth and maturation, root systems capable of mining nitrogen, early spring maturation in areas that dry rapidly, and efficient nitrate assimilation.

Uses and Management

Squirreltail greens up early in spring and provides fair amounts of forage where it grows in dense stands. The bristlelike awns can injure grazing animals. Consequently, animals avoid these plants from seed ripening until seed dispersal. Late summer herbage and especially fall regrowth following rainfall are palatable and used by livestock and wildlife. Squirreltail is a valuable plant for providing energy in winter, as some leaves remain green (Jensen and others 2001; Stubbendieck and others 1992; Vallentine 1971). It is particularly valuable to big game and small mammals in winter (Anderson and Shumar 1986; Beale and Smith 1970; Kufeld and others 1973). Palatability and use by livestock and big game vary geographically (USDA Forest Service 1937).

Squirreltail has considerable potential for revegetating degraded rangelands, particularly those invaded by annual weeds. The USDI Bureau of Land Management considers development of squirreltail seed sources a priority for revegetating Intermountain rangelands (Hardegree 1994). Squirreltail provides a persistent ground cover and can be used to control erosion. Direct seeded squirreltail survived for 30 years on a big sagebrush/bluebunch wheatgrass site in south-central Idaho (Monsen and Anderson 1993). Stand management should emphasize protection from excessive grazing and protection during heading so adequate seed supplies will be produced and the stand maintained (USDA Forest Service 1937; Sanders 1994).

Varieties and Ecotypes

Accessions 9040187 and 9040189 originated in Colorado and are being advanced toward release by the Upper Colorado Environmental Plant Center in Meeker, CO (Alderson and Sharp 1994; UCEPC 2002). They were selected for their potential for revegetation of mined lands and other disturbed rangeland sites. Their forage quality is fair to moderate for livestock and wildlife, especially in winter.

Fish Creek, a *Sitanion hystrix* var. *hystrix* collection, was recommended for release as a Selected Germplasm by the Utah Agricultural Experiment Station in 2002. It was collected from a site near Carey, Blaine County, ID, at an elevation of 4,756 ft (1,400 m) that receives about 15 inches (380 mm) of annual precipitation (Jones and others 2002c). Fish Creek was selected for its low proximal awn mass, a trait that may reduce damage during awn removal. In addition, its spikes disarticulate at the base, facilitating seed harvesting. The intended area of use for Fish Creek is the upper Snake River Plain.

Toe Jam Creek was collected from a site at 6,000 ft (1,829 m) west of Tuscarora, Elko County, NV (Jones and others 2002b). Tuscaraora receives 12.3 inches (312 mm) of annual precipitation. Toe Jam Creek was developed for use in the northern Great Basin and lower Snake River Plain. It was selected for its large seed size and low proximal awn mass. The latter trait may reduce damage during awn removal, a problem encountered in processing Sand Hollow. Toe Jam Creek was identified as *Sitanion hystrix* var. *californicus*. The Utah Agricultural Experiment Station recommended it for release as a Selected Germplasm in 2002.

Sand Hollow (*Sitanion jubatum* or *Elymus multisetus*) big squirreltail Selected Germplasm originated in Gem County, ID, on a loamy, coarse sand site at an elevation of 2,690 ft (820 m) that receives 11 inches (300 mm) of annual precipitation (Jones and others 1998b). It is adapted to sandy soils in southern Idaho and adjacent regions in Oregon, Nevada, and Utah. The variety was developed for revegetation of disturbed sites and rangelands dominated by exotic annuals.

Sporobolus airoides Alkali Sacaton

Synonyms

Agrostis airoides
Sporoblus wrightii

Description

Alkali sacaton is a long-lived, sodforming, native perennial bunchgrass that produces dense clumps that die out in the center over time. In the Southwest this species acts as a warm-season grass, while in the Intermountain area it responds more like a cool-season grass. Plants are stout and tufted forming large clumps clothed with slick, shiny, cream-colored sheaths at the base. Culms are 16 to 47 inches (4 to 12 dm) tall, hairless, round, and usually hollow, but sometimes loosely pith filled. Leaf sheaths are smooth and hairless to slightly silky haired at the upper edges of the margins. Leaf blades are flat to strongly involute, 0.08 to 0.16 inch (2 to 4 mm) wide, smooth below, finely roughened above, and stiff haired near the throat. Ligules are very short with a dense band of hairs. Panicles are 4.7 to 15.7 inches (12 to 40 cm) long, 0.16 to 0.80 inch (4 to 20 mm) wide, open and pyramidal, and often fully exerted or sometimes remaining partially enclosed in the sheath (fig. 48). Spikelets are borne mostly toward the tips of the branches. Glumes are often deciduous. They are tapered to a point, one nerved, roughened or often translucent throughout, and glabrous. The first glume is 0.03 to 0.08 inch (0.7 to 2 mm) long, and the second is about 0.06 to 0.12 inch (1.5 to 3 mm) long. Lemmas are 0.7 to 0.12 inch (1.8 to 3 mm) long and taper to a point; they are usually longer than the second glume (Arnow 1987; Hitchcock 1950; Hitchcock and others 1969; Stubbendieck and others 1986; USDA Forest Service 1937).

Ecological Relationships and Distribution

Alkali sacaton occurs throughout the Western United States, the Great Plains, and Northern Mexico. It is most abundant in saltgrass, salt desert shrub, desert shrub, blackbrush, sagebrush-grass, and pinyon-juniper communities. It can also be found in ponderosa pine, mountain brush, semiarid grasslands, and on prairies. It inhabits lower, slightly moist, alkaline flats, where it frequently develops almost pure stands. Stands are also found scattered along drainages in desert and semidesert areas. Throughout the northern portion of its range, it is scattered and less important, but in the Southwest, it occurs in sufficient abundance to be a major forage species.

Alkali sacaton generally grows in areas receiving 12 to 14 inches (300 to 350 mm) of annual precipitation. It grows on dry to moist sites in saline bottoms and in areas with shallow water tables. It tolerates soils with up to 3 percent total salts, as well as soils high in carbonate and bicarbonate (Blaisdell and Holmgren 1984; Cook and others 1954; Roundy and others 1983; Vallentine 1961). Although it can endure alkali, it is not restricted to alkaline soils. It does poorly on sandy soils, fair on silty soils, and good on clayey soils (Vallentine 1971). Plants exhibit moderate fire tolerance, but little shade tolerance.

Plant Culture

Alkali sacaton reproduces from seeds and tillers. Plants produce numerous seeds from late summer to October. These may remain viable for many years (Blaisdell and Holmgren 1984; Hitchcock 1950). Seeds must undergo an afterripening period of up to 9 months

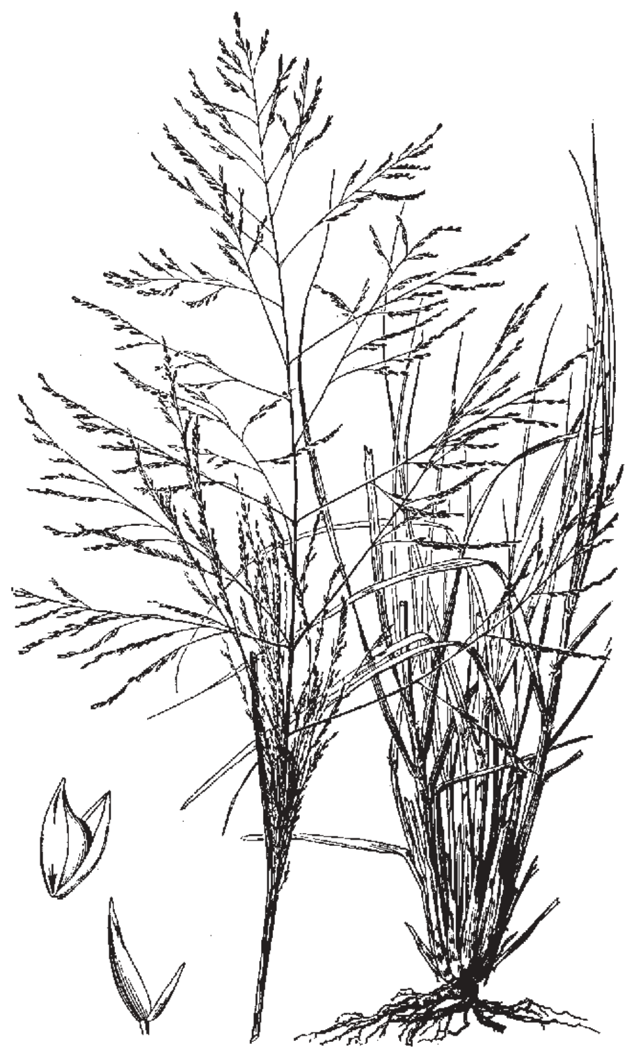

Figure 48—Alkali sacaton is a long-lived bunchgrass that forms large, dense clumps and produces wide, pyramidal panicles (Hitchcock 1950).

to relieve dormancy. Local flooding will move seeds across flood plains to saturated sediments where they germinate when favorable conditions are encountered (Aldon 1981).

Seeds are small with an average of 1.75 million per pound (3.85 million per kg). Purity can be high (98+ percent). Germination of 80 percent is acceptable for seed purchases. Seed viability remains high for more than 10 years when seeds are stored dry in a warehouse.

Seed can be broadcast or drill seeded. Extensive seedbed preparation is not required. Seeds should be planted about 0.25 inch (6 mm) deep. Fall seeding is recommended to permit afterripening and release of dormancy. Within the same seed lot, some seeds germinate within a few days under favorable condtions, but others are dormant and may not germinate for weeks. Seedling establishment is, therefore, erratic without some type of irrigation, flooding, or runoff. Soils that remain moist for 5 to 10 days to support germination can produce fair stands (Aldon 1975). Difficulty in establishment is probably the factor that most limits the wider use of alkali sacaton. Although some plantings produce erratic stands, this species does establish with a good degree of success in quite arid communities. It can be seeded in situations where few other species exist. Planting in mixtures with other species, including some shrubs, does not prevent its establishment.

Uses and Management

Alkali sacaton provides valuable forage for livestock in arid and semiarid situations where it can produce a large quantity of forage. As it matures and dries it can become coarse and somewhat unpalatable. Cattle and horses do, however, use it in winter months. Sheep will use it when forced during drought and on overgrazed ranges (Blaisdell and Holmgren 1984; Cook and others 1954; Vallentine 1961). Palatability has been rated as good for cattle, good to fair for sheep and horses, and fair to poor for antelope, elk, and deer (Dittberner and Olson 1983).

Alkali sacaton is commonly seeded to stabilize disturbed lands, such as raw mine spoils in the semiarid Southwest (Hassell 1982; Oaks 1982; Thornburg 1982). It is also planted in riparian zones in a number of major plant communities in the Intermountain area (Monsen 1983). This species can be superior to western wheatgrass for seeding in drier portions of the southern and northern desert shrub types (Alden 1981; Plummer 1977).

Alkali sacaton has been used in range and reclamation seedings in blackbrush, salt desert shrub, sagebrush, pinyon-juniper, and mountain brush types. It is seeded along roadways and riparian corridors. It can establish well and persist in lower elevation shrublands that support few species. In these situations it is important for controlling weed invasions and protecting unstable, erosive soils. This species could become much more important for the restoration of arid sites.

Varieties and Ecotypes

Two varieties of alkali sacaton have been selected and released (Alderson and Sharp 1994). Salado was selected for use in conservation and range seedings. Collected near Clauch, NM, at 5,800 ft elevation (1,770 m) it is native to a site that receives 11 to 18 inches (280 to 460 mm) of annual precipitation. Salado is seeded on valley bottoms, alkaline flats, rocky soil, and open plains in the Intermountain West to provide forage and soil stabilization. It is used on disturbed sites where moisture accumulates, such as road right-of-ways, depressions, and gravel pits. Fall seeding is preferred because germination may be erratic. Seedling vigor is generally good.

Saltalk, which originated near Erik, OK, has not been seeded to any great extent in the Intermountain West. It is seeded in the Southwest on disturbances in salt-bearing soils around oil wells.

Sporobolus cryptandrus
Sand Dropseed

Synonyms

Vilfa cryptandra
Agrostis cryptanda

Description

Sand dropseed is a tufted drought-tolerant, nonrhizomatous native bunchgrass that sometimes functions as an annual. It performs as a warm-season grass in the Southwest and as a cool-season grass in the Intermountain West and other northern areas. It can be recognized by the large, distinctive, inflated sheathes that subtend and partially enclose the inflorescence. When the sheaths wither, the panicle expands and the seeds are dispersed (fig. 49). Culms are 1.3 to 3.0 ft (4 to 9 dm) tall, erect or prostrate at the base, hairless, and solid. Leaf sheaths are strongly overlapping, ciliate at the summit, and sometimes hairy along the upper margins. The hairs are 0.04 to 0.16 inch (1 to 4 mm) long and sometimes occur across the collar. Blades are usually flat with roughened margins and become involute toward the tip. They are 0.06 to 0.20 inch (1.5 to 5 mm) wide and 2 to 6 inches (5 to 15 cm) long. Ligules consist of a ring of dense hairs about 0.02 inch (0.5 mm) long. Panicles are open, 4 to 12 inches (1 to 3 dm) long, and 0.6 to 2.4 inches (1.5 to

Figure 49—Inflated sheaths that subtend and partially enclose the inflorescence of sand dropseed wither when mature, permitting inflorescence expansion and seed dispersal (photo courtesy of Kevin Jensen, USDA ARS, Logan, UT.

6 cm) wide, with the lower part at least partially enclosed in a sheath. Panicle branches are hairless, spikelet bearing almost to the base, and usually rather stiffly ascending to reflexed. Spikelets are cleistogamous, or self-fertilized, pale olive green, and hairless. Glumes are tapered to a tip, one nerved, and deciduous at maturity. The first is 0.03 to 0.04 inch (0.7 to 1 mm) long and awl shaped. The second is 0.06 to 0.09 inch (1.4 to 2.2 mm) long and broader than the first. Lemmas are about as long as the second glume, 0.06 to 0.10 inch (1.5 to 2.5 mm) long, and also tapered to a tip (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; USDA Forest Service 1937). Sand dropseed roots spread up to 2 ft (0.6 m) horizontally and 3 ft (0.9 m) vertically (Weaver and Albertson 1956).

Ecological Relationships and Distribution

Sand dropseed is an important grass in the Southwest, the Intermountain West, and parts of the Snake, Salmon, and Clearwater drainages in Idaho and Oregon (USDA Forest Service 1937). It is distributed from Ontario, Canada, to Alberta and Washington, and south to North Carolina, Indiana, southern California, and northern Mexico (Hitchcock 1950). In the Intermountain West it is most abundant in deserts or lowlands, and it is especially common on sandy soils. This species can be a major component of sagebrush-bunchgrass types, particularly in Idaho and Utah. It is also important in juniper-pinyon, mountain brush, salt desert shrub, blackbrush, chaparral, and ponderosa pine communities and short-grass prairies. Sand dropseed will invade degenerated wheatgrass, fescue, and bluegrass communities. It is able to persist with heavy ungulate use because it has a protected root crown, matures late, and is not a highly preferred species (Johnson and Simon 1987). Sand dropseed responds rapidly to grazing removal, becoming a major component of overgrazed communities (Blaisdell and Holmgren 1984; Cook and others 1954). It can also be one of the first grasses to regenerate on abandoned fields, disturbed sites, waste places, and along roadsides.

Plant Culture

Sand dropseed is a prolific seed producer. It spreads well from natural and artificial seeding, and it is often one of the first perennial grasses to reestablish following drought. Seeds will lie dormant in the soil for many years until favorable conditions for germination and establishment occur (USDA Forest Service 1937; Weaver and Albertson 1956). Seedling development is rapid, with tillers appearing a few weeks after germination (Weaver and Albertson 1956).

Seeds are small with 5.6 million per pound (12.3 million per kg). Seed is often marketed with 98+ percent purity and total germination of 90 to 95 percent. However, some seed lots may contain as much as 50 percent hard seed. Seed can be stored for 20 years and still be 75 percent germinable (USDA Forest Service 1937). Normally, the older the seed, the better the germination and establishment. The species is widely distributed, and ecotypes differ in germination requirements.

Sand dropseed requires minimal seedbed preparation. It can be successfully seeded by drilling or broadcasting and light harrowing on a variety of sites, including open exposed soils and unstable disturbances. Seed should not be planted deeper than about 0.24 inch (6 mm), especially in sandy soils. The seed coat of sand dropseed is very hard and requires overwinter prechilling for germination. Fall plantings can provide natural prechilling and increase the probability of spring germination. Seed dormancy can be a deterrent to the establishment of uniform seeded stands. The growth rate of sand dropseed is considered good on sandy and salty soils and fair on clayey soils (Stubbendieck and others 1986). It is one of the few grasses that are well adapted to stabilizing sandy sites. Once plants establish, they are long lived and hardy.

Sand dropseed is compatible with many other species and can be seeded in mixtures in disturbed salt desert shrub, blackbrush, big sagebrush, pinyon-juniper, mountain brush, chaparral, and short-grass prairie communities. In the Southwest, it does well in areas that are too hot and dry for wheatgrasses. Sand dropseed is also frequently planted alone.

Sand dropseed will establish on sites that receive less than 9 inches (230 mm) of annual precipitation. The survival of new plantings of sand dropseed is dependent upon the availability of spring and early summer soil moisture. Plantings that receive good spring precipitation emerge, grow quickly, and become vigorous and capable of persisting during subsequent periods of summer drought.

Uses and Management

Sand dropseed is fairly productive and palatable to all classes of livestock and many wildlife species, especially from spring to midsummer (Daubenmire 1970; Hitchcock 1950; Stubbendieck and others 1986; Vallentine 1961). Its palatability is rated from fair to good depending upon associated plants. In many places, this species has been removed due to continued excessive grazing. On ranges in poor to fair condition, sand dropseed may still provide a major proportion of available forage (Alzerraca-Angelo and others 1998; Stubbendieck and others 1986). It is also used in early summer when plants are succulent. Cattle use it in fall following rainfall. This pattern of use favors sand dropseed growth (Johnson and Simon 1987). Plants will respond to fall rains and provide succulent forage into the winter months (Arnow 1987; Stubbendieck and others 1986). In addition, the herbage cures well and can provide fair to good winter forage (USDA Forest Service 1937).

Wild turkeys feed on sand dropseed in south-central South Dakota in the Missouri River Breaks region. This grass is an important component in the summer diet of Rocky Mountain bighorn sheep, and it is important to deer and elk during most seasons (Rominger and others 1988).

Sand dropseed is an important species that can be used to slow the spread of cheatgrass. Remnant stands and established plants are competitive and can reduce weed invasion. The species can often be seeded successfully on weedy sites if some initial control measures are used. Once established, it becomes highly competitive. It has been useful when planted on big sagebrush and mixed pinyon-juniper sites in central and southern Utah where some cool-season bunchgrasses are less well adapted. This species should be included in revegetation programs wherever it occurs naturally. It will tend to dominate in some areas such as sandy outcrops.

Varieties and Ecotypes

There are no released varieties. There is, however, considerable variation within the species. Care should be taken to insure that seed of adapted sources is seeded.

Stipa columbiana
Subalpine Needlegrass, Columbia Needlegrass

Synonyms

Achnatherum nelsonii
Stipa viridula var. *minor*
Stipa nelsonii
Stipa occidentalis

Description

Subalpine needlegrass is an erect, long-lived, cool-season, native perennial bunchgrass. It produces fine, densely bunched culms that are usually 12 to 24 inches (30 to 60 cm) tall, but can be as much as 39 inches (1 m) tall. Leaf sheaths are strongly ribbed. Leaf blades can be 4 to 10 inches (10 to 25 cm) long and 0.04 to 0.12 inch (1 to 3 mm) wide. Leaf edges are flat against the stem and then rolled inward toward the midrib, especially on younger leaves; they are hairless or slightly roughened to densely hairy and often strongly striated. Ligules are short, 0.01 to 0.07 inch long (0.2 to 2 mm), square, rather firm, and usually longest on the side. Panicles are narrow, dense, and 2.8 to 8 inches (7 to 20 cm) long (fig. 50). Panicle branches are short and remain close to each other. Spikelets produce only one floret about 0.8 to 1 inch (2 to 2.5 cm) long. The awn is short with the lower portion twisted. The basal end of the awn is sharp pointed (Arnow 1987; Hitchcock 1950; Hitchcock and others 1969; USDA Forest Service 1937).

Ecological Relationships and Distribution

Subalpine needlegrass grows in all of the Western States, particularly the Central Rocky Mountains. It occurs mostly above 8,000 ft (2,440 m), often in dense stands, on dry soils of open side hills. It also grows in mountain parks, subalpine herblands, and openings in aspen and conifer forests. It may occur as scattered individuals in mountain brush and upper elevation sagebrush areas. There are two recognized varieties: *S. c.* var. *columbiana* occurs from the Yukon to South Dakota and south to Texas and California; *S. c.* var.

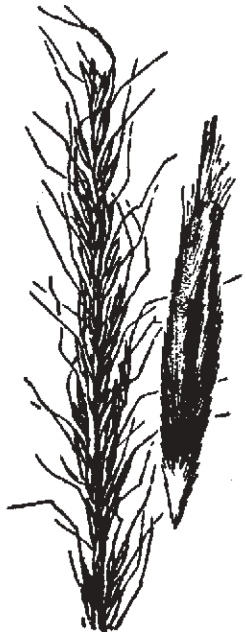

Figure 50—Panicles of subalpine needlegrass are narrow, compact, and up to 8 inches (20 cm) long; spikelets produce a single floret (Hitchcock 1950).

nelsonii occurs from Alberta to Washington and south to Arizona and Colorado (Hitchcock 1950).

Subalpine needlegrass often increases on ranges where wheatgrasses and bluegrasses have been removed by excessive use. It resprouts quickly after fires and is able to persist, while other species are often slower to respond. It recovers readily with rest from grazing, often more rapidly than most associated grasses. It will, however, suffer from use during periods of drought.

Subalpine needlegrass typically occurs as scattered individuals in sagebrush and mountain-brush communities, but denser stands may be found in subalpine grasslands (Vallentine 1961). It often exists on open south and west slopes in association with spreading rabbitbrush, western yarrow, and bluegrasses. Under these conditions it furnishes important ground cover and soil protection. This needlegrass is slightly to moderately damaged by fire (Wright and others 1979). It has moderate tolerance to salinity and will grow on soils ranging from sandy loam to clay loam to dry, rocky, infertile soils.

Plant Culture

Awns can be removed without damage to the seed, and seeds can be cleaned to purities exceeding 90 percent. Seed lots contain between 150,000 to 200,000 seeds per pound (330,000 to 440,000 seeds per kg). Considerable variation in seed weights, size, and dormancy exist among and within separate wildland collections. Afterripening of dry seeds does occur, and most seeds maintained in storage for 6 months will germinate. Seeds stored for 1 to 7 years usually germinate better than fresh seeds.

Cleaned seed lots can usually be planted with most conventional seeders without damaging the seed. Seeds are long and narrow and must be able to pass through openings and regulators that can accommodate long seeds. Seeds must be placed in the soil by drilling or other methods that bury the seed at least 0.25 to 0.50 inch (6 to 12 mm) deep. Broadcasting seeds on the soil surface without some means to cover them is not recommended. Seeds may be dormant, but fall seeding allows seeds to overwinter in the soil, which breaks dormancy and facilitates spring germination. Most species within this genus establish slowly the first season. Although first-year seedlings are normally small, survival may be quite high. Young plants can be slow to reach maturity, especially if seeded in mixtures with other, more rapidly developing species. The slow-developing plants furnish needed ground cover, and are less competitive with establishing shrubs and slower developing herbs. Once established, this perennial can persist with a number of other species in rather harsh environments. It is able to exist in the seedling stage with some degree of shade from mixed overstory shrubs.

Uses and Management

Subalpine needlegrass provides valuable forage for many species of wildlife and livestock. It begins growth in early spring and remains green throughout a long growing season, sometimes until early winter. Most needlegrasses cure well and are grazed during fall and winter (USDA Forest Service 1937). The pointed callus of subalpine needlegrass sometimes works into the mouth and ears of livestock (Stubbendieck and others 1992); this causes animals to often avoid the mature seed.

Palatability of subalpine needlegrass is rated as good for cattle and horses, fair to good for sheep and deer, and fair for antelope. It is especially valuable for sheep in the spring and for livestock in the summer. Deer use it in summer, and many other wildlife species consume it throughout the growing season (Vallentine 1961). It is particularly valuable for deer and elk in late fall and winter, as some green remains on the plant. Like most needlegrasses, subalpine needlegrass is palatable early in the season, becoming less so as the foliage becomes coarse and wiry (USDA Forest Service 1937). This species also provides cover for small mammals and birds (Dittberner and Olson 1983).

Subalpine needlegrass is characterized by a slow to moderate seedling growth rate, moderate salinity tolerance, and the ability to grow on a number of soil types. It is an important species for revegetation of a variety of plant communities that are often seeded to intermediate wheatgrass and smooth brome. It establishes well and can be used to reestablish native communities, especially where a mixture of species and plant types are desired.

Varieties and Ecotypes

A number of accessions are undergoing development. Accession 9040137 from San Lewis Valley and Accession 9024804 from western Colorado, are being advanced toward release by the Upper Colorado Environmental Plant Center, in Meeker, CO. These are adapted to areas at elevations of 5,000 to 12,000 ft (1,525 to 3,660 m) receiving 15 inches (380 mm) or more of annual precipitation. They have potential for soil stabilization, rangeland seedings, and revegetation of disturbed sites in the West (Alderson and Sharp 1994).

Stipa comata
Needle-and-Thread

Synonyms

Hesperostipa comata
Stipa juncea
Stipa tweedyi

Description

Needle-and-thread is an erect, long-lived native perennial cool-season bunchgrass. It is named for the exceptionally long, twisted, and tapering awns that resemble threaded sewing needles. Plants are tufted with culms that are 1.0 to 3.6 ft (3 to 11 dm) tall and often slightly hairy at the nodes. Sheaths are smooth to roughened, strongly ribbed, and usually longer than the internodes. Leaf blades are involute, or if flat, up to 0.12 inch (3 mm) wide and 4 to 12 inches (10 to 30 cm) long, roughened on the upper surface, and smooth to slightly roughened beneath. Ligules are 0.04 to 0.24 inch (1.1 to 6 mm) long, more or less minutely hairy, and usually tapering to a tip. They may become lacerate with age. Panicles are 5 to 15.5 inches (13 to 40 cm) long, narrow, and usually partly enclosed in an inflated sheath. Panicle branches are usually slender and ascending, sometimes with drooping spikelets. Glumes are long and narrow, tapering to a fine point. They are five nerved, slightly convoluted, hairless, and papery, with translucent margins and tips. The first glume is 0.7 to 1.4 inches (1.8 to 3.5 cm) long, and the second is 0.6 to 1.3 inches (1.5 to 3.4 cm) long. Lemmas are 0.32 to 0.55 inch (8 to 14 mm) long, pale green to yellowish or brownish, sparsely covered with appressed silky hairs, and often hairless toward the tip. The swollen node (callus) at the base of the floret is very sharp, about 0.12 inch (3 mm) long. The first joint in the awn is distinct; the second is rather indistinct and more flexuous. The lower segment is tightly twisted and roughened; the terminal segment is not (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; USDA Forest Service 1937) (fig. 51).

Ecological Relationships and Distribution

Needle-and-thread is widely distributed throughout the Western States and Great Plains. It commonly occurs in sagebrush-grass, pinyon-juniper, and ponderosa pine communities of the Rocky Mountains, Intermountain West, and semidesert plains and foothills of the Southwest. Needle-and-thread is most often found on well-drained soils.

With overgrazing, needle-and-thread is one of the first species to disappear from native pastures and

Figure 51—Needle-and-thread is named for the florets with their extremely long awns that resemble threaded sewing needles (photo courtesy of Loren St. John, USDA NRCS, Aberdeen Plant Materials Center, Aberdeen, ID).

range sites. Likewise, it is one of the first species to respond and reoccupy native communities following rest from grazing.

Plant Culture

Needle-and-thread depends on seed for reproduction. In favorable areas, it reproduces well and it is able to withstand grazing in spring and fall if plants are allowed to mature seed in summer. On drier ranges, however, it does not reproduce readily and it is easily killed by overuse.

Needle-and-thread can be established in sagebrush and some salt desert shrublands. It is drought tolerant and requires well-drained soil. Seeds can be drilled or broadcast, but they must be covered with at least 0.25 inch (6 mm) of soil. Needle-and-thread can be seeded successfully with most native perennial grasses and broadleaf herbs. It should not be seeded with species that are vigorous competitors. Seedling development of needle-and-thread can be slow, but even during low-precipitation years some seedlings will generally establish. It may fail to develop dense or dominant stands for the first 5 to 10 years after planting, even when seeded alone. After this time, the stands develop slowly, even during years of low annual rainfall. As the stand becomes denser, persistent perennials may be suppressed. Seeded stands of needle-and thread have displaced intermediate wheatgrass on some pinyon-juniper planting sites in central Utah approximately 25 years after the initial seeding. This species has also recovered naturally on sites where pinyon and juniper trees have been removed and the native understory has been allowed to recover. Heavy grazing by livestock or big game can delay or suppress natural recovery.

Needle-and-thread has not prevented shrub seedling establishment when seeded with big sagebrush, antelope bitterbrush, Stansbury cliffrose, or curlleaf mountain mahogany. It can be utilized to establish a mixed array of native species without necessitating separate planting operations. Stands of this species provide sufficient competition to restrict the spread of annual weeds. It recovers quickly after burning and does not allow weeds to enter after fires.

Needle-and-thread seed is marketed with the awn removed. There is an average of 115,000 seeds per pound (253,000 seeds per kg). Some seed dormancy exists, but seed with 75 to 85 percent germination and 80 to 85 percent purity is generally marketed. Seed can be stored for a number of years with little loss of viability. The long, tough awns limit commercial production and use of this species. Some growth forms produce seeds with flexible awns that do not break from the seeds. Growth forms with brittle awns can be cleaned and seeded with much less difficulty. Techniques and equipment have been developed to de-awn some seeds. Even when cleaned, the sharp tip on the seed and awn fragments can cause handling and seeding problems. Mixtures of needle-and-thread and non-awned seed of other species can be planted with most seeders.

Uses and Management

Needle-and-thread is an important range grass for livestock and wildlife species because of its early spring and late fall greenup, palatability, volume of forage produced, and widespread distribution. The forage value of needle-and-thread varies depending on the region, season, and associated plants. Its palatability is rated very high in early spring before the awns develop and again after the seeds are dispersed. It is especially valuable because it begins development in early spring when other grasses have not yet initiated growth. An abundance of herbage is produced and will remain green through summer and fall if adequate moisture is available. Awns can become a problem when the fruit matures because the sharp, barbed lemmas can injure grazing animals. New growth is produced in summer and fall if rainstorms occur. Needle-and-thread cures well and is often utilized as winter forage. This is one of the most important grasses of semiarid and arid shrublands of the Intermountain region. Its loss due to grazing has resulted in an increase of annual weeds, particularly cheatgrass. Recovery of this perennial is critical to control weeds. This species is an important element of the shrub-bunch grass communities and pinyon-juniper woodlands, and reestablishment of functional communities requires inclusion of this species.

Varieties and Ecotypes

There are no released varieties. Care should be taken to ensure that seed of adapted populations is planted. Great Plains collections do not do especially well in the Intermountain West.

Stipa lettermanii
Letterman Needlegrass

Synonyms

Stipa viridula var. *lettermanii*

Description

Letterman needlegrass is an erect, fine-stemmed, densely-tufted, native perennial bunchgrass that often forms large clumps. Stems are slender and 8 to 20 inches (20 to 50 cm) tall. Leaves are threadlike and somewhat twisted. Culms are 10 to 33 inches (2.5 to 8.5 dm) tall. Culms and leaf sheaths are hairless or minutely roughened. Leaf blades are involute, rounded, rarely flat, and up to 0.08 inch (2 mm) wide and 4.0 to 8.0 inches (10 to 20 cm) long, stiff haired above and hairless to minutely roughened below. Ligules are 0.01 to 0.08 inch (0.2 to 2 mm) long and rounded to square. Panicles are narrow and about 2.8 to 9.5 inches (7 to 24 cm) long with erect branches and spikelets. Glumes are subequal, 0.20 to 0.41 inch (5 to 10.5 mm) long, and taper gradually to a tip. They are often purple with translucent margins, hairless or sometimes minutely roughened, and three nerved. Lemmas are only slightly hardened, 0.20 to 0.26 inch (4.5 to 6.7 mm) long, and pale with soft, slender, somewhat appressed hairs that become longer toward the tip. The callus often has dense, white hairs less than 0.04 inch (1 mm) in length. Awns are 0.40 to 0.87 inch (1.0 to 2.2 cm) long, slender, and twice bent with the lower segment loosely twisted and minutely roughened; the terminal segment is 0.3 to 0.5 inch (7 to 12 mm) long and hairless. The basal end of the seed tapers to a pointed tip (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; USDA Forest Service 1937).

Letterman needlegrass is often misidentified as subalpine needlegrass because the two plants are similar in size. They can, however, be differentiated by the width and length of the palea in relation to the length of the lemma. The palea of Letterman needlegrass is about two-thirds the length of the lemma, and it is often exposed. The palea of subalpine needlegrass is less than half as long as the lemma. The distribution of the two species is about the same, both grow in all Western States, with the Central Rocky Mountains as their center of distribution. Letterman needlegrass is, however, less abundant at the northern and southern ends of its range, and it does not extend to altitudes as high as does subalpine needlegrass.

Ecological Relationships and Distribution

Letterman needlegrass is found on dry soils in open mountain parks, mountain meadows, subalpine grasslands, and in openings in aspen and conifer forest from Oregon and Montana, south to Arizona and New Mexico (fig. 52). It is also found in midelevation pinyon-juniper, sagebrush, and mountain brush communities. It grows best on sandy loam, loam, or clay loam soils 20 inches (51 cm) or more in depth (Dittberner and Olson 1983). It tends to increase under heavy grazing by sheep and decrease under heavy cattle use.

Letterman needlegrass is a climax or late seral species in a number of grassland, sagebrush, mountain-shrub, and pinyon-juniper communities. It also grows well in early successional assemblages, and is well represented in many early to late seral plant associations (Schott 1981).

Plant Culture

Seeds may be drilled or broadcast seeded, but they must be covered with about 0.25 inch (0.60 cm) of soil. Fall seeding is recommended because seed dormancy can be overcome by overwinter stratification.

Letterman needlegrass has been seeded successfully on disturbed sites to control erosion, revegetate mines, and restore lost stands. As is the case for other needlegrass species, seedlings develop slowly. Letterman needlegrass can be planted with most native species that are not highly competitive. Letterman needlegrass usually produces seeds each year, and it will spread into unoccupied sites.

Uses and Management

Letterman needlegrass is an important component of many sagebrush, mountain brush, and aspen communities where it may vary in density and abundance. It recovers well after fires and can persist with some shade or competition. Although it is rated as only fair for cattle and poor for sheep, it is an important forage species on many sites (USDA Forest Service 1937). Heavy grazing by cattle or sheep can cause a decrease, or sometimes a short-term increase, in density.

Letterman needlegrass provides valuable forage for wildlife and domestic livestock. Plants begin growth early in the year, and they remain green throughout the summer and late fall. This enables Letterman needlegrass to be utilized when many other grasses are less available or palatable. Most needlegrasses, including Letterman needlegrass, cure well and can be utilized in fall and winter. This species is particularly

Figure 52—Letterman needlegrass grows in mountain meadows, forest openings, and subalpine grasslands (RMRS photo).

important as late fall and early winter forage for big game; the presence of some green material within the plant attracts these animals and influences their distribution.

Varieties and Ecotypes

There are no releases.

Stipa thurberiana
Thurber Needlegrass

Synonyms

Achnatherum thurberianum
Stipa occidentalis

Description

Thurber needlegrass is a densely tufted perennial with culms 1.2 to 2.6 ft (3.5 to 8 dm) tall that are minutely hairy, at least at the nodes. Leaf sheaths are striated and usually hairless, but sometimes minutely haired below. Blades are needlelike, involute, minutely roughened, and 3.9 to 9.8 inches (10 to 25 cm) long. Ligules are 0.08 to 0.28 inch (2 to 7 mm) long, thin and translucent, hairless to sparsely haired, and tapering at the tip. Panicles are narrow and about 2.8 to 9.5 inches (7 to 24 cm) long with erect branches that are relatively few flowered. Glumes are subequal and 0.31 to 0.63 inch (8 to 16 mm) long with the second slightly shorter than the first. They are three- to five-nerved, often purplish and translucent above, and taper to a soft tip. Lemmas are 0.24 to 0.34 inch (6.2 to 8.7 mm) long and sparsely covered with silky, appressed hairs. The callus is about 0.04 inch (1 mm) long, with dense, appressed hairs. Awns are 1.2 to 1.8 inches (30 to 45 mm) long and bent twice. The lower segments are twisted with stiff, feather-like hairs up to 0.08 inch (2 mm) long. The terminal segment is 0.6 to 1.2 inches (16 to 30 mm) long and roughened to hairless. Thurber needlegrass flowers from late May through July. It is known to hybridize with *Oryzopsis hymenoides*, producing the hybrid *Stipa bloomeri* (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; Johnson 1945).

Ecological Relationships and Distribution

Thurber needlegrass ranges from eastern Washington, Oregon, and California, to northern Nevada, southern Idaho, southwestern Montana, and northeastern Wyoming (Arnow 1987, 1993; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969). It may occur as a dominant or associated mid to late seral species in grasslands, sagebrush deserts, and pinyon-juniper, oak, and ponderosa pine woodlands (fig. 53). In sagebrush deserts it is most common in communities receiving 6 to 16 inches (152 to 406 mm) of annual precipitation (USDA Natural Resources Conservation Service 2003). It is fairly widespread in the northwestern portion of the Great Basin.

Thurber needlegrass is adapted to soils ranging from well-drained clay loams to coarse-textured soils that are fairly neutral (USDA Forest Service 1937; USDA Natural Resources Conservation Service 2003). Plants are tolerant of drought and cold, but they are not salt or shade tolerant (USDA Natural Resources Conservation Service 2003).

Response of Thurber needlegrass to fire is variable, but it is generally less resistant to burning than other bunchgrasses (Wright and others 1979). Burning is more damaging early in the season than later (Britton and others 1990; Ganskopp 1988; Uresk and others

Figure 53—Thurber needlegrass occurs as a dominant or common associated species on dry big sagebrush sites (RMRS photo).

1980). The presence of dry and sometimes abundant leafy culms contributes to surface heating and burning of the root crown during wildfires (Wright and Klemmedson 1965). Accumulations of dead vegetative material contribute to fire damage at all seasons. Plants may be killed or living tissue may survive near the edges of the root crown. Plants then regenerate from tillers if postfire weather conditions permit (Britton and others 1990; Koniak 1985; Uresk and others 1976, 1980). Surviving plants recover slowly and exhibit reduced vigor and productivity for up to 3 years. The number of inflorescences and seed production, however, may be enhanced by burning (Uresk and others 1980), contributing to postburn regeneration from seed (Hironaka and others 1983).

Thurber needlegrass seedlings compete poorly with those of more competitive annual and perennial grasses (Evans and Young 1978; Uresk and others 1980; Young and Evans 1978). Dependence on residual or offsite seed sources and low germination and seedling vigor tend to slow recovery following burns. Consequently, Thurber needlegrass often does not become abundant until communities are mid to late successional (Koniak 1985).

Plant Culture

Thurber needlegrass ripens in mid to late summer (Sampson 1924). Seed production is generally low. There are about 225,000 seeds per pound (496,035 per kg) (USDA Natural Resources Conservation Service 2003). Haferkamp and McSwain (1951) found that germination was enhanced by incubation at a fluctuating (68/86 °F) (20/30 °C) temperature (16 hrs/8 hrs) with exposure to light during the high-temperature periods.

Thurber needlegrass can be seeded on adapted sites receiving as little as 10 inches (254 mm) of annual precipitation (Thornburg 1982). Litter has been found to reduce germination and early growth of Thurber needlegrass seedlings, but it was also associated with improved growth of establishing seedlings 4 weeks after germination (Schlatterer and Tisdale 1969). Seedling vigor is low to moderate (Hironaka and others 1983; USDA Natural Resources Conservation Service 2003), and spread of stands from seed is slow.

Uses and Management

Thurber needlegrass provides valuable forage for livestock and wildlife. Deer, wild horses, pronghorn, black-tailed jackrabbits, and other species graze the herbage (Fagerstone and others 1980; McInnis and Vavra 1987; Trainer and others 1983; Uresk and others 1976). Birds and other small animals use its seeds. Thurber needlegrass and associated species provide cover for many small vertebrates and invertebrates (Stanton 1974). Sage-grouse hens were found to use a Wyoming big sagebrush/Thurber needlegrass cover type in eastern Oregon prior to nesting (Barnett and Crawford 1994).

Thurber needlegrass is valuable for cattle and sheep in early spring when other forage is not available. Palatability and nutritive value of the species is greatest early in the season, declining as plants and seeds mature and the forage becomes coarse (USDA Forest Service 1937). Leaves are used to a greater degree than stems. The species tends to be avoided as the seeds mature because the awns can irritate or injure the ears, eyes, and noses of grazing animals. Because of this, considerable seed generally matures, even in areas grazed by livestock (Jensen and others 2001; USDA Forest Service 1937). Thurber needlegrass remains green after other grasses dry and provides useful forage in fall.

Thurber needlegrass stands are damaged by excessive grazing and fire. Overgrazing in spring can be particularly detrimental because defoliation, particularly during the boot stage, can weaken plants (Ganskopp 1988). The species tends to increase with protection from grazing (Robertson 1971). Thurber needlegrass can be used for reclaiming mine sites and other disturbances on dry sites where it is adapted. Such uses, however, are limited by a lack of seed.

Varieties and Ecotypes

There are no releases.

Stipa viridula Trin. Green Needlegrass

Synonyms

Nassella viridula
Stipa parviflora
Stipa nuttalliana
Stipa sparta

Description

Green needlegrass is a long-lived, native, cool-season, perennial bunchgrass that is tolerant of drought, cold winters, and a wide range of soil types. It is a tufted perennial with culms 1.6 to 3.6 ft (5 to 11 dm) tall. Leaf sheaths are persistent and hairless or hairy along the margins. Blades are flat to involute, smooth or roughened, and 0.80 to 0.24 inch (2 to 6 mm) wide. Ligules are 0.02 to 0.12 inch (0.5 to 3 mm) long. Many plants are functionally pistillate and bear only small, sterile anthers; thus, the species may be semi-dioecious. Panicles are narrowly oblong, 4 to 10 inches (1 to 2.5 dm) long, and approximately 0.8 inch (2 cm) wide. Panicle branches are erect or only slightly divergent. Glumes are translucent throughout, or nearly so, equal or subequal, and 0.32 to 0.51 inch (8 to 13 mm) long, tapering to a long, hairlike tip. They are prominently three to five nerved and hairless. The lemma is brown and leathery at maturity, 0.20 to 0.26 inch (5 to 6.5 mm) long, and narrowed toward the tip into a hairless, whitish "neck" approximately 0.04 inch (1 mm) long. The awn is 0.8 to 1.4 inches (2 to 3.5 cm) long and twice bent, with the two lower segments twisted and minutely roughened. The callus is up to 0.04 inch (1 mm) long, with a very short, blunt, hairless tip (Arnow 1987; Cronquist and others 1977; Hitchcock 1950; Hitchcock and others 1969; USDA Forest Service 1937). Green needlegrass occasionally hybridizes with Indian ricegrass, but the offspring are sterile (Hitchcock and others 1969).

Ecological Relationships and Distribution

Green needlegrass is a perennial bunchgrass distributed from British Columbia to Minnesota, Kansas, New Mexico, Arizona, Nevada, and western Washington. It occurs more commonly in Montana, Wyoming, and Colorado than in the other Western States. Green needlegrass grows on dry slopes, plains, prairies, and foothills at lower elevations and often may be found growing along roadways. It is also common in mountain meadows, open woodlands, and on hillsides at higher elevations. At the southern edge of its distribution, green needlegrass grows in dry parks and canyons and with ponderosa pine (USDA Forest Service 1937). It is a prominent species in many grassland and sagebrush communities, and it grows well on abandoned agricultural lands (Wasser 1982).

Green needlegrass exists as an early or late seral species. It is adapted to a wide range of soils. It grows especially well on clay and moderately alkaline soils derived from calcareous shales. It is somewhat less adapted to loam and sand, and it is not very tolerant of saline conditions (Wesser 1982). This species exhibits considerable drought tolerance, which is nearly equal to that of western wheatgrass. It can be found growing in areas with as little as 10 inches (250 mm) of annual precipitation. Optimum growth occurs with 12 to 20 inches (310 to 510 mm) of precipitation. It grows, however, in areas with as much as 30 inches (760 mm) precipitation and in areas with water tables only 1 to 2 ft (30 to 60 cm) deep (Wasser 1982). Green needlegrass is moderately tolerant of flooding, only weakly tolerant of shade, and somewhat tolerant of fire, depending on the season of burn and site conditions.

Plant Culture

Green needlegrass flowers and disperses seeds from July to September. Cleaning seeds to remove the awns and other debris can be completed without damage to the seed. There are an average of 181,000 seeds per pound (400,000 per kg). Seed of most green needlegrass collections exhibit relatively high levels of seed dormancy. It is not uncommon to purchase fresh seed with less than 10 percent germination and 90 percent hard seed. Considerable afterripening occurs during dry storage with germination percentage increasing up to 7 years after harvest (Rogler 1960). Consequently, better stands are normally obtained with older seed. Fall seeding allows seeds to overwinter in the soil. This can relieve dormancy and allow seeds to germinate and seedlings to establish in spring. For this reason spring seeding is not recommended. Seed can be drilled or broadcast but must be covered because maximum germination occurs in darkness (Fulbright and others 1982). Seed need not be seeded deeper than about 0.25 inch (6 mm).

Germination potential and seed maturity are correlated. Immature seed, which is light gray to yellowish green, has a lower average weight than does mature seed, which is a uniform gray (Kinch and Wiesner 1963). Average viability of immature seed is approximately 22 percent compared with 71 percent for mature seed (Kinch and Wiesner 1963).

Within the Intermountain region, green needlegrass has performed well when planted in aspen, mountain brush, and mountain big sagebrush communities. Sites that receive at least 14 inches (350 mm) of annual precipitation will generally support this grass. Vigor of green needlegrass seedlings is good (Kinch and Wiesner 1963). However, when planted with pubescent or intermediate wheatgrass, its initial performance has been suppressed by these sodformers.

Mature green needlegrass plants are very competitive with annual weeds, but new seedlings are not. When planted in areas with cheatgrass and other annuals, the weedy species must be eliminated or controlled to facilitate the establishment of this perennial. New plants will establish in areas where annual kochia and mustards dominate. New seedlings are also able to establish and survive in mixed grass-forb seedings. Green needlegrass typically establishes well but can decrease over time; it is often planted in mixtures of cool-season, native or introduced grasses or forbs that tend to persist.

Uses and Management

Many *Stipa* species produce awns or calluses that cause injury to grazers. This is not the case with green needlegrass. Green needlegrass provides valuable forage for many species of wildlife and all classes of livestock (fig. 54). It is palatable to cattle and horses season long, but is used by sheep primarily in spring and early summer (USDA Forest Service 1937).

Green needlegrass begins growth in early spring and remains green until late summer when most other grasses have dried. In many areas, annual growth

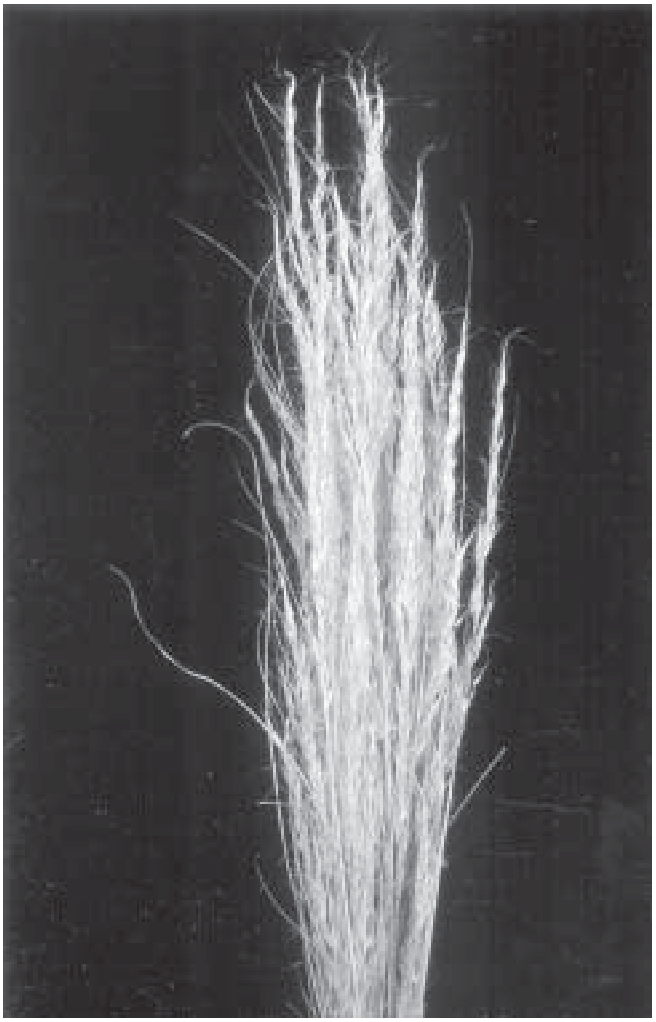

Figure 54—Most common in the northern Great Plains, green needlegrass provides forage for many wildlife species (photo courtesy of Tom Jones, USDA ARS, Logan, UT).

begins as early as March (Wasser 1982), with most growth occurring May and June. Late-season regrowth can be good if fall precipitation is sufficient. This species is generally found in mixed stands with other grasses, although dense stands are common. As a result, succulent forage is available over a longer period of time where green needlegrass is part of the community. Green needlegrass cures well and can be used for fall and winter grazing.

Green needlegrass is moderately resistant to heavy grazing (Wasser 1982), and generally recovers quickly (Kinch and Wiesner 1963). It can be harmed by intense early-season grazing (Wasser 1982). Wasser (1982) recommends moderate grazing of stands and resting a different unit for 2 months during the growing season each year. When green needlegrass occurs with warm-season grasses, seeded stands should be grazed during the spring and fall or in winter (Wasser 1982).

Green needlegrass has been successfully seeded throughout the Intermountain area. It has done especially well on disturbed sites in the mountain brush zone and lower elevation aspen zones. Green needlegrass has been widely used for rehabilitating disturbed sites. This species has a wide range of adaptation and performs well in rangeland plantings in the aspen and mountain brush communities throughout the Intermountain West. It has also performed well on mine and rangeland seedings in eastern Wyoming, Montana, and western Colorado. Green needlegrass is particularly useful for erosion control. It has been successfully seeded on abandoned farmlands and pastures. Seedlings develop slowly, and should not be grazed for up to 4 years following seeding. This species can be planted in mixtures to restore native communities. It does not compete to exclude native shrubs and herbs.

Varieties and Ecotypes

'Cucharas' was collected near Walsenburg, CO, and is recommended for use in the Central Great Plains (Jones and Larson, in press; Jones and others 2002d, 2004b). It was selected for its high germination without a wet prechill treatment. Cucharas was recommended for release as a Selected Germplasm by the Utah Agricultural Experiment Station in 2002.

'Lodorm' originated near Bismarck, ND (Alderson and Sharp 1994), and is seeded for forage, soil stabilization, and revegetation of mined sites and other disturbances. Lodorm was developed for the Northern Great Plains, but it is also being seeded in the Intermountain West. It is adapted to areas receiving 14 or more inches (355 mm) of annual precipitation and elevations above 9,000 ft (2,745 m) in mountain brush, ponderosa pine, and aspen openings. It is seeded on bottomlands, flats, benches, and along streams. Lodorm is adapted to silt and clay soils, and it is tolerant of dense clays. It will also grow on loamy and sandy soils. This variety exhibits rapid vegetative recovery, high palatability, low seed dormancy, and rapid germination. It is compatible with other natives and can be sown in mixtures. Fall seeding is recommended to relieve seed dormancy. This grass is very winter hardy, tolerant of fire and short-duration flooding, and weakly shade tolerant.

Richard Stevens
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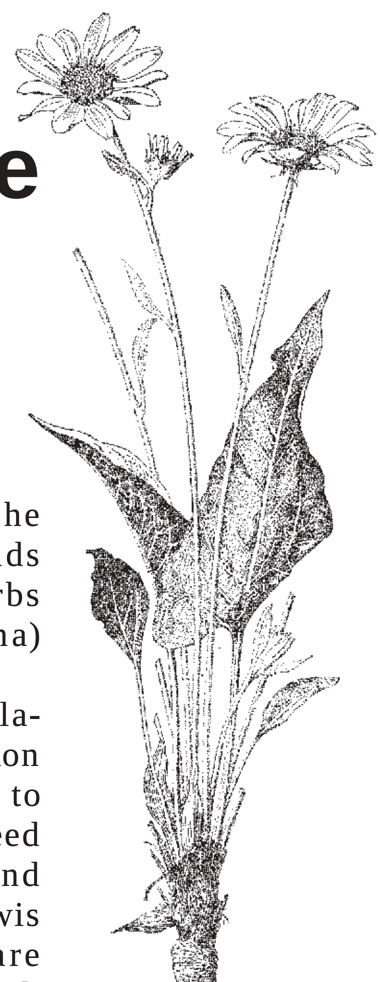
Chapter 19



Forbs for Seeding Range and Wildlife Habitats

Forbs are abundant in all vegetative types throughout the Intermountain West. Most are found intermixed in grasslands and as understory plants in shrub and forest types. Forbs provide ground cover, soil stability, community (flora and fauna) diversity, nutritious forage, and are of aesthetic value.

Forbs should be seeded in most range, watershed, mine reclamation, highway, recreational site, restoration and revegetation projects. Many commonly used forbs have been introduced to the Intermountain West and are now under cultivation for seed production. The principal introduced forbs planted on range and wildlands are alfalfa, small burnet, and cicer milkvetch. Lewis flax, Rocky Mountain penstemon, and Palmer penstemon are the major native forbs being commercially grown and planted. Additional species are being commercially grown in seed fields as demand increases. Seeds of many native species are collected from wildland stands but generally are in short supply.

Chapter Contents by Species

Important characteristics of a number of forbs are listed in table 1. Seeding recommendations for principal vegetative types and conditions are discussed in chapter 17. Seed characteristics and information about collection, cleaning, and storage are provided in chapter 24. Forbs adapted to different vegetative types and conditions are included in the seeding recommendations.

The following forb species have the potential for improving range and wildlife habitats in the Intermountain West. A brief description along with information regarding ecological relationships and distribution, cultural requirements, use, and management of each species are included.

Table 1—Characteristics of Selected Forbs.

	Ratings[b]																			
Species	Ease of handling seed	Ease of seeding	Ease of trans-planting	Germi-nation	Initial estab-lishment	Seedling growth rate	Final estab-lishment	Persis-tence	Natural spread	Forage yield	Early spring palata-bility	Summer palata-bility	Toler-ance to grazing	Evergreen-ness	Compati-bility with other species	Seed produc-tion	Soil stability	Flood toler-ance	Shade toler-ance	Range of adapt-ability	Vegetative type[a] to which the species is adapted
Alfalfa, range type	5	5	4	5	5	5	4	5	4	5	5	4	4	3	5	5	4	2	4	5	SA,A,PP,MB,JP,MS,BS,WS
Alfileria	2	4	2	4	4	5	3	2	5	3	5	3	4	1	3	4	3	1	3	3	JP,MS,BS,WS,BB
Angelica, small leaf	2	5	1	4	5	5	3	3	3	4	5	4	3	1	3	5	3	3	3	2	SA,A,MB
Aster, blueleaf	2	2	5	4	4	4	5	5	5	4	4	5	5	2	2	3	5	4	3	4	A,WM,PP,MB,JP,BS
Aster, Englemann	2	2	4	3	3	3	4	4	5	4	4	5	4	2	4	2	4	4	4	2	A,WM,PP,MB
Aster, Pacific	2	2	5	4	3	3	4	5	5	3	5	5	5	2	3	3	5	4	3	4	A,WM,PP,MB,JP,MS,BS
Balsamroot, arrowleaf	4	4	1	3	1	1	4	5	2	5	5	1	4	1	4	4	3	1	2	3	PP,MB,JP,MS,BS
Balsamroot, cutleaf	4	4	1	3	1	1	4	4	2	3	4	1	4	1	4	3	3	1	2	2	PP,MB,MS
Balsamroot, hairy	4	4	1	3	1	1	4	5	2	4	5	1	4	1	4	4	3	1	3	2	PP,MB,MS
Bluebell, tall	3	3	4	3	2	4	3	4	3	5	5	5	4	1	2	3	4	4	3	2	SA,A,WM
Bouncing-bet	5	5	5	4	4	4	4	5	5	4	3	3	4	2	3	4	5	4	3	3	PP,MB,MS
Burnet, small	5	5	4	5	5	5	3	3	4	3	5	5	3	5	4	5	3	2	2	3	PP,MB,JP,MS,BS,WS
Cinquefoil, gland	4	4	5	4	5	4	5	5	5	5	3	3	5	1	5	4	5	4	1	3	A,WM,PP,MB
Clover, alsike	5	5	5	4	4	3	4	4	4	4	4	4	4	2	3	3	4	5	3	1	WM
Clover, strawberry	5	5	5	5	4	3	4	5	5	2	4	4	4	2	4	3	4	5	3	2	WM,IS
Columbine, Colorado	2	4	4	3	3	3	4	3	2	2	4	4	2	1	4	2	3	5	5	2	SA,A,WM
Cow parsnip, common	3	3	2	3	2	3	4	3	2	5	4	4	2	1	4	4	3	4	4	2	SA,A,WM
Crownvetch	5	5	5	4	4	4	4	5	5	4	4	4	4	2	2	4	5	3	4	3	A,PP,MB,MS
Daisy, common oxeye	3	3	4	2	2	3	5	5	5	2	4	5	4	2	3	3	4	2	3	3	A,PP,MB,JP
Deervetch, birdfoot	3	4	5	4	4	4	4	3	4	5	5	5	5	2	3	3	5	3	3	3	A,PP
Eriogonum, cushion	4	4	2	4	4	3	4	4	3	2	3	5	4	4	3	4	3	2	3	4	PP,MB,JP,MS,BS
Fireweed	1	2	4	5	5	5	3	2	5	4	4	3	5	1	4	4	4	3	4	3	SA,A,WM,PP,MB,JP,MS,BS
Flax, Lewis	5	5	4	4	5	4	4	3	5	3	5	3	4	4	4	4	3	2	3	4	PP,MB,JP,MS,BS,WS
Geranium, Richardson	2	3	4	3	2	4	4	4	3	3	4	4	4	2	4	2	3	4	4	2	SA,A,WM
Geranium, sticky	2	3	4	3	2	4	4	4	3	3	4	4	4	2	4	2	3	4	4	2	SA,A,WM
Giant hyssop, nettleleaf	2	4	3	3	2	3	3	3	3	4	4	4	4	2	4	4	3	3	3	2	SA,A,MB
Globemallow, gooseberryleaf	3	5	3	3	3	3	4	4	4	3	3	2	4	2	4	3	4	2	2	3	JP,MS,BS,WS,SS,BB
Globemallow, scarlet	4	4	4	2	3	4	4	5	3	3	3	3	4	2	4	3	4	3	3	3	MB,JP,MS,BS,WS,SS,BG,BB
Globemallow, stream	4	5	4	3	2	3	4	4	4	4	3	3	3	3	4	3	4	3	2	3	JP,MS,BS,WS,SS,BB
Goldeneye, Nevada	3	3	4	4	4	4	3	3	5	3	4	4	4	1	4	3	3	2	2	3	MS,BS,WS
Goldeneye, showy	3	3	4	4	4	4	4	3	5	3	4	4	4	1	4	4	3	4	3	3	SA,A,PP,MB,JP,MS,BS
Goldenrod, Canada	2	2	4	3	3	3	4	4	4	4	4	4	4	2	4	4	4	4	3	3	A,PP,MB
Goldenrod, low	2	2	4	4	3	4	4	4	4	4	4	4	5	2	3	4	5	3	3	3	A,PP,MB
Goldenrod, Parry	2	2	4	4	3	4	5	4	4	4	4	4	5	2	3	4	5	3	3	4	A,PP,MB
Groundsel, butterweed	4	2	4	3	3	3	4	4	4	4	3	4	4	2	3	4	4	4	3	2	A,PP,MB
Helianthella, oneflower	4	3	3	5	4	3	3	4	4	3	4	3	3	1	5	3	3	2	3	3	A,PP,MB,MS
Iris, German (common iris)	1	4	5	2	1	4	5	5	4	2	5	4	4	5	3	1	4	4	4	4	SA,A,PP,MB,JP,MS,BS,WS
Ligusticum, Porter	4	3	2	4	3	3	3	4	3	3	4	4	4	1	3	4	3	2	3	2	A,PP,MB

(con.)

Table 1 (Con.)

Species	Ease of handling seed	Ease of seeding	Ease of trans-planting	Germi-nation	Initial estab-lishment	Seedling growth rate	Final estab-lishment	Persis-tence	Natural spread	Forage yield	Early spring palata-bility	Summer palata-bility	Toler-ance to grazing	Evergreen-ness	Compati-bility with other species	Seed produc-tion	Soil stability	Flood toler-ance	Shade toler-ance	Range of adapt-ability	Vegetative type[a] to which the species is adapted
	Ratings[b]																				
Lomatium, nineleaf	3	3	4	3	3	4	4	4	3	3	4	3	4	1	4	3	4	3	3	3	PP,MB,MS
Lomatium, nuttall	3	3	3	3	3	3	4	3	3	2	5	2	4	1	3	4	3	2	3	3	A,PP,MB
Lupine, Nevada	5	5	2	3	3	3	4	4	3	4	4	4	4	1	4	3	3	2	3	4	JP,MS,BS,WS
Lupine, silky	5	5	2	3	3	3	4	4	3	4	4	4	4	1	4	3	3	3	3	4	A,PP,MB,MS
Lupine, silvery	5	5	2	3	4	3	4	4	3	4	4	4	4	1	4	3	3	3	3	4	A,PP,MB,MS
Medick, black	4	5	5	5	5	4	4	4	4	3	4	4	4	2	4	5	5	4	3	2	A,WM,PP,MB, JP,MS,BS
Milkvetch, cicer	4	5	5	3	3	3	4	5	5	5	4	4	5	3	4	5	5	3	4	4	SA,A,WM,PP, MB,JP,MS,BS
Milkvetch, Snake River plains	4	5	2	3	3	3	4	5	4	4	4	4	4	3	4	3	4	3	4	3	PP,MB,JP,MS, BS,WS
Milkvetch, tall	4	5	2	3	4	4	4	4	4	2	3	4	4	3	3	3	4	4	4	2	PP,MB,JP, MS,BS
Painted-cup, northwestern	2	4	1	2	2	3	4	3	2	3	4	4	2	1	2	2	1	3	3	3	SA,A,WM,PP, MB,JP,MS,BS, WS
Peavine, flat	4	5	4	3	3	3	3	4	3	4	4	4	3	3	5	2	5	4	4	3	SA,A,PP,MB
Peavine, perennial	4	5	4	3	3	4	4	4	4	3	3	5	3	2	3	3	4	4	4	3	SA,A,PP,MB
Peavine, thickleaf	4	5	4	3	2	3	4	5	3	4	4	4	4	2	4	2	5	4	4	4	SA,A,PP,MB
Peavine, Utah	4	5	3	3	2	3	4	4	3	4	5	5	3	2	4	2	4	4	4	3	SA,A,PP,MB
Penstemon, Eaton	5	5	5	3	5	4	4	3	5	3	4	4	3	3	3	3	3	3	3	4	PP,MB,JP,MS, BS,WS
Penstemon, littlecup	5	5	4	4	3	2	4	4	4	4	3	4	3	3	3	3	4	3	3	3	PP,MB,JP,MS, BS,WS
Penstemon, low	5	5	5	3	4	3	5	5	5	2	4	4	4	3	4	3	5	3	3	3	PP,MB,JP,MS, BS,WS
Penstemon, Palmer	5	5	4	5	4	4	3	3	5	4	4	4	4	5	3	4	3	2	3	4	PP,MB,JP,MS, BS,WS,BB
Penstemon, Rocky Mountain	5	5	4	5	4	3	4	3	4	3	4	4	4	4	4	5	4	3	3	3	A,PP,MB,JP, MS
Penstemon, Rydberg	5	5	4	3	2	3	3	4	4	3	4	3	4	3	2	4	4	5	3	2	SA,A,WM, PP,MB
Penstemon, sidehill	5	5	4	4	3	3	4	4	4	2	3	3	4	3	4	3	4	3	3	3	PP,MB,JP,MS, BS,WS
Penstemon, thickleaf	5	5	4	3	3	3	4	3	4	2	3	3	4	3	4	3	4	3	3	3	PP,MB,JP, MS,BS
Penstemon, toadflax	5	5	4	3	2	3	4	4	4	2	4	3	4	3	4	3	3	3	3	3	PP,MB,JP,MS, BS,WS
Penstemon, Wasatch	5	5	4	3	4	4	3	3	5	4	3	2	4	3	4	4	4	4	3	4	A,PP,MB,JP, MS,BS
Sage, Louisiana	2	3	5	4	2	4	4	4	5	3	2	3	5	3	4	4	5	4	3	4	SA,A,WM,PP MB,JP,MS, BS,WS
Sage, tarragon	2	2	4	3	1	4	4	4	3	3	2	2	4	4	3	3	4	3	3	3	SA,A
Sainfoin, common	5	5	5	5	4	4	4	3	4	5	5	4	4	3	3	4	3	3	4	3	PP,MB,JP, MS,BS
Salsify, vegetable-oyster	3	2	3	4	5	5	3	3	4	3	3	4	3	3	4	4	3	4	4	4	PP,MB,JP, MS,BS
Solomon-plume, fat	4	3	3	2	2	3	4	4	3	2	5	4	3	1	3	3	3	5	3	2	SA,A,WM, PP,MB
Sweetanise	3	3	2	3	4	3	4	4	4	4	4	4	4	2	4	4	3	4	5	3	SA,A,WM, PP,MB

(con.)

Table 1 (Con.)

Species	Ratings[b]																			Vegetative type[a] to which the species is adapted
	Ease of handling seed	Ease of seeding	Ease of trans-planting	Germi-nation	Initial estab-lishment	Seedling growth rate	Final estab-lishment	Persis-tence	Natural spread	Forage yield	Early spring palata-bility	Summer palata-bility	Toler-ance to grazing	Evergreen-ness	- Compati-bility with other species	Seed produc-tion	Soil stability	Flood toler-ance	Shade toler-ance	Range of adapt-ability	
Sweetclover, white	5	5	3	5	5	5	2	2	3	3	3	4	3	3	4	5	2	4	3	4	SA,A,WM, PP,MB
Sweetclover, yellow	5	5	3	5	5	5	2	2	3	4	3	4	3	3	4	5	2	4	3	4	SA,A,WM, PP,MB, JP,MS,BS,WS,
Sweetroot, spreading	3	4	3	2	3	3	4	3	2	2	4	4	3	2	4	4	3	4	4	2	SA,A,WM, PP,MB
Sweetvetch, Utah	2	4	3	3	3	3	5	4	3	4	4	4	4	3	4	4	3	3	3	3	PP,MB,JP,MS, BS,WS
Valerian, edible	3	3	2	2	2	2	3	5	2	3	4	4	4	1	4	3	3	4	4	3	SA,A,WM,PP, MB,JP,MS
Vetch, American	4	5	4	4	2	4	4	5	3	4	4	4	4	3	5	4	4	3	4	3	SA,A,WM,PP, MB,JP,MS
Vetch, bramble	4	5	4	5	3	2	4	5	3	3	4	4	4	3	5	4	4	3	4	3	BS,WS,SS, BG,BB
Yarrow, western	4	4	5	4	4	4	5	5	5	3	4	4	5	4	4	5	5	5	4	5	SA,A,WM,PP, MB,JP,MS,BS

[a]Key to vegetative type: SA = Subalpine; A = Aspen-conifer; WM = Wet and semiwet meadows; PP = Ponderosa pine; MB = Mountain brush; JP = Juniper-pinyon; MS = Mountain big sagebrush; BS = Basin big sagebrush;WS = Wyoming big sagebrush; SS = Shadscale saltbush; BG = Black greasewood; BB = Blackbrush; IS = Inland saltgrass.
[b]Key to ratings: 1 = Poor; 2 = Fair; 3 = Medium; 4 = Good; 5 = Excellent.

Family Compositae
Achillea millefolium ssp. *lanulosa*

Western Yarrow

In the Intermountain West the majority of the yarrows fall into three taxonomic units: *Achillea millefolium* ssp. *millefolium*, which was introduced from Europe and is widely cultivated in North America, and *A. millefolium* ssp. *lanulosa*, a native to North America, which is divided into two varieties—var. *lanulosa* (western yarrow) that occurs from the valley floor to above timberline and var. *alpicola* that is generally found above timberline (Welsh and others 1987). All three taxonomic units intergrade. Western yarrow, a perennial member of the sunflower family, has flowers that are borne in flat-topped cymes (fig. 1) that are white, grayish, and barely pink, all with yellow centers (Hermann 1966). The leaves and flowers are aromatic.

Ecological Relationships and Distribution

Western yarrow is found in Southwestern Canada, in all States west of North Dakota, south to Northern Mexico, and from the low plains to subalpine communities. Greatest areas of occurrence are in mountain brush, ponderosa pine, aspen, and open timber types (USDA Forest Service 1937). Western yarrow has good fire tolerance, some shade tolerance, and is fairly resistant to drought. It grows in sandy to loam soils that range from weakly basic to weakly acidic (USDA Forest Service 1937; Wasser 1982). Yarrow spreads by rhizomes and seed, and is especially useful on disturbed or misused sites. Tolerance to grazing is good.

Figure 1—Western yarrow in a mixed grass forb community.

Plant Culture

Western yarrow can be seeded successfully by drilling or broadcasting. Seeds are small (4.1 million per lb [9.0 million per kg] at 100 percent purity) and should not be planted more than 0.25 inch (6 mm) deep. Seeds germinate uniformly, and produce vigorous seedlings. Seed is usually marketed with about 50 percent purity and 80 percent germination. It is recommended that seed be stored no more than 2 years, due to loss of viability. The species is easily transplanted. Western yarrow can be seeded successfully in mixtures with other species (Stevens and others 1985c).

Uses and Management

Western yarrow has fair forage value for sheep, somewhat less for cattle, and is used by small and large game animals (Hermann 1966; Kufeld 1973; Kufeld and others 1973; USDA Forest Service 1937; Wasser 1982). It provides important habitat for upland game birds. This species has good potential for revegetation and for stabilization of disturbed sites from big sagebrush through the subalpine zones. Western yarrow establishes and spreads well in sites occupied by annual weeds. It persists with heavy grazing, and often recovers well by natural seeding. Areas seeded to western yarrow should not be grazed for at least 1 to 2 years following seeding.

Varieties and Ecotypes

There is considerable variation, and locally adapted ecotypes should be planted.

Family Compositae
Artemisia ludoviciana

Louisiana Sage (wormwood)

There are a number of subspecies and numerous varieties and ecotypes of Louisiana sage in the Intermountain West (Holmgren and Reveal 1966; Welsh and others 1987). Considerable differences occur among the various subspecies, varieties, and ecotypes. Louisiana sage is an herbaceous native perennial that is aromatic and very rhizomatous, with stems that grow from 1 to 3 ft (30 to 91 cm) tall. Leaves are mainly cauline, entire, lobed or pinnately incised, and borne on the stem.

Ecological Relationships and Distribution

Louisiana sage (fig. 2) occurs throughout North America in all vegetation types from sagebrush through alpine and tundra zones. This species does well on shallow as well as on deep, slightly acidic to basic soils. It prefers well-drained soil, but also grows in riparian communities and on other moist sites. Louisiana sage does well on disturbed exposed soils as well as on sites supporting some cover. As a pioneer species, it creates microenvironments suitable for the invasion of other species.

Plant Culture

Flowering occurs in mid to late summer, depending on location, with seed maturing in late August to early November. Seed can be collected by hand stripping, beating, or combining. Most native stands do not produce an abundance of seeds on a regular basis. Seed is cleaned by debearding and screening. There are about 2.5 million seeds per lb (5.5 million per kg) at 100 percent purity. Seed is generally marketed at 10 to 15 percent purity and 80 percent germination. Seed viability declines rapidly with more than 3 to 4 years of storage.

Seed can be drill seeded or broadcast seeded, followed by very shallow soil coverage. Drill seeding requires a purity of greater than 40 percent for seed to flow through most seeding units. Seed can be broadcast with as low as 10 percent purity, depending on the type of broadcaster used. Seed that is fall broadcast on disturbed soil generally does not require mechanical coverage because natural soil sluff is sufficient to bury the seed. Louisiana sage can be seeded as a single species or as a component of a mixture. It also establishes easily from sprigs.

Uses and Management

Louisiana sage plays an important roll in providing soil cover and stabilization in areas where it is adapted (Hermann 1966; McCulloch 1973). It can be an early invader on disturbed sites including mine spoils (Monsen 1975; Monsen and Plummer 1978). Where it is seeded or becomes established, it acts as a nursery crop that allows establishment of other species. Ellison (1951) considered it an important invader of overgrazed sheep range and as a soil stabilizer on the Wasatch Plateau in central Utah. It can be used to stabilize riparian disturbances including dry meadows and areas subjected to infrequent flooding.

Livestock, small and large game, and rodents use this forb (Hermann 1966; Kufeld and others 1973; McCulloch 1973). It has considerable tolerance to grazing and trampling; however, when occurring on shallow soils or disturbed sites, it should not receive extensive use or trampling from grazing animals. Stand density fluctuates, particularly at higher elevations where the species may be suppressed by overstory shading. It recovers well after fires and can be used to prevent the entry of weeds by providing ground cover after a disturbance.

Figure 2—Louisiana sage.

Varieties and Ecotypes

There is one variety. ‘Summit’ was selected for its its ability (1) to establish from sprig planting and direct seeding, (2) increase or spread rapidly by rooting, (3) provide quick cover and soil stabilization, (4) grow on harsh sites, and (5) create microenvironments suitable for the invasion of other species (Stranathan and Monsen 1986). ‘Summit’ is particularly useful as a ground cover or erosion control species for sites above 5,000 ft (1,500 m) elevation.

Family Compositae
Aster chilensis

Pacific Aster

Pacific aster is a native perennial of the compositae family. It is described by Harrington (1964) as developing short to long root stocks and stems that are usually less than 2.5 ft (0.8 m) tall, with long, linear pubescent leaves. Few to numerous heads occur with blue, violet, or rarely white flowers. Seeds or achenes are usually hairy with many white pappus bristles. Plants bloom from July to September. This is an extremely diverse species. Welsh and others (1987) consider Pacific aster a generalized taxon with no well-defined diagnostic features. Hitchcock and others (1955) recognized three subspecies: spp. *hallii*, which occurs in the Oregon Cascades, and in Washington west to the coast, spp. *chilensis*, which is found throughout the Cascades and Sierras; and spp. *adscendens*, which occurs in the Great Basin and eastern Oregon, and on the Snake River plains.

Ecological Relationships and Distribution

Pacific aster (fig. 3) is a native perennial that can spread rapidly by seed or rhizomes. This forb occurs throughout the Intermountain region at elevations between 5,000 and 9,500 ft (1,500 to 2,700 m). It occupies areas from the sagebrush foothills to the subalpine zone (Harrington 1964). It is most commonly found on dry, open sites in the sagebrush-grass and pinyon-juniper types.

Plant Culture

Pacific aster can be established by direct seeding, sprigging, and with nursery or field-grown transplants (Stevens and others 1985c). Seed is best planted by broadcasting; however, if it is cleaned to at least 50 percent purity, it can be drilled. Picker or thimble seeders can be used to plant the uncleaned, trashy seed. Special care must be taken to ensure that seeds are not planted more than 0.25 inch (6 mm) deep. To ensure that viable seed is planted, seed should not be stored more than 3 years. Harvested seed usually consists of the achene and attached pappus. The pappus is removed by gentle hammermilling, or with a debearder. Seed is usually not cleaned to more than 50 percent purity, and most seed is sold at 10 to 14 percent purity. At 100 percent purity, a pound of seed consists of just over 2.5 million seeds (5.5 million per kg).

Seeds of Pacific aster ripen throughout the late summer and fall. Not all seeds ripen uniformly; consequently, considerable debris and immature seeds are often collected. Seeds can be separated from the debris with special cleaning equipment. Seed should be purchased based on the percent of viable seed.

Seeds of Pacific aster germinate readily. Nearly all viable seeds germinate within 15 days. Seedlings appear early. They are able to compete with most seeded herbs and persist under adverse conditions. Young plants usually do not attain large stature the first growing season, but they do form an extensive root system.

Although the seeds are small, they establish well with only minimum seedbed preparation if they are seeded with the pappus attached. Seeding with the pappus on, however, is very difficult.

Neither livestock grazing nor rodent and insect use have been observed to damage new seedings. New plantings are not heavily used by rabbits and can be established where rabbit populations are high. The plant can also be seeded on unstable slopes because small plants do not attract heavy use and provide excellent ground cover.

Figure 3—Pacific aster in full bloom.

Uses and Management

Pacific aster is one of the first forbs to “green up” in the spring, causing it to be highly sought by livestock and big game. Game and livestock do, however, make some use of this species during all seasons because the plants retain some green material most of the year (Hermann 1966; Kufeld and others 1973; Plummer and others 1968). Hermann (1966) and USDA Forest Service (1937) reported that Engelmann aster is more palatable than Pacific aster to most animals. Our observations indicate similar differences, but recognize that Pacific aster receives moderate to heavy seasonal grazing.

Pacific aster is one of the most widely distributed native forbs within the Intermountain region. Selections obtained from the low foothill sagebrush communities are well adapted to semiarid situations. Pacific aster is one of a few forbs that can be easily seeded within the arid region occupied by big sagebrush. It persists well, furnishes good midsummer forage, and can be used to control cheatgrass. It recovers well from wildfires and spreads naturally.

To date, Pacific aster has normally been seeded as a minor component of most seed mixtures, usually at 0.25 lb seed per acre (0.3 kg per ha). However, it can be seeded at higher rates of 2 to 5 lb per acre (2.2 to 5.6 kg per ha) to provide more summer forage. Pacific aster does not restrict seedling establishment of associated herbs, and its own seedlings are not impaired by the presence of other seeded species. Consequently, increasing the seeding rate of this plant usually results in a corresponding increase in plant density.

The strong rhizomes and root system enables the species to be very useful in stabilization of disturbed areas. Pacific aster is a useful species for planting exposed sites with shallow soils, particularly midwinter game ranges. It can be successfully seeded on areas that are difficult to treat with mechanical equipment. It is well suited to infertile, rocky soils and sites subject to erosion.

Pacific aster is a useful pioneer species and nurse crop. The plant is able to occupy harsh sites and improve surface stability, enhancing seedbed conditions for other species. New seedlings are able to establish amid the seemingly dense ground cover provided by this forb. It is not unusual to observe seedlings of other plants establishing and surviving within a clump of Pacific aster. Consequently, the plant is used to furnish cover on steep slopes where pinyon and juniper have been chained. The plant is also valuable for seeding or transplanting roadways, mines, and other major disturbances. Areas seeded to Pacific aster should not be grazed for at least two growing seasons following planting. Creeping rhizomes enable this species to withstand considerable grazing and trampling once plants are established. Pacific aster has only been sparingly used in controlled grazing studies, but it is apparent that this species can be managed to provide midsummer and winter forage. In addition, the plant can be seeded to control cheatgrass and to furnish needed cover on critical semiarid ranges.

Varieties and Ecotypes

There are no releases.

Family Compositae
Aster glaucodes ________________

Blueleaf Aster

Blueleaf aster (fig. 4), a native perennial, has about the same forage value and seed characteristics as Pacific aster. However, its seeds are more than three times as large (500,000 per lb [1.1 million per kg]), and the species is more widely distribted, commonly occurring in all vegetative types from salt desert shrublands and saline seeps to spruce-fir forests. It furnishes an open spreading clump, with short seed stalks and wide leaves. It is well adapted to harsh sites (fig. 5) and tends to exist alone. This species is better adapted to calcareous soils and saline conditions than Pacific aster. When seeded with principal forage grasses, it does not provide a dominant cover. It is grazed by big game and livestock, but it is not heavily used. Like Pacific aster it persists amid heavy infestation of grasshoppers when other succulent herbs are usually consumed. If seed of both species were more available, they would be recommended for planting range, watershed, and wildlife habitats.

Figure 4—Blueleaf aster at seed maturity. This stand was established by broadcast seeding on a raw roadfill in the mountain brush type.

Figure 5—Blueleaf aster stabilizing a severely eroded cut.

Family Fabaceae
Astragalus cicer ________________

Cicer Milkvetch

A native of Eurasia, cicer milkvetch is a perennial member of the pea or legume family. It has vigorous creeping rhizomes and a short taproot. The leafy, succulent, decumbent stems are fairly large in diameter. They grow to about 5.5 ft (1.7m) in length, and originate from crown and rhizome buds. Flowers are born in compact heads and are pale yellow to white. Blooming occurs in midsummer, and seeds mature in late fall. The inflated, bladder-shaped, leathery black pods contain several seeds. Seed pods persist on the plant into the winter.

Ecological Relationships and Distribution

Cicer milkvetch (fig. 6) is an introduced, long-lived perennial from northern Europe. It is bloat free and does not accumulate toxic alkaloids (Davis 1982a; Rumbaugh 1984; Rumbaugh and Townsend 1985; USDA Soil Conservation Service 1968, 1972a; Williams and others 1976). It is safe for grazing (Rumbaugh 1983).

This species has vigorous spreading rhizomes, good frost and drought tolerance, and produces considerable succulent forage with a high protein content and a low crude fiber level (Davis 1982a). It grows in slightly acidic and basic soils, and does especially well in soils derived from limestone. This forb establishes and grows on thin, infertile soils and on disturbed sites. Spring growth starts about 2 weeks later than alfalfa and continues about 2 weeks longer in the fall. Foliage is green and succulent throughout the summer and fall months. Basal leaves remain green through winter. This species has more frost tolerance than alfalfa and remarkable resistance to insects and disease.

Cicer milkvetch requires at least 13 inches (33 cm) of annual precipitation, and does especially well with 16 inches (40 cm) or more. It is tolerant of water tables within 3 ft (91 cm) of the surface and does fairly well on wet sites. It has some shade tolerance, and is well adapted to sagebrush-grass and pinyon-juniper sites with sufficient precipitation. It also does well in the mountain brush type (Plummer and others 1955; Rumbaugh and Townsend 1985) and in openings in aspen and subalpine areas.

Plant Culture

Cicer milkvetch can be broadcast or drilled seeded. There are about 113,000 seeds per lb (249,000 per kg).

Figure 6—Cicer milkvetch growing in association with smooth brome, Gambel oak, and mountain big sagebrush.

Seed should be inoculated with appropriate inoculant before seeding (Carleton and others 1971; Hafenrichter and others 1968), and should not be planted more than 0.25 inch (6.4 mm) deep. Because of its hard seedcoat and dormancy, seeding should be done in the fall. Scarification can improve seeding success. However, once seeds are scarified they will not retain viability over extended periods.

Seed of cicer milkvetch has been stored for up to 14 years without any loss of viability (USDA Soil Conservation Service 1968a). This species is easily transplanted. Cicer milkvetch has done well seeded in mixtures and has been successfully interseeded into various native and introduced grass communities (Rumbaugh and others 1981; Stevens and others 1981b). Because of its lower seedling vigor (Rumbaugh 1984), cicer milkvetch does best when seeded in well prepared seedbeds that are relatively free of competition. This species does not reach full productivity until the third year following seeding. Once established, cicer milkvetch is very competitive and long-lived. It has been demonstrated that cicer milkvetch can stimulate and increase forage production of associated species (Johnson and others 1983).

Uses and Management

Seed of cicer milkvetch is produced commercially and is generally available. Acceptable purity and germination for commercial seed is 95 and 85 percent. Cicer milkvetch is palatable to livestock and big game, and seeds are eaten by small birds, deer, rabbits, sage-grouse, and pheasants (Plummer and others 1968; USDA Soil Conservation Service 1968, 1972a; Wasser 1982). Once established, this species has excellent grazing tolerance. This species can be classified as a semievergreen because basal leaves are green all year.

The rhizomatous characteristics of cicer milkvetch, along with its semiprostrate nature and profuse flowering, make it ideal for use around summer homes, on disturbed sites, in campgrounds and parks, and in areas with high aesthetic value.

This species is useful as a forage and conservation plant, providing excellent ground cover and stabilizing eroding sites. It can be seeded for intensive pasture management. The plant has considerable value for seeding semiwet sites that are used by upland game birds for summer forage. It also provides winter and nesting cover for upland game birds.

Varieties and Ecotypes

'Lutana' was released in 1970 and has the characteristics described for the species. 'Monarch' was selected for its superior seedling emergence. 'Oxley' is a 1971 Canadian release (Rumbaugh and Townsend 1985).

Family Compositae
Balsamorhiza sagittata ___________

Arrowleaf Balsamroot

Arrowleaf balsamroot (fig. 7) is a broadleaf perennial with a deep, woody taproot. It is the most abundant balsamroot in the Intermountain area. Simple deltoid or sagittate leaves are entirely gray-green and heavily pubescent. Flowering stems produce a few reduced leaves. Flowers or heads are usually borne solitary on extended seed stalks. Both disk and ray flowers are produced, but they lack a pappus (Welsh and others 1987). Flowering occurs in early April, and seed matures in late May and early June (Harrington 1964). Leaves dry up between late June and the end of July.

Figure 7—Seed increase planting of arrowleaf balsamroot.

Ecological Relationships and Distribution

A native perennial forb, arrowleaf balsamroot can be found growing on well-drained silty to loamy soils in sagebrush, mountain brush, and ponderosa pine communities, and open slopes in aspen and coniferous forests. This forb is usually found at elevations between 1,000 to 9,600 ft (305 to 2,900 m) (Harrington 1964; Wasser 1982). It occurs in solid stands or mixed communities. Arrowleaf balsamroot is the most widespread species of balsamroot. It ranges from the Sierras east to Colorado and north to southern Canada on acidic and alkaline soils (Hitchcock and others 1955; Plummer 1977). It dominates many extensive foothill areas, often growing as nearly pure stands (USDA Forest Service 1937).

Arrowleaf balsamroot is intolerant of shallow water tables, but withstands brief periods of soil saturation. It is strongly drought resistant, winter hardy, and tolerant of semishade, open sunlight, and of grazing (Wasser 1982).

Plant Culture

Arrowleaf balsamroot is one of the first plants to initiate growth in the early spring. Plants flower in April and usually attain maximum stature in late April or May, and seeds ripen in May and early June. Seed heads are formed individually on extended solitary peduncles, and if plants are not heavily grazed, large quantities of seed can be produced. Seeds ripen uniformly and are large, with just over 55,000 per lb (120,000 per kg). Seed is easily harvested by hand stripping or beating. Extensive areas of level terrain and dense stands can be harvested with a combine or reel-mounted harvester (Plummer and others 1968; Stevens and others 1985c). Seed can also be produced under cultivation (fig. 7).

Seeds lack a fluffy or bristly pappus common to many other compositae. Seeds are long, smooth, and easily cleaned. Wildland stands are often infested with seed damaging insects, and entire seed crops can be damaged. Seed should be carefully inspected prior to collection. Plummer and others (1968) suggest treating seed production areas with insecticides to reduce seed predation However, treatment must be timed to avoid elimination of pollinators. Seed in storage should be treated to prevent insect damage. Seed stored properly in an open warehouse retained good viability after 5 years (Stevens and Jorgensen 1994).

Mature seed will remain on the plant for a short time, but is readily eaten by rodents (Everett and others 1978b). Immature and insect-damaged seed will persist on the plant for longer periods. Too often, the persisting poor-quality seed is mistakenly harvested and marketed. Immature and damaged seed may often be normal size. However, it is light weight and can be separated from fully developed seed by gravity, wind separation, or flotation seed cleaning techniques. Good quality lots will have 95 percent purity and at least 40 percent germination.

Arrowleaf balsamroot seeds can be drill seeded quite easily with conventional equipment. Seeds should not be placed more than 0.33 to 0.5 inch (8 to 13 mm) deep. Seeds can be broadcast planted but only if they are covered. Because of seed dormancy and rodent preference for this species, late fall seeding is recommended (Eddleman 1978; Everett and others 1978b; McDonough 1976; Young and Evans 1979). Arrowleaf balsamroot seeds are often planted alone or with slower developing herbs and shrubs. This species should not be seeded directly with more aggressive developing herbs, but should be planted in separate rows or broadcast onto sites free of competition. If planted with grasses or other broadleaf herbs, arrowleaf balsamroot plants may survive, but would require 10 years or longer to reach maturity.

Although seedlings germinate and emerge quickly, young plants develop slowly. Even under ideal conditions thick, dense stands usually do not develop from artificial seedings. Causes for low return are not fully known, but insects and rodents can cause considerable damage. Seeded plants may produce only two to three small leaves for a number of years following planting. Plants are slow to increase in stature, but they are extremely hardy and persistent.

Uses and Management

Arrowleaf balsamroot is an important forage plant for deer, elk, cattle, and sheep, especially on spring ranges where it greens up early (Harniss and Wright 1982; Hermann 1966; Holecheck and others 1982; Kufeld 1973; Kufeld and others 1973; Mueggler and Stewart 1980; Plummer and others 1968). The plant is also grazed later in the season with considerable use made of the heads during and following flowering. In many plant communities, a major portion of total forage production is arrowleaf balsamroot.

Plantings of arrowleaf balsamroot do well when seeded within areas of its natural occurrence. Attempts to extend or seed this species on areas outside of its natural range or on mine or roadway disturbances have been unsuccessful. This forb is encountered in low, semiarid conditions with Wyoming big sagebrush, but has been difficult to seed in these circumstances, usually because of using unadapted ecotypes, heavy grazing, and competitive effects of associated species. The most successful seedings have occurred in the lower elevation mountains in sagebrush and mountain brush communities.

Arrowleaf balsamroot can be used to improve forage conditions on game and livestock spring and summer ranges. It undoubtedly has been eliminated from some situations, but is extremely hardy and persistent even under heavy use.

Because of a deep fleshy taproot, arrowleaf balsamroot can withstand drought, trampling, fire and considerable grazing pressure. Natural reproduction will occur if seeds are allowed to mature. Seeded areas should not be grazed for at least two growing seasons following planting. New plants are slow to mature, requiring 3 to 4 years to flower on the most preferred sites, and 7 to 8 or even 10 years on the lower precipitation sites.

Varieties and Ecotypes

There are no releases.

Like most other natives, arrowleaf balsamroot grows on many different soil types and in many precipitation zones. Consequently, various ecotypes likely occur. Considerable differences are noted among populations in regard to palatability, seed production, and drought tolerance. Seeds are normally produced each year from upper elevation sites where precipitation is more reliable; however, seeds should be acquired from sites similar to the area proposed for treatment. The genus also appears to lack genetic barriers to hybridization, and intergradation occurs when any two taxa exist together (Welsh and others 1987).

Family Compositae *Balsamorhiza macrophylla*

Cutleaf Balsamroot

Cutleaf balsamroot has large leaves 12 to 24 inches (30 to 61 cm) long that are divided into broad, entire, or few-toothed segments 2 to 5 inches (5 to 13 cm) long (Welsh and others 1987). The leaves have long, soft hairs and a somewhat unpleasant odor.

Cutleaf balsamroot generally occurs at slightly higher elevations and in more moist conditions than arrowleaf balsamroot. It is not distributed as widely as arrowleaf balsamroot and is less palatable to grazing animals. Cutleaf balsamroot ranges from northern Utah and southeastern Idaho to western Wyoming and southwestern Montana (Hitchcock and others 1955). Seed collection, cleaning, and storage as described for arrowleaf balsamroot. Seeds are somewhat larger than those of arrowleaf balsamroot with about 33,000 per lb (73,000 per kg). Seed can only be stored for 3 years without significant loss of viability (Stevens and Jorgensen 1994). Cutleaf balsamroot is better adapted to areas of slightly higher elevations and more moist conditions than arrowleaf balsamroot. Neither species should be seeded in place of the other. Site differences are not easy to differentiate.

Family Compositae *Balsamorhiza hookeri* var. *neglecta*

Hairy Balsamroot

Compared to arrowleaf balsamroot, hairy balsamroot has smaller leaves 4 to 12 inches (10 to 31 cm) long that are divided into narrow segments 0.5 to 2 inches (1 to 5 cm) long (Welsh and others 1987). These segments are often divided a second time into even smaller segments. The leaves are covered with coarse, short, stiff hairs.

This species has a more limited distribution than arrowleaf or cutleaf balsamroot, occurring from eastern Oregon to southwestern Nevada (Hitchcock and others 1955). Welsh and others (1987) report two varieties of Hooker balsamroot are found in Utah, these occur in separate regions, but grow on a variety of sites.

Seed collection, cleaning, and storage are as described for arrowleaf balsamroot. Seed production is much lower than for arrowleaf or cutleaf balsamroot. In addition, plants usually do not exist in large dense patches, but are scattered and intermixed with other herbs.

Plants usually grow as an understory with shrubs, and have been useful in seeding pinyon-juniper and mountain brush sites. Sources that grow in drier circumstances offer opportunity to select and develop materials adapted to sagebrush and salt desert shrublands.

Family Fabaceae
Coronilla varia ____________________

Crownvetch

Crownvetch (fig. 8) is an introduced perennial legume with strong rhizomes and a deep taproot (Leffel 1973). Varigated white to purple flowers start to blossom in early summer and blooming continues for 4 to 5 weeks. Seed matures in early fall in pencil-like pods that break into segments as they dry. Each segment contains one yellow to dark red, rod-shaped seed. Flowers are arranged in an umbrella or crown-like fashion. Basal leaves are green early in the spring and remain green into the winter.

Ecological Relationships and Distribution

Crownvetch is a long-lived, cold-tolerant perennial from the Mediterranean region. This species is not a true vetch because it does not have tendrils for climbing. It does, however, tend to climb if supported by shrubs like mountain big sagebrush, Gambel oak, or serviceberry. This forb does fairly well with 21 inches (530 mm) annual precipitation and thrives with over 30 inches (760 mm) of precipitation. Crownvetch exhibits some shade and fire tolerance. It prefers slightly acidic soils but has also done well on slightly basic calcareous soils. It does not persist on poorly drained soils.

Crownvetch can be seeded in mountain brush, ponderosa pine, and aspen communities. It persists well at lower elevations once established. Although it performs best when grown on fertile soils, it demonstrates unusual ability to persist, spread, and remain productive when planted on mine disturbances and sites lacking top soil. It is especially useful for stabilizing erosive sites. This species is very competitive. Over time it will dominate an area and exclude other species.

Figure 8—Crownvetch stabilizing a road cut.

Plant Culture

Seeds are produced in segmented pods. Cleaned seeds are separated from the pod, and should be inoculated with the proper rhizobium prior to seeding (Magness and others 1971; Wasser 1982). There are about 135,000 seeds per lb (298,000 per kg) at 100 percent purity. Acceptable purity and germination for commercial seed is 95 and 75 percent. Seeding is best accomplished in the fall on a well-prepared seedbed. Stratification requirements can be overcome with fall seeding. Seed can be drilled or broadcast, but it should not be covered deeper than 0.25 inch (6 mm). This forb can be seeded with other species. When seeded with a grass mixture, it is best seeded separately through the legume seedbox. Excellent establishment can be obtained from transplanting or sprigging. Seeding at a rate of 2 to 4 lb per acre (2.2 to 4.5 kg per ha) is satisfactory when seeded in a mixture.

Uses and Management

Crownvetch produces strong, spreading, fleshy rhizomes. This extensive system enables crownvetch to be an excellent soil stabilizer and an aggressive spreader. It has been used to stabilize watershed and mine disturbances at locations receiving over 16 inches (40 cm) of annual precipitation. The plant is characterized as having a succulent dark green appearance, profuse flowering, and excellent ground cover characteristics. These features make crownvetch a prime landscape species for summer home developments, roadways, campgrounds, and areas of high recreational use.

Palatable forage is produced by crownvetch for all classes of livestock and wildlife (Wasser 1982), with little or no bloat hazard (Leffel 1973; USDA Soil

Conservation Service 1978). Deer, elk, and livestock will paw through snow to find and use its semievergreen forage. Birds and rabbits use crownvetch for food and cover. Crownvetch has some poisonous characteristics (Shenk and others 1976). However, when used in conjunction with other species, poisoning has not occurred (Shultz 1984). Crownvetch is normally seeded as a component of a mixture to enhance forage production and quality. This species establishes slowly, and production is low the first or second year following seeding. Once established, it can withstand considerable grazing and trampling. It recovers from close grazing, but does not have the regrowth capabilities of alfalfa. When seeded in mixtures with other species, it will spread vegetatively, and will tend to dominate a community.

Varieties and Ecotypes

'Emerald', 'Penngift', and 'Chemung' have done well in mountain big sagebrush, mountain brush, and aspen communities. Emerald is the smallest in stature and produces less forage, but it is a more aggressive spreader.

Family Geraniceae
Geranium richardsonii ____________

Richardson Geranium

A member of the geranium family, Richardson geranium (fig. 9) is a perennial native forb, with flowers that are generally white with pinkish or dark veins. Stems are single or few and somewhat hairy and viscid. Leaves are large but thin. Flowering occurs in July and early August, and seed matures in September. The foliage gives off a distinctive geranium odor when crushed (USDA Forest Service 1937).

Figure 9—Richardson geranium.

Ecological Relationships and Distribution

Richardson geranium occurs in openings throughout the coniferous forest as an understory species in aspen and subalpine meadows (Judd 1962; USDA Forest Service 1937). It is the most widely distributed geranium in North America (Hermann 1966). The species is not restricted to any particular soil type, but usually occurs on fairly moist gravelly or sandy loams. However, it can be found on drier granitic soils and heavy clay loams (Judd 1962; USDA Forest Service 1937).

Plant Culture

Seed is generally produced yearly if plants are not grazed. Seed can be collected by beating it into a hopper or with a mechanical seed beater mounted on a vehicle. Seed is extracted from the collected material by hammermilling or with a debearder (Stevens and others 1985c). Seed can be stored for at least 5 years without substantial loss of viability. Acceptable germination is 60 percent. There are about 65,000 seeds per lb (143,000 per kg) at 100 percent purity. Seed can be cleaned to 60 percent or higher purity. Seed can be drilled or broadcast seeded on a prepared seedbed, preferably in the fall. Seeding depth should not exceed 0.25 inch (6 mm). This species can be seeded singly or as a component of a mixture of other forbs and grasses. It demonstrates excellent ability to spread by natural seeding. Seeds are small and can establish on a loose seedbed or on sites where litter has accumulated.

Uses and Management

Forage value for cattle and sheep is rated good to excellent during early growth stages, and poor to good later in the season. Forage value for elk (Kufeld 1973) and deer (Kufeld and others 1973), is greater than for livestock (Hermann 1966; Judd 1962; USDA Forest Service 1937).

The species develops a stout, woody root system that enables it to stabilize soil and withstand considerable grazing, trampling, and some drought. Seedings on fertile soils have been most successful. Attempting to seed or use this species on sites where it does not normally occur is not recommended. However, this forb spreads naturally and has successfully invaded roadway disturbances. Richardson geranium can persist with moderate to heavy grazing. Plants appear to be long-lived and spread well from natural seeding. Newly seeded stands should not be grazed for at least two growing seasons following planting. This species frequently increases with proper management. It persists well with seeded grasses, including smooth brome and intermediate wheatgrass. It is useful for adding diverity to mixtures, especially where shade from overstory species exists. Limited seed supplies restrict the use of this species.

Varieties and Ecotypes

There are no releases.

Family Geraniceae
Geranium viscosissimum

Sticky Geranium

This species occurs in the same climatic and edaphic areas as Richardson geranium. Its forage value for cattle is rated from fair to good and from good to excellent for sheep, deer, and elk (Buchanan and others 1972; Kufeld 1973; Kufeld and others 1973; Mueggler and Stewart 1980). Seed is collected, cleaned, stored, and seeded in the same manner as described for Richardson geranium. Seeds of sticky geranium are a little larger with about 52,000 per lb (115,000 per kg). These two species hybridize on the Wasatch Plateau of central Utah (fig. 10) (USDA Forest Service 1937).

Sticky geranium (fig. 11) can be distinguished from Richardson geranium by its multiple, erect stems bearing deep purple to pink colored flowers, and its usually sticky and glandular herbage.

Varieties and Ecotypes

There are no releases.

Family Fabaceae
Hedysarum boreale

Utah Sweetvetch

Utah or northern sweetvetch (fig. 12) is a native perennial member of the legume or pea family that grows 10 to 30 inches (25 to 76 cm) tall and 30 to 80 inches (76 to 203 cm) wide. Blossoms are bright rose-pink to purple and very showy. Leaves are green above and grayish on the underside. Growth begins early in spring and provides a considerable amount of early spring forage that is highly palatable to both big game and domestic livestock. An abundance of forage is provided with some basal leaves remaining green throughout the winter (Rumbaugh 1983). This species produces a tap root (Welsh and others 1987). Some strains are rhizomatous (Ford and others 1984). This species has nitrogen fixing capabilities (Ford 1988; Ford and others 1989; Redente and Reeves 1981). Abundant seed is produced most years. Considerable variation occurs within the species, and there are a number of subspecies and varieties (Ford 1988; Northstrom and Welsh 1970, 1979; Rollins 1940). Utah sweetvetch is the most abundant sweetvetch in the Intermountain West.

Figure 10—Hybrid of Richardson and sticky geranium.

Figure 11—Sticky geranium.

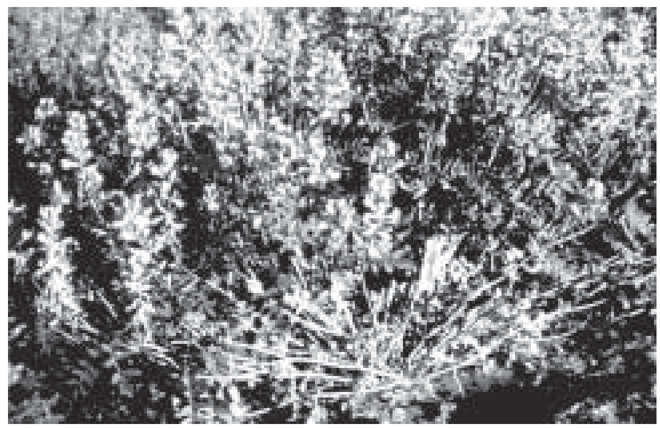


Figure 12—Utah sweetvetch.

Ecological Relationships and Distribution

Utah sweetvetch occurs in most Western States (Ford 1988). It has fair shade tolerance (Rumbaugh and Townsend 1985; Wasser 1982) and can be found in subalpine, aspen, mountain brush, ponderosa pine, pinyon-juniper, and big sagebrush types. In northern Utah it has been found in the shadscale saltbush type (Plummer and others 1968). Sweetvetch grows with 10 to 36 inches (25 to 91 cm) of annual precipitation on acidic or basic soils ranging from sands to heavy clays (Plummer 1977), making it well adapted to semiarid areas of the Intermountain West (Redente 1980).

This species has a stout, branched, woody taproot, thus it can take advantage of deep soil moisture, resulting in considerable drought resistance and winter hardiness. Rhizomatous accessions have been reported (Ford and others 1984, 1989; McKell and others 1979; Plummer and others 1968; Rumbaugh 1984).

Plant Culture

Flowering occurs in late May and June. Seeds mature in late July and early August. A segmented loment or pod is formed (fig. 13) that can be harvested by hand or with a combine. Seed has been successfully produced under cultivation. Seeds can be stored and seeded in or out of the pod. Seeds should be treated with an insecticide to control insect damage. There are about 33,000 seeds per lb (73,000 per kg) at 100 percent purity. Acceptable purity and germination in the commercial market is 90 and 60 percent. By extracting the seed from the pod, unfilled, damaged, and immature seed can be removed. Seed is extracted from the pod with a debearder or Dybvig. Heat and mechanical breakage resulting from improper use of either machine can reduce viability of the seed lot. Seed can be stored up to 5 years without any significant loss in viability (Stevens and Jorgensen 1994).

Figure 13—Segmented loment of Utah sweetvetch.

Good results can be expected from direct seeding. Seeding should occur in the fall or early winter, with the seed covered at least 0.13 inch (3 mm) but not more than 0.38 inch (10 mm) of soil. Seeds should be inoculated with the appropriate inoculant (Redente and Reeves 1981; Rumbaugh and Johnson 1984). Seed can be drilled or broadcast. Utah sweetvetch should not be seeded where its seedlings are in direct competition with seedlings of aggressive species. If drilled, this forb should be seeded in rows separate from grasses. Utah sweetvetch does not produce strong seedlings. Germination is slow and seedling emergence follows that of many other species. Seedlings and young plants also develop slowly. Flowering does not occur until the third or fourth year following planting. Once established, this species is very persistent, particularly when seeded with other herbs. Plants can be established by transplanting in the early spring (Institute for Land Rehabilitation 1979).

Uses and Management

Livestock and big game make considerable use of Utah sweetvetch (Hermann 1966; Plummer and others 1968; Rumbaugh 1984; USDA Forest Service 1937; Wasser 1982). Spring growth provides succulent forage. Considerable green herbage is retained throughout the growing season, and basal leaves remain green through the winter (Redente 1980; Rumbaugh 1984). This species is thought to be a bloat-safe legume (Rumbaugh and Townsend 1985). It has considerable potential for improving big game and livestock ranges, and for stabilization of disturbed and eroding areas (Plummer and others 1968; Redente and Reeves 1981).

Seeded areas should not be grazed for at least 2 years following seeding. Once established, this species can withstand considerable use; however, continual use has reduced its density in some areas.

Varieties and Ecotypes

'Timp' exhibits excellent growth rate, seed production, and nitrogen fixing capacity. This variety is fairly widely adapted.

Family Compositae
Helianthella uniflora ______________

Oneflower Helianthella

There are eight species of *Helianthella* in North America (Weber 1952), with oneflower helianthella having the widest distribution. Plants are upright with erect heads. Seeds are flat and covered with hair, whereas most sunflower seeds are thick and lack pubescence. Oneflower helianthella produces yellow flowers in late May and early June, and seeds mature in July (Hermann 1966).

Ecological Relationships and Distribution

Oneflower helianthella (fig. 14) ranges from Montana to Oregon and south to New Mexico, mainly in mountain brush, aspen, spruce-fir, and ponderosa pine types (Hermann 1966; USDA Forest Service 1937). It does well in full sunlight and partial shade, growing on dry hillsides, open woods, and intermixed in various shrub communities.

Plant Culture

Seed matures in July and can be collected by hand, stripping, mechanical beating, or combining. Seed is easily cleaned, by screening to remove debris. Seeds do not remain viable for more than 2 years (Stevens and Jorgensen 1994). There are just over 52,000 seeds per lb (115,000 per kg) at 100 percent purity.

Direct seeding by drilling or broadcasting has worked well. When seeding oneflower helianthella, seed should be covered no more than 0.38 inch (10 mm). Germination is rapid, and strong seedlings develop quickly. This species does well seeded in mixtures with other herbs. Reproduction from new seedings usually occurs within 3 to 4 years after the initial planting.

Uses and Management

The leaves, flowers, and more tender portions of the stems of oneflower helianthella are eaten by big game and livestock. Palatability is rated as poor to fair for cattle and elk, and fair to good for sheep and deer (Kufeld and others 1973; Mueggler and Stewart 1980). This perennial provides considerable forage in the spring and through the summer.

Oneflower helianthella can be seeded in mixtures with other herbs to furnish diversity and forage. The plant grows on a variety of sites, occupying harsh open conditions, yet also doing well on moist, fertile soils in some shade. When seeded with native and introduced grasses, it persists well and provides useful forage. It will spread to colonize open disturbances, and can be used to beautify recreational sites and roadways. It usually does not provide a dense ground cover, but mixtures of oneflower helianthella with other herbs are useful for controlling erosion.

New seedlings should receive at least two growing seasons of nonuse following planting. Selective grazing of this species does not occur, and it can be easily maintained in a mixture with other herbs on summer ranges.

Figure 14—Oneflower helianthella in full bloom.

Varieties and Ecotypes

There are no releases.

Family Umbelliferae
Heracleum lanatum

Cow Parsnip

There are about 60 species of *Heracleum* throughout the world. However, only one, cow parsnip, occurs in North America (Hitchcock and others 1961). Cow parsnip forms a compound umbel (fig. 15), with flowers occurring at the ends of long, hollow stalks. Plants are tall, often reaching 7 ft (2.1 m). The white to light yellow flowers bloom in July and early August. Seed matures in late August and early September. Roots are woody, short, jointed, and aromatic. Leaves are divided into three very large, irregularly toothed leaflets, each 4 to 10 inches (10 to 25 cm) long.

Ecological Relationships and Distribution

Cow parsnip is found from Alaska, eastward across Canada, and south through the Western States and to Georgia. In the Intermountain West, cow parsnip occurs in aspen, spruce-fir, and subalpine areas, and in meadows, with rich, loamy soils. This species prefer some shade and exists in open woodlands.

Plant Culture

Cow parsnip seeds are flat, obovate in shape, and fairly large, with just over 44,000 per lb (97,000 per kg). Collection of seed is best accomplished by hand stripping or beating. If allowed to mature, good seed crops are generally produced yearly. Seeds are easily cleaned by screening to separate them from debris.

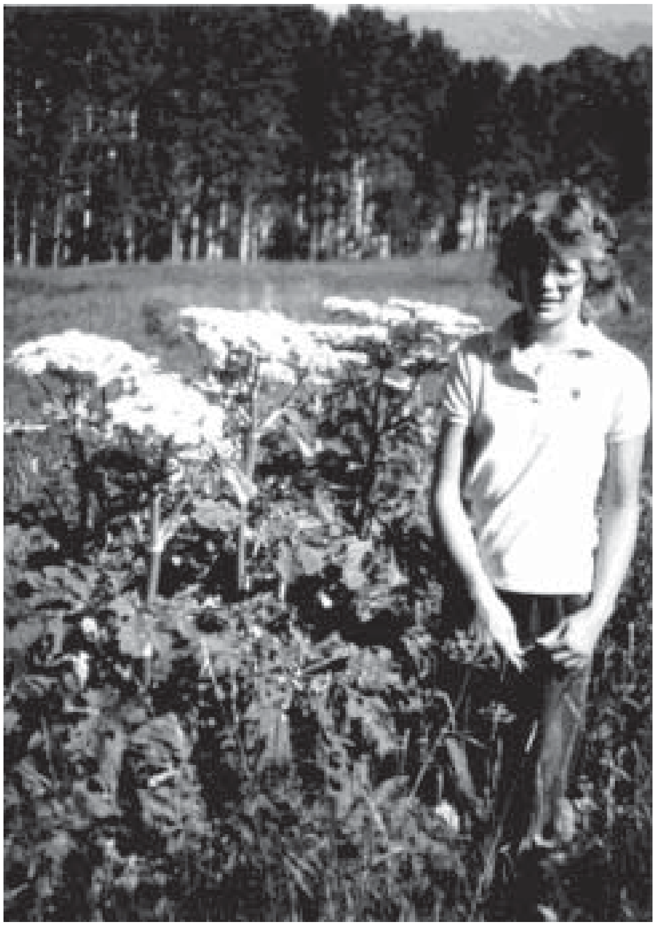


Figure 15—Cow parsnip in full bloom.

Germination is generally low, and viability is not maintained for much more than 2 years (Stevens and Jorgensen 1994).

Seed can be broadcast or drill seeded, preferably in autumn before snowfall. Seed should not be covered more than 0.5 inch (1.3 cm) deep. Seeds are rather large and are difficult to seed in mixtures with smaller seeds. Seeds must be placed in seedboxes separate from smaller seeded species so that planting rates can be properly controlled. Seeds can be easily fractured during cleaning or mechanical planting. Seedlings usually establish and grow rapidly, and can persist when seeded with most herbs. Plants normally require 3 to 4 years to attain maximum size, but once established they remain highly productive.

Uses and Management

Cow parsnip is highly palatable to livestock and big game (Ellison 1951; Hermann 1966; USDA Forest Service 1937). It has considerable potential as an ornamental plant for summer homes, administration buildings, and recreational areas.

Reproduction is by seed only. Continual annual grazing will prevent seed production, reduce vigor, and result in elimination of this forb. Cow parsnip is a highly preferred species that requires deferred grazing. Seeded areas should not be grazed for at least two growing seasons following planting.

Varieties and Ecotypes

There are no releases.

Family Umbelliferae
Ligusticum porteri

Porter Ligusticum

Porter ligusticum (fig. 16) a North American native, is a member of the umbel or carrot family (Welsh and others 1987). Plants are perennial with a characteristic aromatic taproot. White flowers are borne in a terminal umbel which is often subtended by a whorl of three to eight lateral umbels. Flower stalks are hollow and may attain a height of 4 ft (1.2 m). Flowering occurs in July and early August. Seed matures in August and September.

Ecological Relationships and Distribution

Porter ligusticum is the most widespread ligusticum in the Intermountain West. It can be found in openings in aspen, spruce-fir, and subalpine types and as a component of the understory in aspen stands. Porter ligusticum prefers well-drained soils. It has fairly good drought tolerance and good winter hardiness, and can withstand considerable grazing (USDA Forest Service 1937).

Figure 16—Porter ligusticum growing in a subalpine forb community.

Plant Culture

If allowed to mature, good seed crops are generally produced yearly. Seed is collected by hand stripping or beating. Seed is flat, winged, and relatively easy to separate from debris by screening. Dried seeds are brittle and can be fractured or damaged by improper cleaning or mechanical seeding. There are about 70,000 seeds per lb (154,000 per kg).

Seed can be stored for up to 5 years without appreciable loss of viability (Stevens and Jorgensen 1994). Seed can be drilled or broadcast seeded. Fall seeding onto a disturbed seedbed has worked well if the seed is covered with soil. Seeds are heavy, irregularly shaped and do not flow well through most conventional seedboxes. However, when mixed with other seeds of the same size, uniform plantings can be achieved. Seeds are relatively large, and the gates of most seedboxes must be opened wide enough to assure passage. When this is done, seeds of smaller species may be planted too heavily. Consequently, this species is often planted separately from other seeds, and a carrier is added to aid in uniform planting.

Drill seeding at rates of 2 to 4 lb per acre (2.2 to 4.5 kg per ha) in separate rows from seeded grasses is recommended. Broadcast seeding is possible if followed by light harrowing or chaining. Although studies have not identified specific ecotypic differences among populations, survival and growth rate differences strongly indicate distinct ecotypes exist. Seed lots should not be planted in different elevational zones than the collection site. Moving seed from aspen communities to sagebrush types is not advised.

Good germination and seedling establishment usually result from field plantings, but subsequent survival is often low. Plants are suited to grow with other species and persist well in mixtures once established. Some plantings have been conducted in the aspen and oakbrush communities, but this forb also exhibits usefulness in the upper sagebrush communities. It is often encountered in openings and on shallow soils, and can be seeded to improve forage conditions on somewhat harsh situations.

Uses and Management

Livestock, particularly sheep, and big game make considerable use of this species in spring and summer. It is highly sought out at all dates (Hermann 1966; Kufeld and others 1973; USDA Forest Service 1937). Seeded areas should not be grazed for at least 2 years following planting. Established stands should be allowed to produce seed periodically, as reproduction is entirely from seed.

Varieties and Ecotypes

There are no releases.

Family Linaceae
Linum lewisii ssp. *lewisii*

Lewis Flax

There are approximately 100 *Linum* species in the temperate regions of the world (Hitchcock and others 1961), with about 20 species occurring in the western United States. Lewis flax is a delicate, erect perennial sometimes reaching 3 ft (0.9 m) in height. Numerous glabrous stems grow from a single crown with a woody taproot. Flowers are generally sky blue (fig. 17), but also range from white to dark blue. The petals are caducous, dropping within 1 day of flowering. Flowers open in the morning and close by mid-afternoon (Howard and Jorgensen 1980). Flowering begins in May and extends through June. Spherical capsules that produce up to 10 seeds each mature in late July and August.

Ecological Relationships and Distribution

Lewis flax ranges from Alaska south to California and Texas (Harrington 1964). It is a perennial semievergreen that grows on well-drained soils ranging from moderately basic to weakly acidic (Wasser 1982). Lewis flax can be found in shadscale-saltbush, sagebrush grass, and pinyon-juniper communities, and in openings in mountain brush, aspen, and conifer types, especially on warmer south and west exposures. This species is intolerant of poor drainage, flooding, and high water tables (Wasser 1982).

Figure 17—Lewis flax in full bloom.

Plant Culture

Lewis flax can be established easily from direct seeding. Seeding can be accomplished by aerial and hand broadcasting, drilling, and interseeding. Care should be taken to ensure that seeds are not covered by more than 0.13 inch (3 mm) of soil. Lewis flax has been successfully seeded in range, wildlife, roadway, mine disturbance, and landscape plantings. It establishes well when included in mixtures (McKenzie and others 1980; Plummer and others 1970a), and grows and reproduces well in association with other species (Stevens and others 1981b). However, young plants can be suppressed by competitive perennial grasses. This species does well when seeded in mixtures with shrubs. Generally, 0.25 to 0.5 lb per acre (0.3 to 0.6 kg per ha) is seeded in mixtures. Reproduction is entirely from seed. The species is well adapted to sagebrush, pinyon-juniper, and mountain brush communities, and is one of the few forbs that can be seeded successfully in the salt desert types (Monsen and Plummer 1978). Everett (1982) reported that Lewis flax was the superior forb in a number of pinyon-juniper seedings. It has been one of the most successful native forbs seeded in the sagebrush and pinyon-juniper communities in Utah. Seeding is best accomplished in fall or winter (Everett 1982; Howard and Jorgensen 1980). Seeds require an afterripening period to obtain maximum germination (Eddleman 1977; Stevens and Jorgensen 1994). Seed can be held in storage up to 10 years without any appreciable loss of viability (Stevens and Jorgensen 1994).

Seed can be collected by hand, with power-driven beaters, or with a combine. Seed production is generally high. Seed is also being successfully produced under cultivation. Natural reproduction is usually good, resulting in stable numbers and production even though individual plants are relatively short-lived (4 to 7 years). Flowering occurs over a 6 week period, causing seed to mature unevenly over an extended period of time. There are about 280,000 seeds per lb (617,000 per kg) at 100 percent purity.

Uses and Management

Lewis flax produces basal foliage from a woody taproot (Plummer and others 1968). This species can be classified as a semievergreen because some basal foliage remains green throughout the winter. Animals paw through the snow to reach the green growth in winter. Early spring growth is grazed by big game, upland game birds, and livestock. Forage value for livestock and big game is moderate to high, and birds and rodents seek out the seed (Everett and others 1978; Howard and Jorgensen 1980; Plummer and others 1970a). Lewis flax responds well to late summer and fall storms by producing new basal leaves. Because it maintains green basal foliage year round, this species does not burn readily, and it can be used as a fire suppressant species. Lewis flax has the ability to compete with and spread in some cheatgrass communities. When seeded in mixtures, Lewis flax establishes and spreads well. It quickly occupies open areas and slowly suppresses annual weeds.

Flower color ranges from nearly white to dark blue. Profuse flowering occurs for about 6 weeks (Addicott 1977), beginning in mid-May. The flowering characteristics of this species make it a prime ornamental candidate. When seeded in a mixture, Lewis flax can help make a seeding more aesthetically pleasing.

Seeded areas should not be grazed for at least 2 years on better sites and 3 years on drier, poorer sites. Seed should be allowed to mature periodically. Individual plants are relatively short-lived (4 to 7 years). Abundant seed is produced when plants are not excessively grazed. Lewis flax will reproduce and remain in most seedings if properly managed.

Varieties and Ecotypes

'Appar' Lewis flax was released by the Utah Division of Wildlife Resources, the USDA Forest Service Intermountain Forest and Range Experiment Station, and the USDA Soil Conservation Service Aberdeen Plant Materials Center in 1980. This cultivar was named for A. Perry Plummer. It was initially selected for its appearance and competitiveness with native grasses. It is easily grown under agricultural conditions and has produced up to 700 lb of seed per acre (785 kg per ha) with irrigation. 'Appar' exhibits a wide adaptability to sites in the Intermountain area. It is recommended for sites receiving 10 to 23 inches (25 to 58 cm) of annual precipitation (Howard and Jorgensen 1980; Shaw and Monsen 1983a). Pendleton and others (1993) report that the origin of the cultivar appears to be European and that it is derived from a naturalized population of *Linum perenne*.

Maple Grove Lewis flax was released by the USDA Forest Service, Rocky Mountain Research Station, and the USDA NRCS Aberdeen Plant Materials Center. It is a selected germplasm of *Linum lewisii* that originated near Maple Grove, UT.

Family Umbelliferae
Lomatium triternatum ___________

Nineleaf Lomatium

Nineleaf lomatium (fig. 18) is a member of the umbel or carrot family (Welsh and others 1987). It was formerly identified as *Lomatium simplex*. It has now been divided into two subspecies, *L. triternatum* spp. *platycarpum* and *L. triternatum* spp. *triternatum* (Hitchcock and others 1961; Welsh and others 1987).

Figure 18—Lomatium in full bloom.

This aromatic perennial forb, with yellow flowers and green leaves, grows to about 14 inches (36 cm) in height. It blooms in April and May, and seeds mature in July and August.

Ecological Relationships and Distribution

Nineleaf lomatium occurs in central and southwestern Colorado, Montana, southwestern Canada, and south from California, to Colorado (Hermann 1966; Hitchcock and others 1961; Welsh and others 1987).

Nineleaf lomatium prefers well-drained or dry rocky soils on flats, sunny open ridges, and slopes. *L. triternatum* ssp. *triternatum* occurs in mountain brush, ponderosa pine and aspen forests, and dry valleys from 5,200 to 8,500 ft (1,600 to 2,600 m). *L. triternatum* ssp. *platycarpum* is present in sagebrush-grass types, pinyon-juniper, mountain brush, ponderosa pine, lodgepole pine, and dry meadow communities from 4,300 to 9,500 ft (1,300 to 2,900 m) (Welsh and others 1987).

Plant Culture

Seed matures in July and August. It can be hand collected. Screening to remove debris is all that is generally required to clean field-harvested seed. Viability of freshly harvested seed is generally good and remains high for 3 to 4 years. There are about 42,000 seeds per lb (93,000 per kg) at 100 percent purity. Seed can be drilled or broadcast seeded. Seeding is best accomplished in the fall, with seed being covered not more than 0.25 inch (6.4 mm) deep. This species does well when seeded in mixtures with other herbs.

Uses and Management

Nineleaf lomatium is one of the first species to begin growth following snowmelt. Extremely early growth and development takes advantage of spring soil moisture and provides much needed spring succulence for big game and livestock. Deer, elk, antelope, cattle, and sheep make use of the foliage (Hermann 1966; Mueggler and Stewart 1980; USDA Forest Service 1937).

Large, deep taproots enable nineleaf lomatium to withstand considerable drought, grazing, and trampling. Newly seeded areas should be given at least two seasons of growth before they are grazed.

Varieties and Ecotypes

There are no releases.

Family Umbelliferae
Lomatium kingii

Nuttall Lomatium

Nuttall lomatium, (fig. 19) formerly referred to as *Lomatium nuttallii* (Welsh and others 1987), is a native perennial forb that can be found growing from sagebrush-grass up through the subalpine communities. It exists on basic and acidic soils (Plummer 1977; Welsh and others 1987). Nuttall lomatium is not as widely distributed as nineleaf lomatium. It does, however, occur on drier sites and may have more drought tolerance. Seed is best collected by hand. Viability is generally high. Seeds are large with approximately 12,500 seeds per lb (28,000 per kg). More

Figure 19—Nuttall lomatium setting seed.

than 70 percent germination can be expected even after 5 years of storage (Stevens and Jorgensen 1994). Seed is collected and cleaned in the same manner as described for nineleaf lomatium.

This species is readily grazed by big game during spring months. It is one of the first forbs to green up, thus providing much sought after spring and early summer succulence.

Family Fabaceae
Lupinus sericeus

Silky Lupine

Silky lupine (fig. 20) is a highly variable native perennial legume. Plants are usually 12 to 47 inches (30 to 120 cm) tall, growing from a branching caudex. Flowers and foliage are usually quite abundant. Flowers are large, blue, blue-purple, or white (Welsh and others 1987). Flowers emit a distinctive pungent odor. The leaves are large, palmately compound, often pubescent, and gray-green (Welsh and others 1987). Individual seedpods usually contain 3 to 5 seeds.

Ecological Relationships and Distribution

Silky lupine ranges from southern Canada south to New Mexico (Hermann 1966). It is common in the Great Basin and can be found in sagebrush-grass, pinyon-juniper, mountain brush, ponderosa pine, and aspen types. Welsh and others (1987) reported that silky lupine is one of the most widely distributed species in Utah, with four different varieties reported. It is most abundant in upper mountain brush and aspen communities. This species grows on basic, neutral, and slightly acid soils. It prefers open sunlight, but possesses some shade tolerance.

There are a number of perennial lupines in the Intermountain West. Most tend to intergrade with each other. Two common and abundant species are silky lupine and silvery lupine.

Plant Culture

Seed is usually ready to harvest in early September. Seed pods must be collected before they dry and seeds are shattered. Consequently, seed is collected by hand stripping of the complete inflorescence and, if in pure stands, by mechanical seed beaters or combines. Following collection, the pods need to be further dried before seeds can be extracted. During drying, collected material must be covered with a screen to prevent seed loss. As pods dry, they open, twist, and propel the seed a distance of 3 to 10 ft (0.9 to 3.0 m). Lupine seeds have considerable longevity. Silky lupine seeds have been stored for 20 years and still retained 72 percent germination (Stevens and Jorgensen 1994).

Figure 20—Silky lupine.

Seeds are rather large with only 13,000 per lb (29,000 per kg). Most seeds imbibe water when planted but some fail to germinate. Some seeds that fail to germinate are lighter in color than healthy seeds. Silky lupine should be seeded in the fall to meet stratification requirements. Seed can be drilled or broadcast, with seed covered not more than 0.25 inch (6.4 mm) deep.

Silky lupine establishes well when seeded on disturbed or depleted sites in acid or basic soils (Plummer 1977). Fairly strong seedlings are produced; however, full plant development can be somewhat slow, with flowers not being produced for 3 to 5 years following seeding.

Good numbers of seedlings appear from most plantings. However, plant numbers are generally reduced quite dramatically the first growing season. Plants that persist the first year are usually very hardy and will persist even under adverse conditions. Young plants are quite competitive and persist with some competition. To date, most range seedings have been conducted using seed collected from aspen communities. These sources are not suited to lower, drier elevations.

Uses and Management

Silky lupine is one native legume that has good potential for revegetation of ranges in upper sagebrush-grass, mountain brush, ponderosa pine, and aspen types. This species provides early spring succulence and is grazed by cattle, sheep, deer, rodents, and small mammals throughout the year (Hermann 1966; Holechek and others 1982; Kufeld and others 1973; Plummer and others 1968). It can be seeded in mixtures or in separate drill rows from grasses and other broadleaf herbs. It is extremely productive and provides not only useful forage but also soil protection and erosion control. It persists with grazing, and does well as an understory species. It can be used in riparian disturbances and on dry meadows that are not flooded.

Silky lupine often recovers well when disturbed sites are protected for a number of years. Rodents gather and forage on lupine seeds and can interfere with seedings and natural spread. Seeded areas should not be grazed for at least 2 years, and in some cases, 3 years following planting. Once established, this species has excellent grazing and drought tolerance.

Varieties and Ecotypes

There are no releases.

Family Fabaceae
Lupinus argenteus _______________

Silvery Lupine

A major difference between silvery lupine and silky lupine is the presence of less pubescence on the leaves and stems of silvery lupine. Its flowers are predominantly blue-purple, blue, and white. Meeuwig (1960) reported that silvery lupine has outstanding forage, ground cover, and revegetation potential at higher elevations. Most of the perennial lupines readily hybridize (Hermann 1966). *Lupinus alpestris* is now included as part of the silvery lupine complex (Welsh and others 1987). Seed production, seed handling, seeding, and seedling establishment characteristics of silvery lupine are similar to those of silky lupine.

Silvery lupine occurs at higher elevations than does silky lupine. Major areas of occurrence are aspen, spruce-fir, and subalpine herblands (fig. 21).

Figure 21—Silvery lupine in a subalpine community.

Figure 22—'Nomad' alfalfa. Yellow- and blue-flowered alfalfa growing together on a pinyon-juniper site.

Poisonous Characteristics

Some lupines, including silky and silvery, have poisonous characteristics and can cause death if used improperly during some seasons of the year (Davis 1982b; Davis and Stout 1986; James and others 1980; USDA Soil Conservation Service 1968). Care should be taken with livestock where substantial quantities of lupine are available. Livestock that obtain forage of other species in addition to lupine are generally not adversely affected (USDA Soil Conservation Service 1972b). When planting lupine, care should be taken to ensure that it is seeded in mixtures with other species, and that large, solid stands are not established.

Family Fabaceae
Medicago sativa
Medicago falcata _________________

Alfalfa
Sicklepod Alfalfa

Two species, *Medicago sativa* (alfalfa) and *M. falcata* (sicklepod alfalfa), were introduced to North America (Hansen 1913). Alfalfa is generally blue-flowered (fig. 22) and nonrhizomatous, whereas sicklepod alfalfa is generally yellow-flowered and somewhat rhizomatous.

Both species are perennials. Stems normally reach 11 to 40 inches (30 to 100 cm), depending on growing conditions. Stems are branched; some are ascending. Most range varieties form decumbent stems at the base of the plant. Varieties cultivated for hay production or irrigated pastures are normally more erect.

Leaves of alfalfa are glabrous to hairy, alternate, and pinnately trifoliolate; the leaflets are serrate distally and oblanceolate to oblong. Flowers are small, usually less than 7 to 10 mm long. Fruits consist of several-seeded spiral pods (Harrington 1964). Plants produce an abundance of herbage, with growth beginning early in the spring.

Alfalfa is a complex taxon with nine recognized subspecies (Gunn and others 1978). These express intergrading morphologies and hybridize quite freely. The genus evolved in the Mediterranean region. The perennial mesophytic subspecies arose in Western and Central Asia (Lesins and Lesins 1979). Diploid (2N = 16) and tetraploid (2N = 32) forms commonly occur. Most cultivars are tetraploid (Rumbaugh and Townsend 1985). Lesins and Lesins (1979) report that the diploid populations of alfalfa originate from steep mountainous regions.

Miller and Melton (1983) described over 400 cultivars and strains of alfalfa in North America. Today there are many more. The origin of the 15 most commonly grazed populations are described by Rumbaugh (1982a). All dryland forage types are interspecific hybrids of alfalfa and sicklepod alfalfa (Rumbaugh and Townsend 1985) (fig. 23). These authors reported that sicklepod alfalfa contributes genes that increase drought tolerance, winter hardiness, and tolerance to grazing. Alfalfa germplasm enhances resistance to disease and insects and improves forage and seed production.

Most range and field varieties of alfalfa used in Western range plantings arose from the early efforts of Dr. N. E. Hansen (1913) of South Dakota. Early testing conducted by Dr. Hansen, led to identification of population with spreading root systems. This characteristic has subsequently been bred into field and range varieties (Rumbaugh and Pedersen 1979). Canadian scientists later advanced the usefulness of this species by breeding varieties with better grazing and cold tolerance (Heinricks 1963). Alfalfas were entered into extensive field plantings within the Intermountain region in the 1930's. Numerous field and range varieties have subsequently been developed.

Ecological Relationships and Distribution

Rangeland varieties of alfalfa are well adapted to areas that receive 10 inches (25 cm) or more of annual precipitation. They are especially well-adapted to sagebrush/grass, pinyon-juniper, and mountain brush (fig. 24) communities. They have been seeded and have performed fairly well in aspen, spruce-fir, and subalpine types. This forb is semievergreen, having green basal leaves throughout the winter. Growth starts in the spring when the plant is exposed from underneath the snow. Once grazed, regrowth of rangeland types is limited compared to that of irrigated alfalfas.

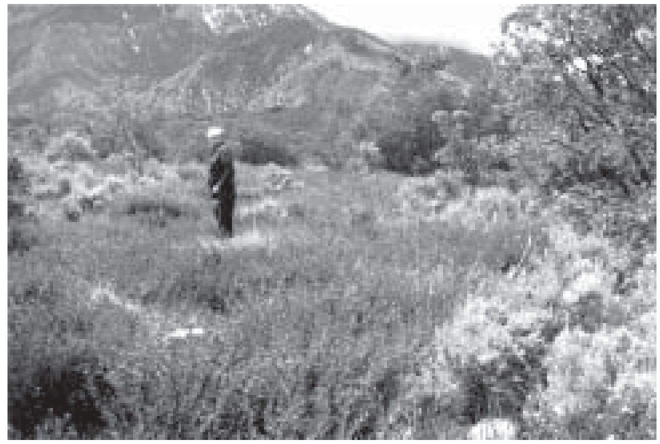


Figure 23—'Rambler' alfalfa seeded into rootplow strips in a Gambel oak-mountain big sagebrush community.

Seedling establishment is rapid, and seeding success rate can be high. Grazing stimulates rhizome production, which results in increased crown size and ground cover (Rosenstock and Stevens 1989).

Alfalfa is well suited to harsh sites and infertile soils. Under these conditions seedlings of few other herbs survive as well as alfalfa. Once established, alfalfa serves as an excellent nurse crop. Although plants begin growth early in the spring, they do not prevent the entry of other species. Alfalfa may produce considerable annual litter that provides a good cover for the seedbed. Once established, alfalfa is very persistent (Rumbaugh 1982b) (fig. 25), but little reproduction has occurred from established stands on rangeland sites (Rosenstock and Stevens 1989). Rhizomatous forms do spread vegetatively even under arid conditions.

Figure 24—'Ladak' alfalfa on a 27-year-old pinyon-juniper chained site.

Figure 25—Rehabilitated range 21 years following chaining of juniper-pinyon and aerial seeding. Thirteen grasses, shrubs, and forbs were seeded. After 21 years alfalfa is the predominant forb.

Plant Culture

Alfalfa is the most widely seeded rangeland forb in the Intermountain West (Rumbaugh 1984; Rumbaugh and Townsend 1985). Depending on the rangeland sites and seeding technique, it can be seeded in the fall or spring. Planting early in the spring usually produces good stands, but plantings in late fall or winter have been satisfactory in large restoration programs. Late winter plantings may prevent precocious germination (Plummer and others 1968), but alfalfa germinates quickly in early spring and may succumb to spring frosts.

Seed can be drilled or broadcast seeded, but it must be covered. Aerial seeding followed by anchor chaining or pipe harrowing and aerial seeding on snow over disturbed soil has produced excellent rangeland stands. Broadcast planting has often been more successful than drilling (Plummer and others 1968). Fall aerial seeding on a rough seedbed has resulted in excellent stands (fig. 25). Whether broadcast or drilled, seed should be covered 0.25 to 0.5 inch (6 to 13 mm) deep (Plummer and others 1968; USDA Soil Conservation Service 1971a).

Alfalfa is particularly adapted to drill or broadcast seeding in mixtures with other species. Seeds are rather small, round, and smooth. When mixed with grasses, seed sorting and separation can occur in the seedbox. Alfalfa seed usually does not separate when mixed with grasses if planted at a ratio of 1 to 5. Separate legume seedboxes are mounted on most drills. The legume boxes are designed to dispense the small alfalfa seed more accurately than the larger seedboxes and eliminate seed separation when mixtures are planted.

Although alfalfa seeds should be planted slightly shallower than large seeded grasses, adequate stands normally appear when they are drilled together. Alfalfa seedings develop rapidly and compete favorably with many grasses and other broadleaf herbs. Alfalfa seedlings, however, do not compete well with seedlings of crested and intermediate wheatgrass and smooth brome.

Because of the possibility of bloat, alfalfa should be seeded as a component of a mixture when planted in a pasture (Lorenz 1982). Up to 40 percent by weight of a grass-legume mixture has been seeded to alfalfa without causing bloat problems to livestock. Bloat has not been observed as a problem on mixed rangeland seedings.

Because alfalfa is highly utilized by livestock, big and small game, birds, rodents, and rabbits, a sufficient number of plants must be established to ensure the species is not eliminated by overuse. On most ranges, at least 2 lb of seed per acre (2.2 kg per ha) should be planted in the seed mix. Seed costs are generally not prohibitive, and under some conditions alfalfa should be planted at even higher rates. As seeding rates are increased, stand density also increases. Seeding alfalfa at rates exceeding 6 to 8 lb per acre (6.7 to 9.0 kg per ha) is unnecessary. There are about 220,000 seeds per lb (485,000 per kg). Purity is generally over 95 percent with germination at least 85 percent. Under warehouse storage seed longevity is excellent and little viability is lost after 25 years (Stevens and Jorgensen 1994).

Alfalfa is able to fix nitrogen, thereby improving soil fertility. Johnson and Rumbaugh (1981) reported that alfalfa appears able to fix nitrogen even during periods of drought when other legumes do not nodulate.

Uses and Management

Alfalfa is heavily grazed by livestock, big and small game, upland game birds, rodents, and rabbits during all seasons (fig. 26). The inclusion of alfalfa in a rangeland seeding can have a number of positive effects. It can (1) increase total herbage production, (2) increase production and protein content of associated species (Johnson and others 1983; Rumbaugh and others 1981, 1982), (3) extend the grazing season, both during spring and fall, (4) increase diversity (flora and fauna) of seeded communities, and (5) improve soil stability. Species growing in association with alfalfa are generally positively affected by its ability to fix nitrogen (Johnson and others 1983; Rumbaugh and others 1981, 1982). Consequently, alfalfa can be interseeded into established grass stands to improve vigor and herbage production.

Figure 26—Alfalfa seeding in a chained pinyon-juniper basin big sagebrush area. Deer use only on left, rabbit and deer use on right.

Alfafa is compatible with native species in seedings in mountain brush, pinyon-juniper and big sagebrush communities. The forb has not noticeably diminished or eliminated native broadleaf herbs or grasses.

Regrowth capacity varies among varieties. Deep-rooted types possess better regrowth capabilities than rhizomatous range types. Alfalfa initiates growth early in the spring and remains green and productive as long as soil moisture permits. It can recover following grazing or clipping. It normally attains maximum production after most cool-season grasses cease growth. Certain strains of grass, including 'Latar' orchardgrass and 'Greenar' intermediate wheatgrass, mature when alfalfa is at the optimum stage of growth for harvesting as hay (Hafenrichter and others 1968). These species can be planted in mixtures to significantly extend the season of grazing and enhance total herbage production. Alfalfa also furnishes excellent fall green-up, and standing crops cure quite well. Consequently, this species has been used in wildlife seedings to attract and keep game animals from trespassing in agricultural fields. Areas seeded to alfalfa should not be grazed for a minimum of two growing seasons following seeding. Early use can result in poor survival and loss of vigor (Berdahl and others 1986). Drier areas may require additional time before stands fully establish.

It is not unusual for seedlings and young plants to succumb during the first 1 to 3 years following planting (Rosenstock and Stevens 1989). Once established, however, alfalfa has considerable longevity, resistance to grazing and trampling, and moderate shade tolerance. Kilcher and Heinrichs (1966b), Pearse (1965), Rosenstock and Stevens (1989), and Rumbaugh and Peterson (1979) reported excellent stands persist 23 to 28 years after seeding on sites with 8 to 11.5 inches (20 to 29 cm) of precipitation. The Utah Division of Wildlife Resources has aerial seeded alfalfa on over 150,000 acres (60,700 ha) of game range during the past 30 years. At a few sites, there has been a major loss in plant density. Where a decrease in density has occurred, it has been a result of continuous heavy rabbit use and continual spring use by cattle. Similar results have been reported by Rumbaugh and Pedersen (1979) and USDA Soil Conservation Service (1971a). Rumbaugh (1982b) reported that stand density of eight different varieties was adequately maintained during a 25-year period, with proper spring grazing by cattle. Where insufficient seed is planted and plant density is low, considerable grazing pressure will reduce the stand At least 2 lb. (0.9 kg) of seed per acre should be seeded to ensure sufficient density to sustain grazing.

Alfalfa generally receives more grazing pressure than other associated species and withstands greater use than other broadleaf herbs. Weakened stands recover readily when grazing pressures are removed. The deep taproot, large crowns, and extensive rhizomes enable the plant to persist over extended periods of drought.

New seedings can be damaged by continuous grazing by rabbits, rodents, livestock, or big game animals. Insects, including grasshoppers, have seriously defoliated alfalfa, often within a 2 to 5 day period. Attempting to seed alfalfa and palatable grasses in areas with high rabbit populations can be risky. Once established, mature plants can usually recover from cyclic periods of heavy use, but young seedlings cannot.

Alfalfa can be used to sustain big game animals during the early spring and summer months. Plantings established on pinyon-juniper sites in central Utah clearly attract deer and provide a substantial part of their diet, beginning in early March and continuing until early June (Rosenstock and others 1989). Wildland sites seeded to support big game should be grazed only lightly by livestock. If plants are subjected to stress by drought or excessive use by insects or rabbits, livestock grazing should be curtailed.

Alfalfa has been seeded on some rather arid sites, including sites dominated by Wyoming big sagebrush and shadscale saltbush. When seeded during years of average precipitation, plants usually establish. However, failures can be expected if seeding occurs during years with low precipitation. Plantings can be maintained under arid circumstances if grazed judiciously.

Varieties and Ecotypes

A number of strains of alfalfa—'Ladak', 'Rambler', and 'Nomad'—are adapted to ranges where annual precipitation exceeds 10 inches (25 cm) (Plummer and others 1968; Rumbaugh 1982b). These strains produce much larger crowns than the usual field strains and have more complex root systems. In addition, they survive better from underground attacks by gophers and other rodents. Some plants also spread by stem layering. Consequently, these strains are superior for seeding rangelands (Plummer and others 1968).

'Ladak' is the best known and most widely used rangeland variety. If seeds of several strains are available, a mixture may be used. The varieties mentioned above have shown unusual persistence and production under heavy grazing and lower precipitation (Plummer and others 1968). Other cultivars—'Spreader', 'Spreader II', 'Rhizoma', 'Runner', 'Travois', 'Teton', and 'Drylander'—have also demonstrated good adaptability to wildland sites. Additional varieties are currently being developed for rangelands. A major concern is to improve drought tolerance so the forb may be planted in more arid environments.

Family Fabaceae
Melilotus officinalis ______________

Yellow Sweetclover

The two most abundant sweetclovers on Western ranges are yellow sweetclover (yellow-flowered), and white sweetclover (white-flowered). Neither are native to North America. There are annual and biennial forms of each; however, most populations are biennials (Rumbaugh 1984; Smith and Gorz 1965). During the first season, only vegetative growth occurs; during the second season, long, well-branched stems 1 to 6 ft (0.3 to 1.8 m) tall (fig. 27) develop. Leaves are trifoliolate, and dentate margined, with small narrow stipules. Flowering occurs on long narrow racemes, and single seeds are produced in straight smooth pods (Hermann 1966). After flowering and seed maturation, plants usually die.

Ecological Relationships and Distribution

Yellow sweetclover originated in Europe and Asia and is now distributed over most of the United States and Southern Canada. The species is especially adapted to disturbed sites. It has a strong seedling, fairly good drought resistance, and good winter hardiness (USDA Forest Service 1937; USDA Soil Conservation Service 1971b). It grows well with over 10 inches (25 cm) annual precipitation in aspen, mountain brush, ponderosa pine, big and black sagebrush, and pinyon-juniper types. Yellow sweetclover also does well in saline and alkaline soils and on many riparian sites (Plummer 1977; USDA Soil Conservation Service 1968, 1971b; Wasser 1982).

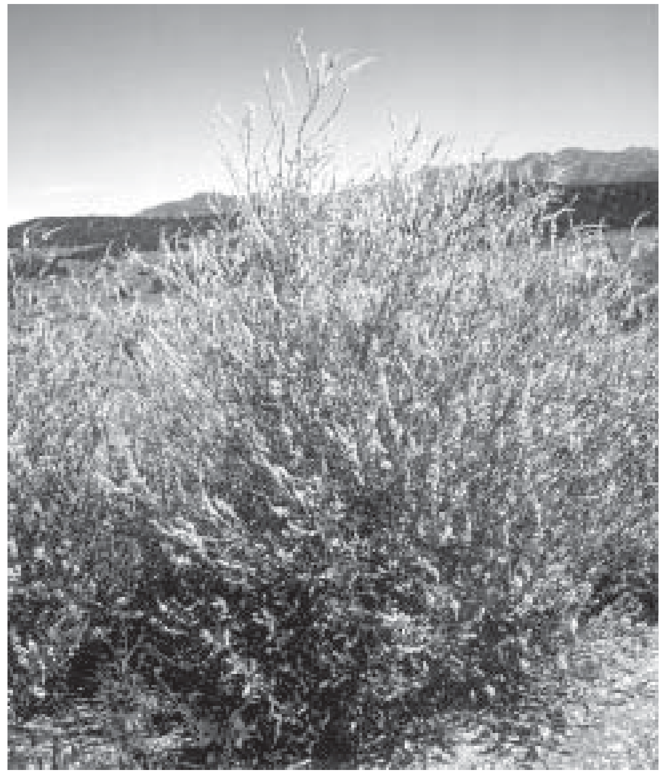


Figure 27—Yellow sweetclover.

Plant Culture

Seed production of yellow sweetclover is generally high. There are more than 250,000 seeds per lb (550,000 per kg). Germination is generally high, and good viability is retained for at least 2 years with warehouse storage. Adequate, inexpensive seed is generally available. Like most legumes, sweetclover seeds have a hard coat and are best seeded in the fall or winter. Seeds can lie dormant in the soil for years and then germinate when temperatures and moisture conditions are favorable. In central Utah, seedings more than 35 years old still retain some yellow sweetclover. Nichols and Johnson (1969) report that with 15 inches (38 cm) of precipitation, yellow sweetclover will reseed successfully. Seeds can be drilled or broadcast on relatively unprepared seedbeds. Best stand establishment occurs when seeds are planted 0.13 to 0.25 inch (3 to 6 mm) deep, preferably on a fairly firm seedbed.

Uses and Management

Yellow sweetclover is frequently seeded on Western rangelands (Rumbaugh and Townsend 1985). It is an effective erosion control species because it has an extensive, deep taproot system and a strong vigorous seedling. It also produces a dense ground cover in 1 or 2 months and fixes nitrogen. Up to maturity, palatability is high for big and small game (Graham 1942; Kufeld 1973; Kufeld and others 1973; Mueggler and Stewart 1980; Plummer and others 1968; Rumbaugh 1984; USDA 1971b) and for livestock (Hermann 1966; USDA Forest Service 1937; USDA Soil Conservation Service 1971b), with forage quality reportedly higher than that of alfalfa (Magness and others 1971; Rumbaugh 1984). Waterfowl, upland game birds, and bees also use yellow sweetclover (Autenrieth and others 1982; Rumbaugh 1984; USDA Soil Conservation Service 1971b). The species has a very strong seedling that emerges in the spring, providing early succulence. Yellow sweetclover provides much needed live ground cover and forage during the critical first and second years. It can be seeded at 0.5 to 2 lb per acre (0.56 to 2.2 kg per ha), (Nichols and Johnson 1969; Plummer and others 1968; USDA Soil Conservation Service 1971b). Yellow sweetclover is generally seeded with perennials on disturbed sites. It furnishes initial cover and forage as slower developing herbs attain mature stature. It withstands heavy use and can reseed following fires or other disturbances.

Varieties and Ecotypes

There are three released varieties—‘Goldtop’, ‘Madrid’, and ‘Yukon’ (Wasser 1982). These varieties have not performed any better than the common seed sources. Most seed marketed is from uncertified common lots.

Family Boraginaceae
Mertensia arizonica

Tall Bluebell

Tall bluebell is the most widely distributed *Mertensia* in the Intermountain West (Higgins 1972; Mathews 1968). There are, however, other bluebells that are locally important (Hermann 1966). Different varieties of tall bluebell have been described, particularly from collections obtained in Utah (Cronquist and others 1984; Welsh and others 1987). Tall bluebell is a rhizomatous native perennial with a thick, woody root. It grows to a height of 2 ft (61 cm) and produces an abundance of pale blue to very dark blue flowers (fig. 28). Leaves are abundant and are borne on erect stems. Fruits are hard and consist of four nutlets (Cronquist and others 1984).

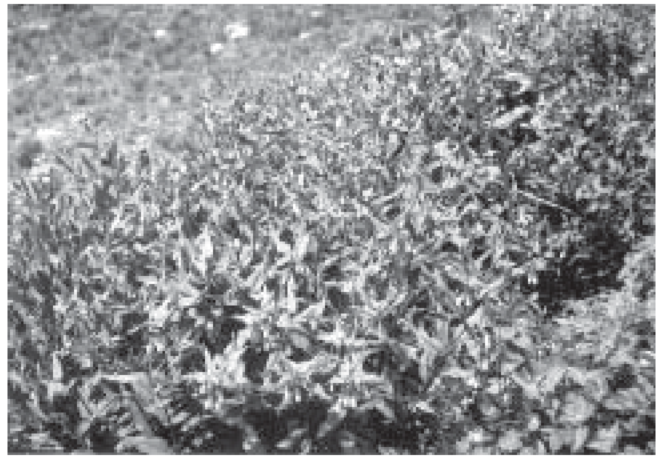


Figure 28—Tall bluebell in full bloom.

Ecological Relationships and Distribution

Tall bluebell occurs in fairly moist to well-drained soils in aspen, spruce-fir, ponderosa pine, and subalpine types, usually at elevations from 6,000 to 11,000 ft (1,800 to 3,400 m). The species can be found along streams in canyon bottoms, meadows, parks, and in scattered timber stands. It grows well in shade and open situations in pure stands as well as in mixed communities. Tall bluebell is present in all mountain regions of Utah, southwestern Wyoming, and northwestern Colorado (Cronquist and others 1984).

Plant Culture

Flowering occurs during midsummer. Seeds mature in September and can be collected by hand stripping, beating, and in pure stands with various types of combines. Germination is generally high (60 to 70 percent), with good viability being maintained for at least 5 years. Seeding is best accomplished in the fall on disturbed soil, with seed covered 0.25 to 0.5 inch (6 to 13 mm) deep. Tall bluebell can be seeded in mixtures with other herbs. It usually grows on fertile soils. When planted on disturbed, degraded sites it has not done well. Under good conditions, plants establish quickly and reach maturity in 3 to 5 years. Plants spread slowly by rhizomes, yet are very persistent and compatible with other native species when seeded in mixtures.

Uses and Management

Sheep, elk (Kufeld 1973), and deer (Kufeld and others 1973) seek tall bluebell and gain weight exceptionally well on the herbage. Cattle prefer the flower stalks but will make use of all plant parts (USDA Forest Service 1937). Sheep graze the herb whenever available. The bluebells are generally very showy and fairly easily seeded or transplanted, and are good soil stabilizers. Consequently, the plant is a good candidate for use in recreational areas, summer home sites, and areas with high aesthetic value and use. The plant furnishes such excellent forage that it should be included in most seedings on adapted sites. However, the lack of sufficient seed currently curtails the use of this forb. This species has not done well if planted off site, particularly at lower elevations where it normally does not occur.

Newly seeded areas should not be grazed for at least 2 years. Large fibrous root systems, once established, allow tall bluebell to withstand periods of drought, grazing, and trampling. Concentrated use can occur if seedings are not properly managed.

Varieties and Ecotypes

There are no releases.

Family Fabaceae
Onobrychis viciaefolia

Sainfoin

Sainfoin (fig. 29) is a perennial, nonbloating, introduced legume that grows 1 to 3 ft (30 to 91 cm) tall, and produces white or pink to purplish pea-like flowers. Stems are semierect, originating from a branched root crown attached to a deep main taproot. Leaves are alternate, odd-pinnate and oblong to elliptic or oblanceolate (Rumbaugh and Townsend 1985; Welsh and others 1987).

Ecological Relationships and Distribution

Sainfoin was introduced into North America from Europe. It has been used primarily as a hay or pasture crop. However, the species demonstrates considerable usefulness for rangelands.

Sainfoin is adapted to sagebrush, pinyon-juniper, and mountain brush areas that receive at least 14 inches (36 cm) of annual precipitation. Sainfoin prefers well-drained, deep calcareous soils (Eslick 1968), exhibits fairly good salt tolerance (Jensen and Sharp 1968), and grows well in soils low in phosphorus (Rumbaugh and Townsend 1985).

Figure 29—Sainfoin growing with crested wheatgrass and basin big sagebrush.

Plant Culture

Single seeds are produced in pods and are marketed unshelled. There are about 26,000 unshelled seeds per lb (57,000 per kg). Unshelled seeds are best drilled, but can be broadcast if covered sufficiently. Seed should be covered at least 0.25 inch (6 mm) and not more than 0.75 inch (19 mm) deep (Jensen and Sharp 1968). Seeding is best done on a firm seedbed that is relatively weed free. For range seeding, it is best to seed in the fall. Seed should be inoculated with the proper rhizobium (Dubbs 1968). Seed is marketed with about 70 percent germination and 95 percent purity. When seeded in a mixture, about 2 to 5 lb per acre (2.2 to 5.6 kg per ha) is recommended. Seed can be stored up to 4 years without much loss of viability.

This species can be seeded individually or as a component of a mixture. A strong seedling is usually produced. Rate of growth following seeding is only fair on mesic sites. However, plants are quite persistent and hardy. Two years are required for flowering to occur under favorable conditions.

Uses and Management

Sainfoin is nonbloating and palatable to livestock, big game, and sage-grouse (Autenrieth and others 1982; Holder 1968; Rumbaugh 1984; Shaw and Cooper 1973; USDA Soil Conservation Service 1968a). Mule deer in Utah have been observed to prefer sainfoin hay over alfalfa hay. Sainfoin has a deep taproot and has wilt and drought hardiness equal to or slightly less than does ‘Ladak’ alfalfa (Dubbs 1968; USDA Soil Conservation Service 1968a). Some basal leaves remain green throughout most of the winter. Sainfoin starts growth early in the spring, usually prior to alfalfa. It continues to grow or remains green throughout the summer period. Once grazed or clipped, regrowth is limited. Characteristics that give sainfoin considerable potential in the Intermountain area as a forage crop include early greenup, cold and drought tolerance, nonbloating characteristics, high forage production potential, ability to grow with other species, and adaptation to calcareous soil.

Areas seeded to sainfoin should not be grazed for at least the first two growing seasons. Every 2 to 3 years, seed should be allowed to mature and seed naturally. Plants are persistent and withstand heavy clipping or grazing. Once established, this species also competes fairly well in mixed communities.

Varieties and Ecotypes

A number of improved varieties have been released, including 'Eski', 'Melrose', 'Nova', 'Onar', 'Remont', and 'Runemex'. All were released for cultivated pastures and for hay. 'Eski' is the most commonly seeded variety on ranges. This variety does well when seeded in upper pinyon-juniper, mountain big sagebrush, and mountain brush areas.

Family Umbelliferae
Osmorhiza occidentalis __________

Sweetanise

Sweetanise is an erect, perennial, aromatic native that grows up to 4 ft (1.2 m) tall (Welsh and others 1987) (fig. 30). Crushed leaves and seed give off a heavy licorice odor (Hermann 1966). It is a member of the umbel or carrot family and produces small umbels of yellowish-green flowers. Flowering occurs in May and June, and seed matures in September. Fruits are slender and sharp-pointed.

Ecological Relationships and Distribution

Sweetanise occurs from Western Canada south through Utah and Colorado. It grows well in shade, open areas, mixed communities, and in solid stands. Sweetanise prefers cool, moist woods, moist hillsides, valleys, and forest openings in aspen, spruce-fir, and subalpine types. It grows on basic, neutral, and slightly acidic soils.

Plant Culture

This species can be successfully established by direct seeding. Lack of a consistent seed source reduces seeding of this species. It establishes easily and spreads quickly from seed. Seeding is best completed in the fall. Seed should be covered, but not more than 0.25 inch (6 cm). Sweetanise does well seeded in mixtures. Seed is usually collected by hand, but dense stands can be mechanically harvested. Seeds are brittle and can be damaged during cleaning and seeding. Seeds can generally be cleaned by screening from harvested debris. There are about 30,000 seeds per lb (73,000 per kg). Seed should not be stored more than 2 years, or considerable loss in viability can occur. Thirteen year old seed is reported to exhibit 44 percent germination (Stevens and Jorgensen 1994). Seeds are large and usually must be drilled seeded to ensure proper soil coverage. Seeds are approximately the same length as some grass seed and can be planted in a mixture, depending on the species sown.

Figure 30—Sweetanise with mature seed.

Uses and Management

Cattle, sheep, and big game show a particular fondness for the foliage and for developing seeds of sweetanise (Hermann 1966; Kufeld 1973; Kufeld and others 1973; Plummer and others 1955; USDA Forest Service 1937). The plant is palatable and remains green throughout the grazing season. Consistent seed crops are produced yearly if seeds are allowed to mature before being grazed. Large, thick, woody roots allow the plant to withstand considerable use during dry periods. This species does not furnish a dense ground cover and is not recommended for erosion control. Heavy grazing can eliminate or reduce its density.

Seeded areas should not be grazed for at least 2 years following planting. A fairly strong seedling is produced, and the rate of growth is good. Seeds are generally produced the second year following planting. Maturing seeds are readily eaten by grazing animals. Some type of deferred grazing should occur to allow seeds to mature at least every 2 to 3 years.

Varieties and Ecotypes

There are no releases.

Family Scrophulariaceae
Penstemon palmeri ______________

Palmer Penstemon

In North America there are over 200 native species of *Penstemon* (Hermann 1966; USDA Forest Service 1937). Many are short-lived herbaceous species that spread readily by seed. A number are rhizomatous. Some penstemon are semievergreen, producing basal leaves that persist the entire year. They can be found in most vegetative types of Western North America.

Palmer penstemon (fig. 31) has long flowering stalks 20 to 55 inches (50 to 139 cm) tall with large showy pink blossoms that are produced in late spring and early summer. Seed matures in September. Flowers give off a pleasant fragrance that is unique among the penstemons, as they usually have little or no scent (Stevens and others 1985b).

Ecological Relationships and Distribution

Palmer penstemon is an evergreen native perennial that occurs in blackbrush, sagebrush-grass, pinyon-juniper, mountain brush, and ponderosa pine types of the Intermountain West. It is a fairly short-lived (4 to 5 years) pioneering species. Plants spread by seed. This species can be found growing on basic and acidic soils (Plummer 1977). It produces long seed stalks and an abundance of basal evergreen leaves that usually remain gray-green throughout the year. A large fibrous root system is produced. Palmer penstemon has considerable grazing tolerance and good drought tolerance.

Figure 31—Palmer penstemon in full bloom.

Figure 32—Broadcast seeding of Palmer penstemon on a roadside disturbance.

Plant Culture

Good results can be expected from drilled or broadcast seedings on disturbed soils and on raw and eroding sites (fig. 32) where it occurs naturally as an early invader. Seed can be drilled or broadcast onto disturbed soil, with covering not to exceed 0.15 inch (3 mm). Natural reproduction generally compensates for the short-life span of individual plants. Seed is generally produced in abundance. Some dormancy exists that allows seeds to accumulate in the soil until favorable conditions occur for germination and establishment.

Seeds of most penstemons, particularly Palmer penstemon, can be seeded in mixtures with most other herbs. Small vigorous seedlings appear early in the spring. They compete well and usually are not eliminated by competition from other species. When seeded heavily, considerable thinning or dieoff of young seedlings normally results. However, sufficient survival usually occurs to provide adequate stands. Palmer penstemon is particularly adapted to harsh situations and tends to dominate or establish on areas where other species fail. It is one of the few native broadleaf herbs that most consistently establishes from seeding. It is particularly important for its ability to establish and enhance the establishment of other plants on harsh sites.

All species of penstemon have small seeds that are easily cleaned to a purity that exceeds 90 percent. Palmer penstemon has 350,000 seeds per lb (770,000 per kg) at 100 percent purity. Seeds are so small that they are difficult to meter through most conventional drills. If seeded alone, a carrier is often used to regulate planting rates. Seeds can be mixed with seeds of most other species although some separation can occur in the seedbox. When seeded in mixtures, 1 to 3 lb per acre (1.1 to 3.4 kg per ha) are adequate.

Seeds can be collected by hand stripping or beating; pure stands can be combined. Seeds are cleaned by hammermilling and screening. Storage of up to 5 years has resulted in no significant loss in germination (Stevens and Jorgensen 1994). Seeds are being produced commercially.

Uses and Management

Palmer penstemon is eaten readily by deer and elk, especially during winter and spring months (Kufeld and others 1973; Plummer and others 1968). Basal leaves are green and succulent all year long. Cattle and sheep also make use of this species. The large, fibrous root system and large, succulent basal leaves provide considerable soil protection. This species is an early invader and does especially well on disturbed raw soils. Pink blossoms in late spring and early summer make this plant useful for beautification projects.

Because of seed dormancy, seeding should occur in the fall. Once established, stands are self-perpetuating. Seeded areas should not be grazed for at least two growing seasons following planting. Flowering and seed production often occur the second year following planting. This species has little shade tolerance, but grows as an understory with sagebrush. It is somewhat resistant to fire and trampling, but can be eliminated by excessive grazing.

Varieties and Ecotypes

'Cedar' was selected and released in 1985 (Stevens and others 1985b) for its wide area of adaptation, winter succulence, forage and seed production, and grazing preference by livestock and wildlife. 'Cedar' does well in blackbrush, salt desert shrub, sagebrush-grass, pinyon-juniper, and mountain brush types within the Intermountain region. Commercial seed is readily available and recommended for use.

Family Scrophulariaceae
Penstemon cyananthus

Wasatch Penstemon

Wasatch penstemon (fig. 33) is a native perennial with bright semievergreen basal leaves. Plants develop from a primary taproot and produce several 2 to 3 ft (61.0 to 91.4 cm) long stems with deep blue to nearly purple flowers. Wasatch penstemon can be found on rocky soils, but is usually associated with more fertile, deeper soils that may be slightly acidic or basic. It occurs from the mountain brush type to higher elevations, including the subalpine zone. Flowering occurs from May through July. Seeds are formed in September. Seed processing and planting features are similar to those of Palmer penstemon and most other penstemons. Seeds are, however, somewhat larger with about 230,000 per lb (510,000 per kg) at 100 percent purity. This species is particularly important as a forage and cover plant, and establishes readily from artificial seeding. It persists under heavy grazing and can be seeded in mixtures with other herbs.

Figure 33—Wasatch penstemon in a mixed subalpine forb community.

Family Scrophulariaceae
Penstemon eatonii

Eaton or Firecracker Penstemon

Eaton or firecracker penstemon (fig. 34) is a bright red to scarlet-flowered perennial semievergreen native that occurs primarily on rocky soils. It occurs in

Figure 34—Eaton or firecracker penstemon.

mixed desert shrubs, sagebrush-grass, mountain brush, and aspen communities. This species forms a taproot. It is generally found on harsh, rocky sites; but it also occurs on more favorable sites. Seed collection, handling, and seeding techniques are similar to those described for Palmer penstemon. Seeds can be stored up to 12 years without much loss of viability (Stevens and Jorgensen 1994). Eaton penstemon is particularly useful for seeding in pinyon-juniper, mountain brush, and big sagebrush sites. It is not an abundant seed producer but establishes easily and is a useful forage species. Its brilliant flowers are extremely attractive and useful in landscape plantings. 'Richfield', a source-identified variety, has been released.

Family Scrophulariaceae *Penstemon humilis* ______________

Low Penstemon

This semievergreen native penstemon is a low-growing, 12 inch (30 cm) tall perennial forb with a matted, much-branched root system. Flowers are borne on short flower stalks and range in color from deep-blue to violet-blue. Foliage is light green. Low penstemon can be found in sagebrush-grass, pinyon-juniper, mountain brush, aspen, and subalpine communities, generally on gravelly, well-drained soils.

Planting procedures and seed collection are similar to those of other penstemons. This penstemon is eaten by wildlife and livestock and can be used to stabilize erosive sites.

Family Scrophulariaceae *Penstemon pachyphyllus* __________

Thickleaf Penstemon

Thickleaf penstemon, as its name indicates, has broad, fleshy, thickened, bluish-green leaves covered with wax. Flowers are light purple to bluish-violet. Seeds are small with 335,000 per lb (739,000 per kg) at 100 percent purity. Seeds can be stored for up to 14 years without appreciable loss of viability (Stevens and Jorgensen 1994). Seeding requirements are similar to those of Palmer penstemon. This species occurs in eastern and northern Utah in salt desert shrub, sagebrush-grass, pinyon-juniper, mountain brush, and conifer communities. It is eaten by wildlife and livestock, and provides excellent soil protection.

Family Scrophulariaceae *Penstemon rydbergii* ______________

Rydberg Penstemon

This species occurs in mountain brush, aspen, coniferous forests, and open parklands on basic and acid soils. Rydberg penstemon has a dark violet-purple flower and dark green basal leaves that are present throughout the year. It is highly sought by sheep and big game animals. Seed and seeding characteristics are similar to those of Palmer penstemon.

Figure 35—Rocky Mountain penstemon.

Family Scrophulariaceae *Penstemon strictus* ______________

Rocky Mountain Penstemon

This is a semievergreen penstemon that has an abundance of dark, shiny green leaves and blue to violet flowers borne on stalks 1 to 2.5 ft (30 to 76 cm) tall. Rocky Mountain penstemon (fig. 35) does well on rocky and sandy loam soils that range from weakly acidic to alkaline. This species does best with 15 to 20 inches (38 to 50 cm) of annual precipitation. Seeding and seed handling requirements are similar to those of Palmer penstemon. One variety, 'Bandera', has been released, and seed is being produced commercially. 'Bandera' was selected for its longevity and excellent forage and seed production. It is well adapted to mountain brush, ponderosa pine, and spruce-fir areas.

Family Rosaceae *Sanguisorba minor* ______________

Small Burnet

A member of the rose family, small burnet (fig. 36), is an introduced perennial with a basal rosette of pinnately compound leaves arising from a caudex and taproot. Numerous flowering stalks may grow from 2 to 20 inches (5 to 51 cm) in height. Flowers are

Figure 36—Small burnet.

formed in dense, terminal heads. Basal leaves remain green nearly the entire year. Growth starts in early spring, flowers appear in May and June, and seed matures in August and early September.

Ecological Relationships and Distribution

There are approximately 30 species of burnet, occurring primarily in Europe and the Middle East (Hermann 1966). Two species, western burnet and Alaskan burnet, are native to Western North America. They are locally valued as forage plants (Hermann 1966; Hitchcock and others 1961). Selections of small burnet from Mediterranean and Middle Eastern countries have been more widely adapted to sites in the Intermountain region than any of the Western North American species. Small burnet has proven to be well adapted to pinyon-juniper, basin big sagebrush, and mountain big sagebrush communities, and to drier exposures in the mountain brush and aspen types. Small burnet will grows well on acid or alkaline soils (Plummer 1977). The species is adapted to sandy and clay soils, with silty and loamy soils the most preferred (Wasser 1982). Small burnet has good winter hardiness and some fire and shade tolerance.

Introduction of *S. magnollii*, *S. dictyocarpum*, and *S. muricata* have exhibited characteristics similar to those of *S. minor* when grown on southwestern Idaho rangelands (Shaw and Monsen 1983a).

Plant Culture

Excellent seed production, high seed quality, and ease of seed processing and planting have contributed to the widespread use of small burnet. Aerial or hand broadcasting, drilling, and dribbling have all proven to be successful means of seeding. Seed needs to be covered, but not more than 0.25 inch (6 cm) deep. Fall and winter seedings have proven to be the most successful. Because of the rapid rate of germination and seedling development, small burnet can usually be successfully established by spring seedings. Small burnet has been seeded widely throughout the West (Plummer 1977; Plummer and others 1970a,b; Stevens and others 1977). Following germination, growth is rapid, resulting in good ground cover within 1 or 2 years. A large amount of foliage and seed is usually produced, even during the first year of growth. Small burnet is a excellent species to seed in mixtures.

Seed lots of small burnet germinate between 80 and 95 percent, and retains high viability when stored for over 25 years (Stevens and Jorgensen 1994). Seeds undergo afterripening, with germination improving yearly up to 3 years following harvest (Stevens and Jorgensen 1994). There are 55,000 seeds per lb (120,000 per kg) at 100 percent purity. Seed is marketed at about 95 percent purity and 90 percent germination. Seedling emergence and establishment for small burnet is high (5 to 8 percent) compared to many other range species (Everett 1982).

Most plants appear to have a lifespan of 7 to 12 years, but some have persisted to 20 years (Plummer and others 1968; Stevens and others 1977b). Because seeds are readily eaten by rodents (Everett and others 1978b) and rabbits, little natural increase has occurred on many areas. Where seeds are allowed to mature and rodent and rabbit populations are low, reproduction will take place. Dense stands of small burnet have remained in some seedings for as long as 25 years. Vegetative propagation can be accomplished by dividing and transplanting the somewhat rhizomatous plants.

Uses and Management

Small burnet forage and seeds are highly preferred at all seasons by livestock, big game, rodents, and upland game birds (Autenrieth and others 1982; Wasser 1982). Birds and rodents also make considerable use of the seeds. Seed caches and resulting plants are common. Small burnet is particularly important in late winter, early spring, and late summer when other species provide less green forage. Plants produce an abundance of basal leaves that remain green and persist throughout the dry summer and winter months. Stand vigor and density may be reduced by selective grazing during these periods.

Once established, small burnet can compete fairly well with cheatgrass. This forb has done well on mountain brush, pinyon-juniper, and upper sagebrush sites. Although it exhibits useful attributes for the drier sagebrush and desert shrublands, it is not adapted to areas receiving less than 10 inches (25 cm) of moisture. Under favorable circumstances, seedlings will establish when planted on dry sites. However, seedlings often fail if seeded when spring moisture is low. Mature plants are hardy and competitive and will persist, once established, on areas receiving 8 to 10 inches (20 to 25 cm) of moisture. Currently, some ecotypes express much better drought tolerance and longevity than most cultivated strains. These selections offer opportunity to expand the use of this forb to drier environments.

Seeded areas should not be grazed for at least 2 years following seeding. Because plants live from 7 to 12 years, every effort should be made to ensure that seed crops are not grazed and are allowed to mature every 3 to 4 years.

Small burnet can be seeded, grazed, and maintained in mixed grass and broadleaf herb plantings. Too often, the species is heavily grazed with livestock in the spring and early summer, and later grazed by game animals in the fall and winter periods. Use can be expected during any season as the plant retains some green foliage throughout the entire year. Rodents, insects, and game animals will forage on the plant whenever it is available. Consequently, livestock grazing must be regulated to compensate for wildlife uses. The plant should be seeded heavy enough to lessen concentrated use and satisfy animal needs.

If seeded in mixtures with perennial grasses, the species can diminish in density because it is short-lived. Competitive grasses and heavy grazing can prevent natural seeding. Sufficient plants have persisted on most wildlife plantings where livestock grazing has been controlled.

Varieties and Ecotypes

'Delar' small burnet was released in 1979. It is recommended for sites in the Intermountain region that receive at least 12 inches (30 cm) of annual precipitation. It will, however, establish and do fairly well with as little as 10 inches (25 cm) of precipitation. Forage production is excellent, even the first growing season. Under irrigation 'Delar' has produced up to 1,050 lb seed per acre (1,177 kg per ha) (Howard 1981).

Additional selections are being investigated. There are some selections that do well with as little as 7 inches (18 cm) of annual precipitation, but these strains are not commercially available.

Family Compositae
Senecio serra

Butterweed Groundsel

This native perennial is a member of the sunflower family. It grows in clumps of several stems 2 to 6 ft (0.6 to 1.8 m) tall and has a woody base. It produces numerous yellow heads about 0.25 inch (1.0 cm) in diameter with black-tipped bracts (Welsh and others 1987). Flowering occurs in May to July.

Ecological Relationships and Distribution

A native in all Western States, butterweed groundsel (fig. 37) can be found in plant communities ranging from sagebrush to subalpine. Welsh and others (1987) describe two varieties with somewhat separate areas of occurrence. *Senecio serra* var. *serra* exists in the sagebrush, pinyon-juniper, mountain brush, lodgepole pine, and spruce-fir communities at 6,000 to 10,000 ft (1,800 to 3,000 m). *Senecio serra* var. *admirabilies* grows in ponderosa pine and subalpine meadow communities (Welsh and others 1987). Both varieties are early colonizers of disturbed sites and grow on sites ranging from open, dry slopes with sandy to gravelly loam soils to forest openings. Both varieties grow well in association with wheatgrasses, bromes, wildryes, and a large number of forbs.

Figure 37—Butterweed groundsel in full bloom.

Plant Culture

Seeds usually mature in September, and can be collected by hand stripping or by using small paddles to beat them into collection trays. Seeds are attached to a white pappus that should be removed to facilitate seeding. This can be accomplished by mechanical debearding and screening. Seeds are very small, with just under 3.5 million per lb (7.7 million per kg) at 100 percent purity and with the pappus removed. Seed is best broadcast planted unless the pappus is removed, after which seed can be drilled. Acceptable purity and germination is 50 to 70 percent.

This species does well when seeded in mixtures with other herbs because it has a fairly strong seedling. Fall seeding is preferred. Seed should not be covered more than 0.13 inch (3 mm).

Uses and Management

Butterweed groundsel is grazed extensively by sheep, cattle, and big game (USDA Forest Service 1937). It greens up early in the spring and retains a large amount of green growth late into the summer. It can tolerate considerable grazing, trampling, and drought. It persists well in partial shade and frequently remains green late in the season. Deer and elk (Kufeld 1973; Kufeld and others 1973) make good use of it in the spring and early summer. Cattle and sheep may forage on the entire plant late in the season when the leaves are partially dry. Because of its woody base and stout, fibrous, rhizome system, this species does an exceptionally good job of stabilizing disturbed soil. It can be used to plant both dry and wet sites, although it does not tolerate prolonged flooding. This species can be seeded in disturbed riparian sites where the water level has been lowered by down cutting of the channel. It establishes well from broadcast seeding and can be planted with a grass-forb mixture. Young plants persist well amid competition, but the plants are slow to attain maximum stature. Because it is slow to achieve dominance, it can be seeded with slower developing shrubs and trees without limiting their survival.

Young plantings are usually not adversely effected by grazing. Plants normally require 2 to 3 years to fully establish. When planted with a grass mixture, this forb persists equally well and does not require special management. Established stands should be allowed to set seed periodically.

Varieties and Ecotypes

There are no releases.

Family Compositae
Solidago canadensis

Canada Goldenrod

A native perennial composite, Canada goldenrod (fig. 38) produces stems 1 to 6 ft (0.3 to 1.9 m) tall that grow from creeping rhizomes. Flowering occurs from July to October. Pale golden-yellow flowers occur along only one side of the curved flowering stalk. Basal leaves are deciduous or become withered at the time of anthesis (Welsh and others 1987).

Ecological Relationships and Distribution

Canada goldenrod occurs from southwestern Canada to New Mexico and California in pinyon-juniper, mountain brush, ponderosa pine, and aspen-spruce-fir types. It occurs along riparian areas, in moist places and forest openings, and on dry slopes. It grows on basic, neutral, and slightly acidic soils.

Plant Culture

Flowering occurs during midsummer, and seeds mature in October. Generally, an abundance of seeds are produced each year. Seeds are best collected by hand stripping or beating. The pappus can be removed from the seed using a debearder. Seeds are then separated from the debris with a screening type cleaner. The seed pappus is generally removed to facilitate seeding. Cleaned seeds can be drilled or broadcast planted. Uncleaned seeds can only be hand broadcast. Seeds should not be covered more than 0.13 inch (3 mm) deep. Good results can be expected

Figure 38—Canada goldenrod.

from broadcast seeding on prepared seedbeds and on disturbed or eroding soils. Once established, plants spread well from creeping rhizomes. Wildland collected seed lots are generally highly viable. Only fresh seed should be planted because viability declines with 1 year of storage. This species does well when seeded in mixtures with other herbs because it has fairly vigorous seedlings. More successful stands usually establish from fall seedings.

Uses and Management

Canada goldenrod is palatable to livestock and big game. Some use is made at most seasons. Plants green up early in the spring and remain green longer in the fall than most associated species. Canada goldenrod invades disturbed areas and provides an effective ground cover. It can be used to control erosion on extremely disturbed areas and is often used in watershed plantings. This species can be used to beautify recreational areas, summer home sites, administrative areas, and other areas with high aesthetic value. It is adapted to semiwet situations and can be used to treat riparian disturbances where dry and semiwet sites are closely aligned. Canada goldenrod establishes well by transplanting and can be used to provide immediate ground cover. It persists with heavy trampling and grazing disturbances.

Canada goldenrod usually occurs in aspen and conifer forest communities. It recovers well following burning, logging, and grazing. Established stands should be allowed to set seed periodically. Newly seeded stands should not be grazed for at least 2 years following planting.

Varieties and Ecotypes

There are no releases.

Family Malvaceae
Sphaeralcea grossulariifolia ______

Gooseberryleaf Globemallow

There are approximately 200 species of globemallow; about 20 are native to Western North America (Hermann 1966). A member of mallow family, the genus is variable and complex, and its taxonomy has been extensively revised (Jefferies 1972; Kearney 1935; Welsh and others 1987). Gooseberryleaf globemallow (fig. 39) is a densely, gray-green, pubescent perennial. Leaves are gooseberry-like. Floral stalks grow from 1 to 2.5 ft (30 to 76 cm) tall. Plants develop a branched taproot, and a near-surface fibrous root system. Flowers have showy orange to reddish petals (Hitchcock and others 1961). Flowering occurs from May to July, and seed matures unevenly from June to August.

Ecological Relationships and Distribution

This species is a drought-tolerant native forb that occurs in blackbrush, shadscale, rabbitbrush, sagebrush, and pinyon-juniper communities, and occasionally in the mountain brush zone on sites receiving 8 to 12 inches (200 to 300 mm) of annual precipitation (Stevens and others 1985c). It is common on disturbed and burned pinyon-juniper sites (Everett 1982; Plummer and others 1968). It ranges throughout the West from Washington to Arizona (Welsh and others 1987).

Gooseberryleaf globemallow prefers full sunlight. It exhibits good winter hardiness, grazing tolerance, resistant to burning, and considerable drought resistance. Gooseberryleaf globemallow is found in alkaline soils and tolerates moderate salinity, but not sodic soils (Pendery and Rumbaugh 1986).

Plant Culture

Gooseberryleaf globemallow can be established on harsh sites. It is one native forb that has been successfully seeded in blackbrush, shadscale, pinyon-juniper, and sagebrush communities and in disturbances with basic soils (Monsen and Plummer 1978; Plummer 1966, 1977).

Figure 39—Gooseberryleaf globemallow.

Seeds can be collected by hand or with mechanical strippers. They are easily cleaned. There are just over 500,000 seeds per lb (1.1 million per kg) at 100 percent purity. Seeds should be dusted with an appropriate insecticide to prevent destruction by weevils (Pendery and Rumbaugh 1986). Seed viability is, however, maintained for up to 15 years without any significant loss (Stevens and Jorgensen 1994). Page and others (1966) reported that low germination results from a combination of low fill and a hard seedcoat impregnated with nonwetable substances. Mechanical or acid scarification can increase germination. It can be seeded on disturbed and burned pinyon-juniper areas. Because the species has fairly strong, competitive seedlings and a moderate growth rate, it can be seeded in mixtures with other species. Fall and winter seeding is recommended (Monsen and Plummer 1978). Seeds can be drill seeded and should be planted at depths of 0.25 inch (6 mm). Seeds may lie in the soil for years and germinate when conditions are suitable (Plummer and others 1968). This species can be successfully transplanted and will reproduce from stem cuttings (Everett 1982).

Uses and Management

Forage value of gooseberryleaf globemallow is rated as good for sheep and cattle (Hermann 1966; Wasser 1982). Preference or palatability is rated as none to fair for cattle and sheep (Hermann 1966), and fair to excellent for antelope (Hancock 1966; Smith and Beale 1980), elk, and deer (Kufeld 1973; Kufeld and others 1973; Urness and McCullock 1973). Antelope especially prefer this herb when it is flowering (Pendery and Rumbaugh 1986). Protein content during winter and early spring has been found to be high, ranging from 10 to 20 percent (Pendery and Rumbaugh 1986; Urness and McCullock 1973). Gooseberryleaf globemallow greens up early in spring and will green up again in autumn after fall storms.

This species establishes well on disturbed sites from seed or from transplanting. Because of its drought resistance, continuous, colorful flowering, and ease of establishment, this species has been recommended for use in dryland ornamental landscaping (Natural Vegetation Committee 1973). Gooseberry globemallow is quite competitive and can be used to suppress cheatgrass and other annuals. It is one of only a few native herbs that can be seeded on low elevation Wyoming big sagebrush and shadscale sites.

Following germination gooseberry globemallow produces strong and persistent seedlings. It has a deep taproot. Plants are tolerant of grazing, but can be weakened by close grazing in late spring. Drought tolerance is excellent, but plants should not be grazed following extended periods of drought. Plant density tends to fluctuate from year to year.

Varieties and Ecotypes

There are no releases.

Family Malvaceae
Sphaeralcea coccinea

Scarlet Globemallow

Scarlet globemallow (fig. 40) is a low-spreading, native perennial with creeping rhizomes (Arnow 1971; McKell and others 1979; Welsh and others 1987). It prefers clay soils and can be found on hills and dry plains in blackbrush, shadscale-greasewood, sagebrush, pinyon-juniper, mountain brush, and ponderosa pine communities from Southern Canada to Texas and Arizona (Hermann 1966; Welsh and others 1987).

Scarlet globemallow exhibits considerable drought resistance, and establishes especially well on disturbed sites. This species can be successfully seeded or transplanted in blackbrush, shadscale, black greasewood, sagebrush, and pinyon-juniper types. It is particularly useful for planting on disturbed sites, as it is drought tolerant and can spread by rhizomes. It is well suited to adapted sites where wildfires frequently occur.

Palatability for livestock and big game is rated from poor to good (Hermann 1966; Kufeld 1973; Kufeld and others 1973; McKell and others 1979; Wasser 1982).

Varieties and Ecotypes

There is one released germplasm, 'ARS 2936'.

Figure 40—Scarlet globemallow.

Family Fabaceae
Trifolium

Clovers

Taylor (1985) reported that about 250 species of true clovers occur throughout the world. All species possess the typical papilionaceous legume flower with 10 stamens. Leaves usually consist of three leaflets. Most have simple taproots; some produce stolons or rhizomes. About one-third are perennials and the others are annuals. About one-third are self-pollinated; the others are cross-pollinated and require bees for pollination (Taylor and others 1980). All species are able to fix nitrogen if nodulated with strains of *Rhizobium* (Allen and Allen 1981).

Within the contiguous United States, clovers are most important as range plants from the Rocky Mountains west to the Pacific Coast (Crampton 1985). Approximately 65 species occur in the Western States. Most species, particularly many annuals, are abundant in the central valley of California (Crampton 1985; Küchler 1977).

Although native perennial clovers are found abundantly throughout the mountains, meadows and wetlands of the Intermountain area, and to a lesser extent in the drier sagebrush habitats (Crampton 1985), few natives have been utilized in range revegetation efforts. Most clovers of agricultural interest were introduced from Europe. There are about 15 species that are used in North America (Hermann 1953; Hollowell 1960). Most are adapted to temperate climates and are used to improve irrigated or native meadow pastures. Because they are legumes, clovers are particularly useful in fixing atmospheric nitrogen and enhancing soil fertility. A cool, moist climate is required for the best growth (Taylor 1985). Spring and fall periods are favorable for adequate growth in the Intermountain area.Various species demonstrate usefulness on a variety of sites, and future trials will undoubtedly result in more widespread use of different clovers.

Most clovers are quite palatable, shade tolerant, and tolerant of flooding for short periods. Consequently, they are useful for seeding semiwet meadows, and as understorys in conifer forests and aspen stands. All species attract use by wildlife and can be planted to supply forage for extended periods. Most species demonstrate good regrowth and, thus, withstand heavy grazing.

Seeds are small and include a high percentage of hard seeds. Seeds should be treated with an inoculum to assure establishment.

Family Fabaceae
Trifolium fragiferum

Strawberry Clover

Strawberry clover was introduced to the West from Eurasia and the Mediterranean region (Forde and others 1981). It is not known when it was introduced into the United States, but specimens were collected in 1878 in Pennsylvania.

Strawberry clover is a low-growing stoloniferous perennial used primarily as a pasture legume (Townsend 1985). Stems are decumbent to creeping and root at the nodes. Plants are less than 10 inches (25 cm) tall. White to pink flower heads are borne at the ends of each seed stalk (Gillett 1985; Harrington 1964; Hermann 1966). The flower and seed head resemble a strawberry—hence the name. Plants are pubescent or glabrous. The leaves are congested on auxiliary peduncles that are curved and ascending (Bendixen and others 1960).

Ecological Relationships and Distribution

Strawberry clover has spread or been seeded throughout North America and has become naturalized in some locations (Townsend 1985). It is noted for its ability to grow on wet saline or alkaline soils and has demonstrated adaptability to wet meadows, streams, and seeps. Bendixen and Peterson (1962) report that strawberry clover withstands flooding because the stolons exhibit a tropic response that causes the tips to be elevated above the water level. Light, oxygen deficiency, and atmospheric conditions also influence the tropic response.

Strawberry clover is not hindered by wet-saline conditions; consequently, it is very useful on many seeps and salty sites at a wide range of elevations. Seedlings are not suppressed by high osmotic conditions that depress the growth of white clover (George and Williams 1964).

Plant Culture

Strawberry clover can be drill or broadcast seeded on a prepared seedbed. Seed coverage should be shallow, less than 0.25 inch (6.4 mm). When seeding irrigated pastures, a planting depth of about 0.50 inch (13 mm) is recommended (Townsend 1985). Seeds are small with about 290,000 seeds per lb (650,000 per kg) at 100 percent purity. They require planting into a firm seedbed. Evers (1982) found that drill seeding produced only slightly higher yields than broadcasting. Seeding rates vary depending on seeding methods, but acceptable stands are achieved with 6 to 8 lb per acre (6.7 to 9.0 kg per ha) when seeded alone, and 2 to 4 lb per acre (2.2 to 4.5 kg per ha) when planted in a grass mixture.

Strawberry clover seedlings are easily established and grow rapidly. The plant establishes well with minimal seedbed preparation. Successful stands establish from broadcast seeding and natural spread. This clover does well when seeded in mixtures with grasses. When planted in mixtures under irrigation, herbage production can be increased and better distributed throughout the growing season (Peterson and others 1962).

Uses and Management

Forage and seeds of strawberry clover are used extensively by livestock, big and small game, and upland game birds.

Strawberry clover is especially well suited to close and continuous grazing (Raguse and other 1971), and when seeded on most rangeland sites, tends to attract heavy use. In vitro digestibility compares favorably with white clover, red clover, and alfalfa (Reed and others 1980).

This forb can be successfully seeded onto depleted riparian habitats, degraded meadows, and inland saltgrass areas. It can be used to stabilize streambanks, erodible soils, and related disturbances. It is particularly useful for seeding disturbances on saline soils and sites subjected to frequent periods of flooding.

Varieties and Ecotypes

No selection or cultivar has been developed for rangeland uses, although various cultivars have been developed for pasture seedings in the United States (Peterson and others 1962).

Family Fabaceae
Trifolium hybridum ________________

Alsike Clover

Alsike clover is a native of northern Europe that was introduced into the United States in about 1839 (Townsend 1985). It was thought to be a hybrid of red and white clover—hence its species name "hybridum". It is well adapted to high elevations within the Intermountain region where conditions are cool and moist. It is a short-lived perennial, but can be managed to reseed and maintain itself. Alsike clover is an excellent hay and pasture species (Townsend 1985), but is also useful as a range forage species. It is adapted to sites that are too wet or acidic for red clover or alfalfa (Townsend 1985). Plants establish well from either spring or fall plantings. Drilling or broadcast seeding on a firm seedbed is recommended. Planting with grasses to improve forage productivity is a common practice (Grable and others 1965).

Seeding in mixtures at a rate of 2 to 4 lb per acre (2.2 to 4.5 kg per ha) produces excellent stands. There are approximately 68,000 seeds per lb (150,000 per kg). Seeds have a hard seedcoat, but this does not prevent good establishment even from spring seedings.

No cultivars have been developed for rangeland conditions in the United States, but two Canadian cultivars, 'Aurora' and 'Dawn', have been developed for pasture plantings.

Family Fabaceae
Trifolium pratense ________________

Red Clover

Red clover is perhaps the most widely used pasture clover in the United States. It is generally grown in mixtures with grasses for intense pasture management. It is also grown for hay or silage production, or as a soil improvement crop. Plants produce nitrogen that favors growth of companion species and improves soil conditions (Smith and others 1985).

Red clover can be used as a short-term perennial or winter annual to furnish immediate forage and improve soil fertility. It requires 20 or more inches (51 cm) of annual precipitation, but it is well suited to cut over timber lands and moderately acid soils (Hafenrichter and others 1968). It can be used to improve meadows and degraded riparian sites.

Hafenrichter and others (1968) reported that the commercial varieties—'Kenland', 'Pennscott', 'Dollard', and 'Lakeland' are well adapted to conservation plantings in the Northwest. None have been extensively evaluated for range sites in the Intermountain area.

Family Fabaceae
Trifolium repens ________________

White Clover

White clover is a shallow rooted perennial with creeping stems that root at the joints. This introduced European species has become naturalized in North America in fairly moist areas on medium and high elevation mountain ranges. White clover is winter hardy and can withstand more extreme temperatures than either red or alsike clover (USDA Forest Service 1937). Livestock and wildlife make good use of this species. Areas of adaptation include sites with fertile and well-drained soils that are moist throughout the growing season, and along streams. It has good soil stabilization characteristics. White clover is generally seeded in a mixture with perennial grasses.

Family Compositae
Viguiera multiflora var. *multiflora*

Showy Goldeneye

There are about 150 species of *Viguiera*. Most species occur in the new world (USDA Forest Service 1937). Two varieties of goldeneye, showy goldeneye and Nevada goldeneye, occur within the Intermountain region (Welsh and others 1987).

Showy goldeneye (fig. 41), a member of the sunflower or compositae family, is a perennial native forb growing from a short, branched, woody taproot. It is usually 1 to 3 ft (30 to 91 cm) high with leaves commonly more than 0.25 inch (6 mm) wide and 0.50 to 0.75 inch (12 to 19 mm) long. Two or more showy, yellow, sunflower-like blossoms (heads) are borne on each plant. Flowering begins in July. Seed matures in late August and September. Basal leaves elongate and green up shortly following snowmelt (Welsh and others 1987).

Figure 41—Showy goldeneye.

Figure 42—Showy goldeneye in an aspen opening.

Ecological Relationships and Distribution

Showy goldeneye is a very attractive perennial, that occurs throughout the Intermountain West at elevations between 3,500 to 11,000 ft (1,100 to 3,400 m) (Stevens and others 1985c). Showy goldeneye can be found from moderately moist habitats to dry, open, rocky slopes in sagebrush-grass, pinyon-juniper, mountain brush, aspen (fig. 42), spruce-fir, subalpine, and often in riparian communities (Welsh and others 1987).

This species is not restricted to full sunlight, but can be found in partial shade and in densely wooded areas (Arnow 1971; Plummer and others 1955). Showy goldeneye can be found on a wide variety of soils ranging from heavy clays to gravel (USDA Forest Service 1937), and from acidic to basic conditions (Plummer 1977). It establishes quickly on disturbed sites, has a rapidly developing seedling, and competes well with annuals and perennials.

Plant Culture

Each showy goldeneye plant can support numerous, golden yellow, sunflower-like heads that generally produce an abundance of seeds. Seeds are collected by hand, mechanical beating, or stripping. Viability of wildland lots is only fair. Seed can be stored up to 7 years without any major loss in viability (Stevens and Jorgensen 1994). There are just over 1,000,000 seeds per lb (2.2 million per kg) at 100 percent purity.

Showy goldeneye develops strong seedlings. Plants establish quickly, and can spread from seed. Showy goldeneye will invade disturbed sites and may quickly become the dominant species. Seeds can be broadcast or drilled with equal success. Seeds should not be planted more than 0.25 inch (6 mm) deep. Seeding is best accomplished in the fall or winter. The species does well when planted as a component of a mixture (Stevens and others 1981b).

Principal Areas of Use

Showy goldeneye is an early spring-greening forb that is sought by big game (Kufeld 1973) and livestock. Foliage and flower heads are readily consumed by cattle, sheep, deer, and elk. Birds also make considerable use of the seeds.

Strong seedlings and a rapid rate of growth enable showy goldeneye to be seeded in conjunction with other species. These features also contribute to its establishment and spread into annual communities.

Profuse flowering of this species makes it a prime candidate for summer home sites, campgrounds, administration sites, and other areas with high aesthetic values. This species has potential as an erosion control species on disturbed and burned sites.

Newly seeded areas should not be grazed for at least 2 years following planting. Established stands should be allowed to set seed every 3 to 4 years.

Varieties and Ecotypes

There are no releases.

Family Compositae *Viguiera multiflora* var. *nevadensis*

Nevada Goldeneye

Compared to showy goldeneye, Nevada goldeneye has narrower leaves (usually less than 5 mm wide) and can be found on drier sites in southwestern Utah, Nevada, and California. It occurs with pinyon and juniper, Wyoming and basin big sagebrush, black sage, and various saltbushes. Plummer (1966) recommends it as a candidate species to be used in seeding areas in the salt desert shrublands. Coles (1982) reported that Nevada goldeneye rapidly invaded Wyoming and basin big sagebrush burns in southwestern Utah. He further reported that mule deer tend to seek out and concentrate on areas with high densities of Nevada showy goldeneye. The species invades roadsides and other disturbed areas. Seed production and seeding procedures are similar to those described for showy goldeneye.

E. Durant McArthur
Stephen B. Monsen

Chapter

20

Chenopod Shrubs

Chenopod plants (Family Chenopodiaceae) are distributed worldwide but are especially prominent in some wet and dry saline or alkaline situations. Chenopods are both herbaceous and woody. The relative proportions of life-forms in the family is demonstrated by data from the important center of chenopod diversity in south-central Asia, where n = 341 species: 76 percent are herbaceous (mostly annual), 23 percent are shrubs or subshrubs, and 1 percent is arborescent (McArthur and Sanderson 1984; Shishkin 1936). Chenopod shrubs grow over wide expanses of Intermountain rangelands as well as on large saline and alkaline tracts on all continents, except Antarctica. In the Intermountain area, seven genera (table 1) with 28 species make important contributions to the landscapes or to revegetation needs.

As a group the chenopod shrubs exhibit the ability to grow in low fertility, salt-bearing soils as well as on more favorable sites. Their presence is essential for maintaining a stable soil in many xeric environments where soil is too salty or dry for most other classes of plants to live (Blauer and others 1976; Goodall 1982; Sanderson and Stutz 1994b; Wilkins and Klopatek 1984). Chenopod shrubs grow well in high concentrations of calcium and potassium salts and can endure considerable concentrations of

Chapter Contents by Species

sodium salts (Gates and others 1956; McNulty 1969; Moore and others 1972). Certain ones grow through a much wider range of alkalinity than others (table 2). A few tolerate such high salt concentrations that they are the only plant life. As a group they are especially suited for planting on depleted salt desert shrub type range areas as well as on construction scars, mine spoils, and roadcuts (McArthur and others 1978b; Plummer 1977).

Within species, large differences exist between ecotypes in morphological and physiological traits. The smaller ecotypes are usually from dry, severe sites, whereas the larger ones are from more favorable areas. Size of the shrubs is, to a large extent, genetically controlled as demonstrated by maintenance of ecotypic form in accessions grown together in uniform gardens (McArthur and others 1983a). Furthermore, Stutz and Sanderson (1983) have shown in shadscale that the smallest ecotypes growing on the most severe sites are higher polyploids, whereas lower ploidy levels occur on more favorable mesic sites. The gigas form of fourwing saltbush reported by Stutz and others (1975) is a diploid. Dunford (1985) reported consistent morphological differences among the chromosome races of fourwing saltbush. Even though genetic factors are important, moisture does, of course, markedly affect luxuriance and growth. Wallace and others (1974) reported that 40 percent of the biomass of fourwing saltbush is in the root system.

Shrubby chenopods have a chromosome number based on x = 9. Polyploids occur in most genera (Blauer and others 1976; McArthur and Sanderson 1984). They are wind pollinated, occur in sympatric distributions, are monoecious, dioecious, or even trioecious—factors that lead to common interspecific hybridization (McArthur 1989). Woody chenopods show remarkable capability to hybridize both naturally (Sanderson and Stutz 1994b; Stutz 1978, 1984) and under controlled conditions (Blauer and others 1976; Drobnick and Plummer 1966; Stutz 1982). Most of the hybridization occurs within *Atriplex*, although some possible intergeneric hybrids have been reported (Blauer and others 1976).

Hybridization allows opportunity to create new gene combinations to fill new niches—for example, those in newly created mine spoils. Stutz (1982),

Table 1—Shrubby chenopods in Western America useful or potentially useful for restoration and revegetation (adapted and expanded from McArthur and others 1978b).

Scientific name	Common name
Allenrolfea occidentalis	Iodine bush or inkbush
Atriplex aptera	Wingless saltbush
Atriplex bonnevillensis	Bonneville saltbush
Atriplex canescens	Fourwing saltbush
Atriplex confertifolia	Shadscale
Atriplex corrugata	Mat saltbush
Atriplex cuneata	Castle Valley clover saltbush or cuneate saltbush
Atriplex falcata	Falcate saltbush
Atriplex gardneri	Gardner saltbush
Atriplex hymenelytra	Desert holly saltbush
Atriplex lentiformis	Big saltbush or quailbush
Atriplex navajoensis	Navajo saltbush
Atriplex obovata	Broadscale saltbush
Atriplex polycarpa	Cattle saltbush or allscale saltbush
Atriplex robusta	Robust saltbush
Atriplex semibaccata[a]	Australian saltbush
Atriplex tridentata	Trident saltbush
Camphosoma monspeliaca[a]	Mediterranean camphorfume
Ceratoides lanata	Winterfat
Ceratoides latens[a]	Pamirian winterfat
Grayia brandegei	Spineless hopsage
Grayia spinosa	Spiny hopsage
Kochia americana	Gray molly
Kochia prostrata[a]	Forage kochia
Sarcobatus vermiculatus	Black greasewood
Sarcobatus baileyi	Bailey greasewood
Suaeda suffrutescens	Desert sumpbush
Zuckia arizonica	Arizona zuckia

[a]Introduced species.

Ferguson and Frischknecht (1985), and Stutz and Estrada (1995) found that several hybrid combinations within *Atriplex* performed well on mine spoils in Utah and New Mexico. Blauer and others (1976), Carlson (1984), Stutz (1983, 1984), and Stutz and Carlson (1985) showed that there is ample opportunity to: (1) make selections from natural populations, (2) locate natural hybrids, and (3) make artificial hybrids. All three plant classes can be useful in providing plant materials to rehabilitate harsh disturbed landscapes. Sanderson and colleagues (Sanderson and Stutz 1984, 1994a; Sanderson and others 1988, 1990) have identified flavonoid compounds that are useful genetic markers in population biology and hybridization studies.

Woody chenopods show remarkable ability to grow through a wide climatic variation. Some grow in the coldest parts of the northern desert shrublands and adjacent grasslands to warmer desert ranges in the Southwestern United States and Mexico (fig. 1). Three examples are Gardner saltbush, black greasewood, and winterfat. Several chenopods readily establish, grow, and produce in areas of severe aridity or where the average annual precipitation may be less than 5 inches (12.7 cm). Important among these are winterfat, shadscale, and falcate saltbush. However, they can also quickly take advantage of three to four times this precipitation to make luxuriant growth. While the shrubby chenopods are most characteristic of the salt desert shrub type in Western North America, some grow well in limey soils on mountain ranges in association with ponderosa pine, Utah juniper, pinyon pine, Saskatoon serviceberry, and Utah serviceberry. Winterfat, fourwing saltbush, and spiny hopsage grow best in these areas. However, on

Table 2—Physical dimensions and tolerance to alkalinity of some chenopod shrub taxa (from McArthur and others 1978b).

Species	Height/crown	Adaptation to alkalinity	
		Optimum	Range
	Inches (cm)		
Atriplex canescens (Fourwing saltbush)	12-78/12-178 (30-200/30-450)	Low	Low-medium
Atriplex confertifolia (Shadscale)	6-47/6-30 (15-120/15-75)	High	Low-high
Atriplex corrugata (Mat saltbush)	1-8/8-40 (2-20/20-100)	Medium	Medium-high
Grayia spinosa (Spiny hopsage)	12-47/12-70 (30-120/30-180)	Low	Low
Ceratoides lanata (Winterfat)	2-47/6-30 (6-120/15-75)	Low	Low-medium
Allenrolfea occidentalis (Iodine bush)	6-47/12-70 (15-120/30-180)	High	High
Sarcobatus vermiculatus (Black greasewood)	40-118/40-78 (100-300/100-200)	Medium	Low-high

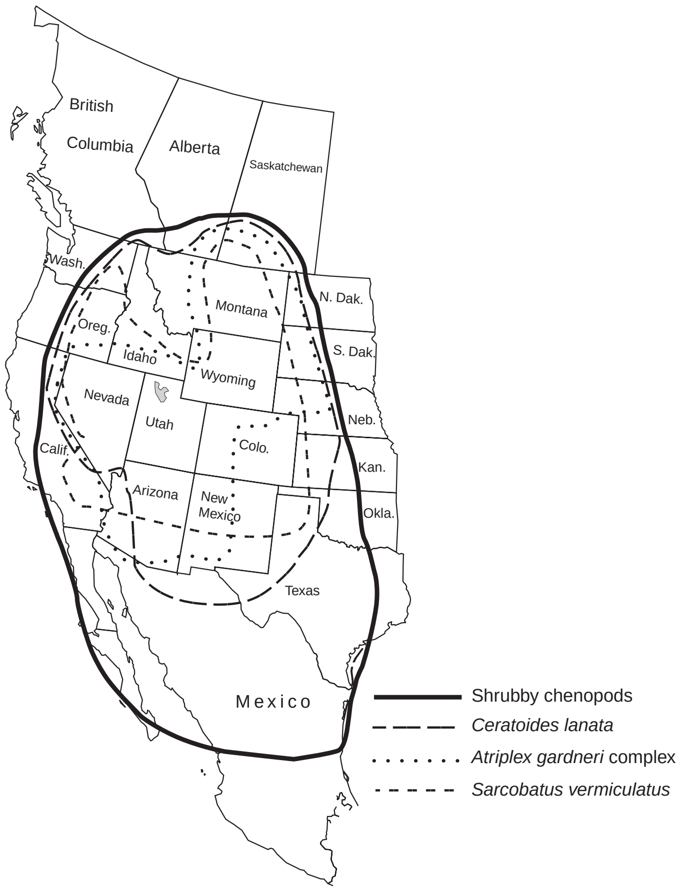


Figure 1—Distribution of shrubby chenopods in general and winterfat, greasewood, and the Gardner saltbush complex in particular. Distributions from Hall and Clements (1923), Branson (1966), and McArthur and others (1978b).

highly alkaline extrusions in these higher elevations are precipitation areas on mountain ranges where shrubby chenopods may grow to the virtual exclusion of other species (McArthur and others 1978b).

All shrubby chenopods bear a carpellate, loculed one-celled fruit known as a utricle, within which is a single seed. Actual seeds are small, usually no larger than an alfalfa seed. The utricle wall may be quite thin and easily removed from the seed, as in winterfat; or may be hard, as found in shadscale and some accessions of fourwing saltbush. Production of fruits varies widely among plants and from season to season as does percentage fill (Crofts 1977; Gamrath 1972; McArthur and others 1978b; Monsen and McArthur 1985; Springfield 1970b). To a considerable degree this relates to how favorable the growing season may be. Unless seed coats are restrictive, germination takes place quickly in a favorable environment of temperature and moisture. Utricles having indurated walls, such as in some ecotypes of fourwing saltbush and shadscale, may lay a year or more in the ground before germination. This may provide some survival value for the species because it ensures that some seeds remain in the ground to germinate and establish when temperature and moisture are most favorable. Apparently, saltbush seeds are not highly palatable to small rodents (Everett and others 1978) so they are retained in the soil. Some buildup occurs in the ground of fruits that have a tendency for delayed germination. Consequently, in favorable years many seedlings become established. Young seedlings, however, are particularly susceptible to rodent depredation (Nord and Green 1977; Young and others 1984e).

Shrubby chenopods express a number of traits that aid in artificial revegetation. The appendages attached to the utricles can be removed from most species. Except for winterfat, all seeds can be cleaned to a form that is easily handled and planted with conventional equipment (chapter 19). Cleaned seeds are of a size and shape that different seeding rates can be employed. Within a specific collection, seed germination features are uniform. However, seed germination is not so specific to a particular set of climatic conditions that all seeds germinate at any one time. An extended period of germination often assures the survival of a satisfactory number of plants. However, seed germination of winterfat is usually confined to a short duration. Seedlings and young plants are quite vigorous and are able to compete well with herbs (Giunta and others 1975).

The growth rate of nearly all shrubs is excellent. Even under adverse conditions plants grow remarkably well, often exceeding most herbs. Plants are well adapted to infertile soils and can be used to restore vegetation throughout variable, but harsh, situations. Young plantings withstand heavy browsing by game, livestock, and rodents. Individual plants normally reach maturity within 3 to 5 years, and natural spread can be expected thereafter. Once established, young plants persist under adverse climatic conditions. In addition, established plants provide high yields even when grown with a dense understory.

Chenopod shrubs frequently grow with a sparse understory but persist and grow well when seeded with numerous other plants. These shrubs normally occur throughout some principal sites or vegetative conditions important to both livestock and wildlife. The plants can be increased in density or seeded with a combination of herbaceous plants to improve forage or habitat. Many other shrubs exist within specific site conditions and do not grow well when moved to adjacent locations. Some ecotypes of many chenopod shrubs also exhibit specific site adaptation requirements, but others can be extended to additional sites (see McArthur and others 1983a).

Most shrubby chenopods are highly nutritious. They have higher protein content than most plants, particularly in the winter (Chatterton and others 1971; Esplin and others 1937; Tiedemann and others 1984a; Welch and Monsen 1981). On several species and accessions, leaves persist and remain green well through winter. These are preferred by grazing animals during the winter and provide an important source of protein, which is vital to the well being of browsing animals on desert ranges of the West.

Without doubt, the shrubby chenopods have an important future for development of cover and forage on the generally basic soils of arid ranges worldwide. They are widely used in land rehabilitation programs (Aldon and Oakes 1982; Plummer 1984; Tiedemann and others 1984b).

Recently, Nechaeva and others (1977), Rumbaugh and others (1981, 1982), and Ostyina and others (1984) showed that most shrubs, especially some chenopods, provide complementary forage to grasses in mixed stands on semiarid ranges. Forage quality is enhanced in the mixed stands and the effective season of grazing is expanded. In addition, the forage resource is made less susceptible to attack from insects and diseases than are monocultures (Moore and others 1982).

Nord and Green (1977) identified several chenopod shrubs with potential to reduce the hazards of fire in the California chaparral. Among these were North American fourwing saltbush, Castle Valley clover saltbush, Gardner saltbush, allscale saltbush, and three Australian saltbush species.

From 1985 through 1988 a significant die-off of chenopod (and some other families) shrubs occurred in the Intermountain area (McArthur and others 1990b; Nelson and others 1989; Wallace and Nelson 1990). This die-off was particularly serious for shadscale. The die-off was not unique in time, but it was large in scale; and recovery will be complicated by the recent large-scale invasion of exotic annuals into chenopod shrublands.

Important characteristics of a number of chenopod shrubs follow. Seeding recommendation for principal vegetative types and conditions are discussed in chapter 17. Chenopod shrubs adapted to these vegetative types and conditions are included in the seeding recommendations. Seed characteristics are found in chapters 24 and 26.

Included in the remainder of this chapter are a brief species description, ecological relationship, distribution, culture requirements, use, improved varieties, and management of each of the species appearing in the chapter contents list.

Atriplex canescens ________________

Fourwing saltbush

Fourwing saltbush is an upright shrub (fig. 2). Its height may vary from 1 ft (0.3 m) to 6.7 ft (2.04 m), depending on site conditions and genotype. It branches freely from the base. Its mature branches are quite brittle. Both young leaves and twigs are gray-green because of the white, scurfy vestiture. The linear to oblanceolate or spatulate evergreen leaves are 1 to 4 cm long and 2 to 6 mm wide. Fourwing saltbush is usually dioecious with a low frequency of monoecy. Pistillate (female) flowers are small and inconspicuous with no flower parts except pistils. Each pistil is enclosed by a pair of small bracts that are united along their edges to form winglike expansions. In addition, each bract of the pair has a wing down the middle; so the utricle (fruit) has, at maturity, a varying prominence of four wings (fig. 3, 4). The yellow to red to brown staminate flowers are more or less naked anthers (only a few bracts are present) borne in glomerules 2 to 3 mm wide (Blauer and others 1976; McArthur and others 1978c). Sex expression in fourwing saltbush is apparently a dioecious system for the only diploid population known in Utah (Freeman and McArthur 1989; McArthur and Freeman 1982; Stutz and others 1975). Barrow (1987) has shown that diploid New Mexico and Texas populations may contain rare monoecious plants. At the higher and more common (tetraploid, hexaploid) ploidy levels, fourwing

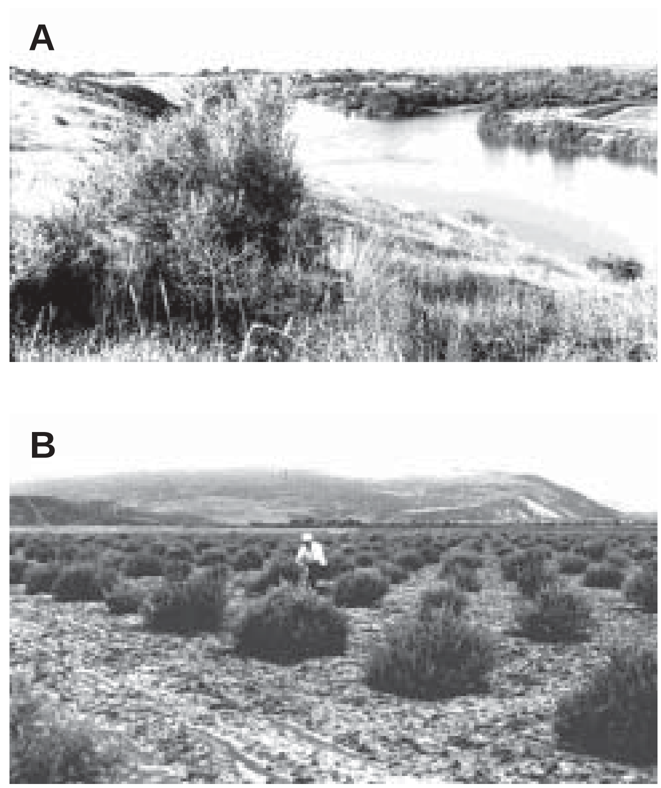


Figure 2—Fourwing saltbush is an upright shrub. (A) A large plant along the Snake River, Payette County, ID, opposite Nyssa, OR. (B) A 'Rincon' fourwing saltbush orchard at the Upper Colorado Environmental Plant Center, Meeker, CO.

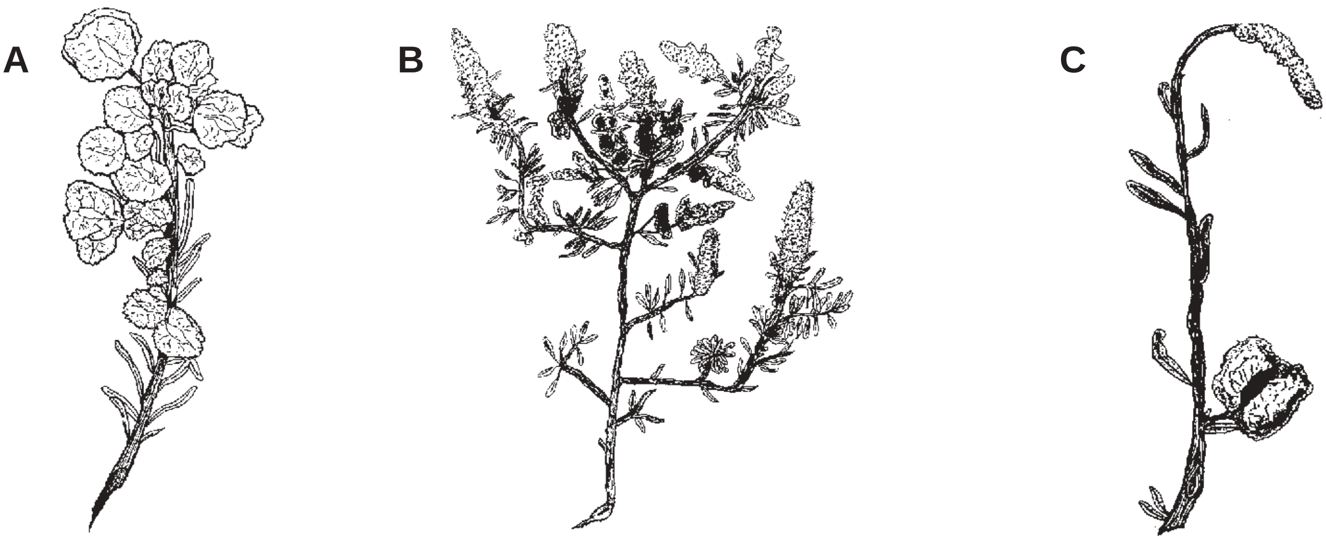


Figure 3—Flowers and fruits of fourwing saltbush (A) A pistillate (female) plant in fruit (McArthur 722, seeded near Mountain Home, Elmore County, ID, from seed collected near Panaca, Lincoln County, NV; 0.65x). (B) A staminate (male) plant in flower (McArthur 378, St. George, Washington County, UT; 0.87x). (C) A monoecious plant (McArthur 723, Payette County, ID; 0.56x).

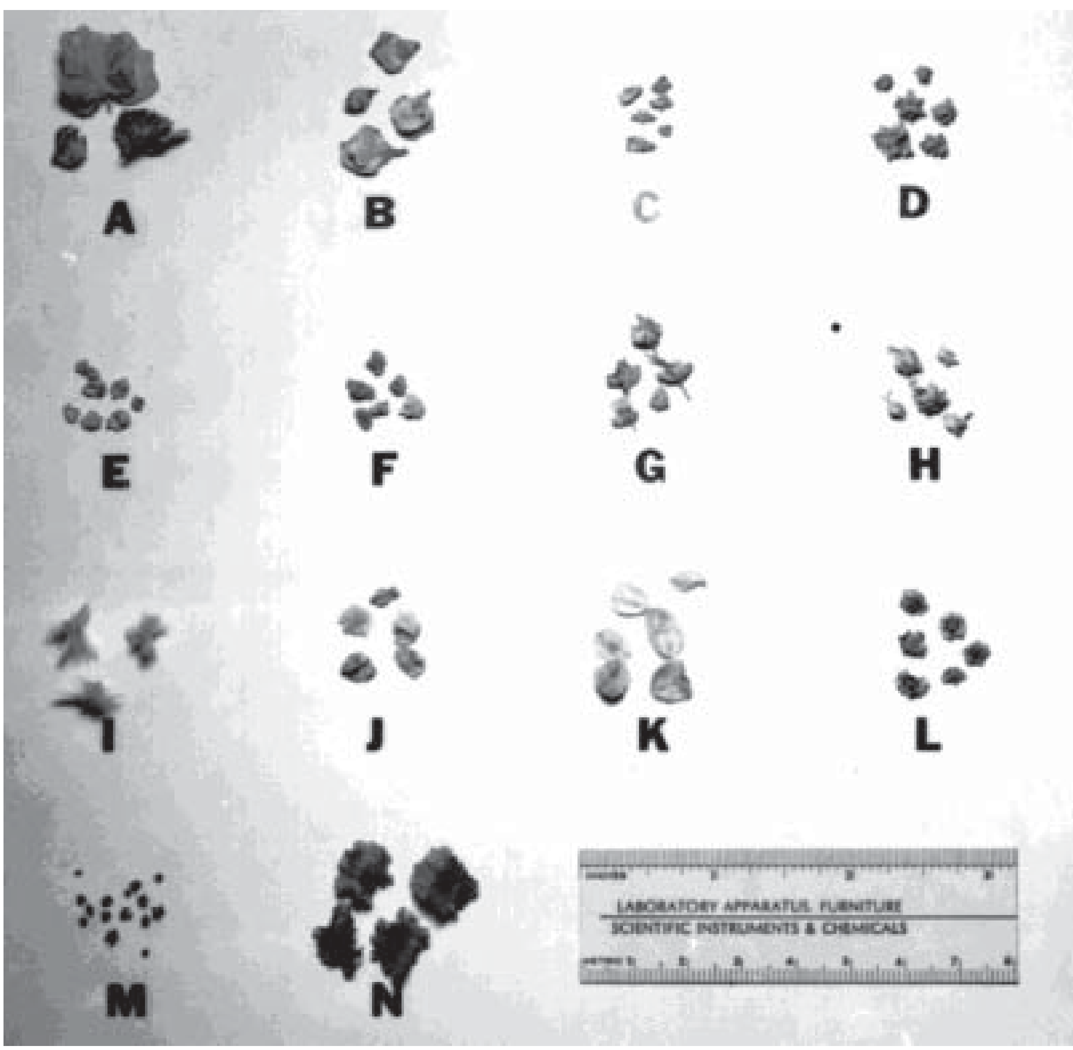


Figure 4—Fruits (utricles) of various chenopod species. (A) Fourwing saltbush. (B) Shadscale. (C) Mat saltbush. (D) Castle Valley clover saltbush. (E) Trident saltbush. (F) Broadscale saltbush. (G) Hybrid of fourwing saltbush x shadscale. (H) Fourwing saltbush x trident saltbush. (I) Winterfat. (J) Spineless hopsage. (K) Spiny hopsage. (L) Gray molly. (M) Forage kochia. (N) Black greasewood. (After Blauer and others 1976).

saltbush is trioecious (three sexual states). In the trioecious condition, some plants are lifetime constant females, others lifetime constant males, and some plants are apparently able to avoid stressful situations by switching away from the physiologically taxing female state (Barrow 1987; Freeman and McArthur 1989; Freeman and others 1984; McArthur 1977; McArthur and Freeman 1982; McArthur and others 1992; Noller and others 1984). Gender differences appear to be adaptive and allow fuller exploitation of habitats (Freeman and others 1993, 1997; Pendleton and others 1992). Dr. Daniel J. Fairbanks and his students at Brigham Young University have made progress toward understanding the molecular genetics basis of sex expression in woody *Atriplex* (Freeman and others 1993, 1997; Randell 1997; Ruas 1997).

Ecological Relationships and Distribution

The species grows in a variety of soil types from the Great Plains to Pacific Coast ranges and from Canada to Mexico (fig. 1); it occurs from elevations below sea level to about 8,000 ft (2,400 m). This shrub is well suited to deep, well-drained sandy soil, sand dunes, gravelly washes, mesas, ridges, and slopes; vigorous plants have been found in heavy clays. Ecotypes of the species may grow in widely different soil types and plant communities (Dunford 1985; McArthur and others 1978b; Richardson and McKell 1980). Fourwing saltbush is frequently found intermixed with black greasewood, shadscale, Castle Valley clover saltbush, basin big sagebrush, and occasionally black sagebrush and pinyon-juniper. In many Western regions it is the main shrub over extensive grassland areas. Important grasses on these tracts are galleta grass and blue grama. It is not unusual to find it growing in association with spring-growing grasses such as bluebunch wheatgrass and Sandberg bluegrass.

Plant Culture

This species may be propagated by direct seeding, transplanting nursery or container stock, or by rooted stem cuttings (Hennessey 1985; Kay and others 1977b; McArthur and others 1978c; Richardson and others 1979; nine papers in the revegetation section of Tiedemann and others 1984b). Shaw and Monsen (1984) give information on growing fourwing saltbush and other chenopod shrubs in a nursery setting to provide suitable bare root transplant stock. Ferguson (1980) recommended a growth medium of 50 percent sphagnum peat moss, 30 percent arcillite aggregate, and 20 percent vermiculite for growing Bonneville saltbush and other plant species native to semiarid alkaline soils. Use has been made of rooted stem cuttings (McArthur and others 1984a) to establish seed orchards that combine desired vegetative and floral traits together for seed production (Briggs 1984; McArthur and others 1978c; Noller and others 1984; Van Epps and Benson 1979). Such orchards may not only provide superior seed but may also provide income from marginal agricultural land.

Most wildland stands of fourwing saltbush produce a harvestable seed crop at least 3 out of every 5 years. Production and seed quality vary among sites, but fourwing saltbush is an abundant seed producer. Seed is collected by hand stripping or beating, although some vacuum and reel-type harvestors have been modified for this purpose (Monsen 1978; Monsen and others 1985b; Van Epps 1978). Seed is reasonably easy to harvest and process. Consequently, seed costs are not excessive. Seed is harvested in late fall and early winter, and seed can be cleaned immediately after collection. Various commercial growers have recently established seed orchards of fourwing saltbush. Seed yields from these centers appear to be more reliable than wildland stands. Seed quality differences may be better as well (Briggs 1984; McArthur and others 1978c; Noller and others 1984; Van Epps and Benson 1979).

The wings are removed from the utricles using hammermills, flail-type beaters, Dybvigs or cylinder grinders (chapter 24). If correctly operated, these cleaners can be used to fracture the utricle to aid seed germination. Removal of the wings greatly reduces the bulk and allows the utricles to be planted with most seeding equipment.

Only about 50 percent of the utricles contain a full viable seed. Seed "fill" can be increased by cultivation and culture of nursery plantings. Seed fill from wildland collections may vary from a low of 10 to 20 percent to as high as 80 percent (Crofts 1977; Gamrath 1972; Gerard 1978; Springfield 1970b). Seeds should be carefully inspected prior to harvest to ensure the acquisition of high quality seed. Acceptable fill is about 40 percent. Seeds can be stored for a number of years (up to 7) in an open warehouse without loss of viability. Even after 15 years storage, viability is acceptable (Stevens and others 1981a).

Seeds of fourwing saltbush normally require 20 to 30 days of stratification to initiate and assure uniform germination. Thick impermeable utricles often require much longer periods before water and oxygen can gain entry. Springfield (1966) and Potter and others (1986) found temperatures required for germination varied among ecotypes, but the optimum range was 15 to 18 °C (59.0 to 64.4 °F). Potter and others (1986) reported seeds are able to germinate at low media osmotic potential if optimum temperatures are maintained. However, ecotypes differed in their tolerance to moisture stress. Seeds germinate early in the spring, and if fall seeded, high mortality to spring frost can occur. Consequently, spring plantings are sometimes recommended. However, seeds must be planted early enough to facilitate stratification. If this is not possible or if seeds with impermeable seedcoats or long-term stratification period requirements are to be planted, fall seeding should be conducted. Where the climate permits, fall or winter planting is preferred.

Seed should not be covered more than 0.5 inch (1.2 cm) deep. Broadcast seeding followed by chaining has produced excellent stands. Satisfactory stands have also developed from drill and interseeding. Plants can also establish when seeded in separate rows with herbs using a conventional rangeland drill. However, fourwing saltbush seedlings are not able to compete with herbs if drilled together in a single row. Separating seeds of different species and reducing herb seedling density by broadcast seeding is beneficial to shrub establishment. Most satisfactory stands have been achieved when fourwing saltbush was seeded at 1 to 2 lb PLS/acre (1.2 to 2.2 kg/ha) or between 2 to 4 lb (2.2 to 4.5 kg) bulk or cleaned utricles. Between 0.3 and 4.67 percent of all viable seed planted ultimately emerge and develop into mature plants (Richardson and others 1986).

Fourwing saltbush is well adapted to interseeding. Plants can be established in strips or furrows separate from herbs (Giunta and others 1975; Ostyina and others 1984; Rumbaugh and others 1982; Stevens and others 1981b). Interseeding is a useful means of seeding the shrub into established stands of perennial herbs. Narrow furrows or strips approximately 28 to 30 inches (71.1 to 76.2 cm) in width can be created using various interseeders (Giunta and others 1975; Stevens and others 1981b). Herbicides have also been used for this purpose (Petersen and others 1990). Shrub seeds are placed in the clearing. Furrows can be interspaced at desired intervals, usually 10 to 12 ft (3.0 to 3.7 m) apart. Fourwing saltbush grows profusely and quickly produces a dense overstory. Fourwing saltbush grows well with understory herbs and other shrubs. When grown in association with other species, herbage production of the fourwing saltbush plants and the understory herbs remains quite high (Rumbaugh and others 1981, 1982).

Fourwing saltbush is naturally susceptible to basal decay disease in both plantation and natural populations (Nelson and Welch 1984). This is not usually a serious problem. Insects can be troublesome to fourwing saltbush plants and populations, especially when plants occur at heavy densities (Haws and others 1984; Moore and Stevens 1984). In seed orchards the case-bearing moth can be devastating if not controlled. Malathion will effectively control this pest (Moore and Stevens 1984).

Uses and Management

Fourwing saltbush is one of the most valuable forage shrubs in arid rangelands because of its abundance, accessibility, palatability, size, evergreen habit, nutritive value, rate of growth, and large volume of foliage (McArthur and others 1978; Petersen and others 1987). Its leaves, stems, and utricles provide browse in all seasons. Sanderson and others (1987) have shown that saponin content may be important in the palatability of fourwing saltbush. In addition to providing forage and cover, this species is one of the most important shrubs for use in rehabilitation of depleted rangelands and in soil stabilization projects in Western desert areas (Blaisdell and Holmgren 1984; Blauer and others 1976; Plummer 1984; Plummer and others 1966b). Stutz (1982) and Stutz and Carlson (1985) have shown that fourwing saltbush hybridized with other saltbush species can be effective in an *in situ* selection process in revegetation efforts. Many lines of potentially adaptive plants are established under this technique. Additional onsite hybridization and rapid natural selection allow sustained establishment of adapted plant materials.

Fourwing saltbush is widely planted in revegetation projects. When the seedings are carefully planted they are usually successful. Evidence shows that fourwing saltbush increases the value of otherwise herbaceous pastures (Ostyina and others 1984; Rumbaugh and others 1982; Ueckert and others 1990). Giunta and others (1975) demonstrated the value of interplanting fourwing saltbush in cheatgrass-dominated ranges. Sometimes, however, stands do not persist, perhaps because of planting in sites that will not support the species or because the source planted is not adapted to the site. The species is a secondary or facultative selenium absorber and thus may be mildly poisonous where selenium occurs in the soil (Davis 1972; Kingsbury 1964). Minor losses have occurred when livestock had little or nothing else to eat (Hitchcock and others 1964).

In propagating fourwing saltbush, it is especially important to be sure that the strain being planted is adapted to the site. If possible, seed should be from a source growing in a climate similar to that of the site being seeded unless other tested strains are known to have similar or better adaptation. Strains adapted to the mountain brush types, where soils tend to be neutral, mature rapidly; but in deeper soils of this type, the life span has often been not more than 10 years. On drier sites having higher alkaline content, life span of the same types has been much longer. However, persistence of different accessions has been quite erratic. Various biological and climatic influences apparently affect persistence. Plants established from seed collected in the blackbrush-mesquite belt in southern Utah have not persisted in colder parts of the State. Seed collected from colder areas have persisted well on warmer sites (Plummer and others 1966, 1968).

Varieties and Ecotypes

Fourwing saltbush probably has the greatest potential among the woody chenopods for reclaiming arid ranges. It is one of the most widespread and adaptable western shrubs. Fourwing saltbush is the center of a large species complex. It hybridizes widely with other woody saltbushes (Blauer and others 1976; Sanderson and Stutz 1994b; Stutz 1978, 1984). Several subsidiary species have been recognized. These species are all fourwinged and likely have *A. canescens* in their ancestry or are directly derived from that species. Five of the allies of fourwing saltbush (*A. aptera*, *A. bonnevillensis*, *A. garrettii*, *A. navajohensis*, and *A.* "*robusta*") are listed in table 3. Each species has a habitat requirement different from *A. canescens*, and consequently would be useful for restoration and revegetation of particular kinds of sites (table 3).

Fourwing saltbush proper is composed of widely occurring polyploid races ($x = 9$). Diploids are mostly restricted to the southern portion of the species range—New Mexico and Texas and south (Dunford 1984; Stutz and Sanderson 1979). Hexaploids, too, are restricted mostly to the west Texas and New Mexico area. Other high polyploids (up to 20x), usually restricted endemics, occur in the southern portions of the species range (Sanderson and Stutz 1994a; Stutz and Sanderson 1979). Tetraploids ($4x = 2n = 36$) are the common plants of the Intermountain areas.

Fourwing saltbush, with its outcrossing habit and common polyploidy, exhibits both allo- and autopolyploidy (Stutz 1978, 1984). Many of the common tetraploids of the Intermountain area appear to be autotetraploids (McArthur and others 1986).

Differences have been demonstrated among several accessions in winter protein content (Welch and Monsen 1981, 1984) and in both growth performance and survival (Geist and Edgerton 1984; McArthur and others 1983a; Shaw and others 1984; Young and others 1984e). In planting fourwing saltbush, either a proven accession or accessions obtained from nearby or from higher latitudes or higher elevations than the planting site should be used (McArthur and others 1983a; Van Epps 1975).

Three releases of fourwing saltbush of proven quality and adaptability have been made (Carlson 1984). Additional work is under way to provide more plant material with known characteristics by identifying and testing promising accessions and through hybridization and selection procedures (Carlson 1984; Stutz and Carlson 1985).

The three releases are 'Rincon', 'Marana', and 'Wytana'. 'Rincon' is well adapted to a wide range of

Table 3—Other fourwing saltbushes in addition to *Atriplex canescens*.

Species	Postulated origin	Habitat	Distribution	Distinguishing characteristics	References
Atriplex aptera	*A. canescens* x *A. gardneri*	Clay hill badlands	Upper Missouri River Drainage, Montana, Wyoming, the Dakotas	Diminutive (or lacking) utricle wings. Small 24 inches (60 cm) plants	Brown 1956; Stutz 1978; Stutz and others 1979.
Atriplex bonnevillensis	*A. canescens*	Alkaline playas	Eastern and Central Great Basin, Utah and Nevada	Small 30 inches (75 cm) highly variable plants	Hanson 1962; Frischknecht and Ferguson 1979.
Atriplex garretti	—	Rocky, sandy soils; in canyons	Colorado River and tributary canyons, southern Utah, northern Arizona	Early flowering, succulent, yellow-green leaves. Small 16 inches (40 cm)	Brown 1956; Hanson 1962; Blauer and others 1976.
Atriplex navajoensis	—	Rocky, sandy soils	Vicinity of Navajo Bridge, Coconino County, AZ	Woody, yellow-green leaves. Up to 40 inches (100 cm) tall	Hanson 1962.
Atriplex "robusta"[a]	*A. canescens* x *A. tridentata*	Highway disturbances in salt flats	East of Wendover, Tooele County, UT	Rapid growth rate, utricles rarely winged but with variously shaped protuberances	Stutz and others 1979.

[a]This taxa has not been formally named.

soil textures: sandy areas, gravely washes, loamy soils, heavy clay soils, and moderately saline soils. This strain is best adapted to big sagebrush and pinyon-juniper zones, but it also does well in the more mesic portions of the salt desert shrub area. It appears to have tolerance to salt similar to that of other fourwing saltbush ecotypes. Because of its high elevation origin, 'Rincon' has shown an adaptability to more northern climates than might be expected, considering its origin in northern New Mexico. It has performed well at 3,000 to 8,000 ft (910 to 2,400 m) elevation where the average annual precipitation ranges from 9 to 23 inches (22.9 to 58.4 cm) (McArthur and others 1984b). 'Rincon' is being grown in seed orchards for commercial seed production (fig. 2b). The recommended design and early orchard performance characteristics of 'Rincon' are given by Noller and others (1984).

'Marana' is recommended for Mediterranean type climates below 4,000 ft (1,200 m) in elevations with minimum temperatures of 10 °F (–10 °C) generally in California and adjacent areas (Carlson 1984; Hassell 1982; McArthur and others 1984b). 'Wytana' is closely related to *A. aptera* (table 3), and is adapted to eastern Montana and Wyoming (Carlson 1984; McArthur and others 1984b).

Several other accessions may have utility for widespread planting although they haven't been formally released (McArthur and others 1983a; Petersen and others 1987; Shaw and others 1984; Young and others 1984e). One particular accession with a proven performance record is the gigas diploid (up to 10 ft [3 m] tall) that grows naturally only in Utah's Little Sahara Sand Dunes (Stutz and others 1975). This giant form layers readily and appears to have an important place in the stabilization of dunes or other sandy areas. In trials since the 1980's, the giant form has grown well on clay, as well as sandy soils.

Several other Utah accessions perform well in pinyon-juniper and big sagebrush communities and on mine disturbances throughout the Intermountain region (McArthur and others 1983a). Some selections or ecotypes are nearly evergreen; that is, they retain a high percentage of their leaves on a year-round basis. Ecotypes that have this feature occur in both the warmer and cooler portions of the plant's natural range. Consequently, the feature is not restricted to limited areas. Among ecotypes considerable differences exist in seed size, utricle thickness, and germination patterns (Monsen and McArthur 1985; Springfield 1970b). Similar variation also occurs among seeds collected from a single bush. However, germination traits are distinct with different ecotypes, and the features can be used to increase stand establishment. Small utricles normally germinate more rapidly and uniformly than large utricles. Large, thick utricles must be mechanically fractured to attain uniform germination (Monsen and McArthur 1985).

Atriplex confertifolia ______________

Shadscale

Shadscale is a compact spinescent shrub, growing typically in dense clumps from 0.5 to 4 ft high (15.2 to 121.9 cm) and 1 to 5.5 ft (30.5 to 167.6 cm) wide (fig. 5). The rigid, brittle branches are scruffy when young but become smooth and spiny with age. The leaves are nearly circular to elliptic, oval, or oblong, 9 to 25 mm long, 4 to 20 mm wide. They are scruffy and gray especially at maturity (Blauer and others 1976).

Flowers of shadscale are similar to those of fourwing saltbush except in the nature of the bracts enclosing the seed. The bracts of shadscale are foliose, 5 to 12 mm long, broadly oval to almost round, united at the base, and have entire, free, somewhat spreading margins (fig. 5). Shadscale blooms from late March in the southern portion of its ranges to mid-June in the northern portion (Hanson 1962). Utricles mature about 15 weeks after blooming. They are fairly persistent through the winter months (Blauer and others 1976).

Although sex expression in shadscale has not been studied in the detail accorded fourwing saltbush, it shares some of the characteristics of that species. For example, shadscale populations may exhibit biased sex ratios and include monoecious as well as pistillate and staminate individuals, and individual plants of different genders behave different physiologically (Freeman and Harper 1980; Freeman and McArthur 1982, 1984).

Figure 5—Shadscale growing near Elberta, Utah County, UT.

Ecological Relationships and Distribution

Shadscale is widely distributed in the Western United States from Chihuahua to northern Montana and from North Dakota and Texas to California and Oregon (Branson and others 1967; Hall and Clements 1923; Sanderson and others 1990; Stutz and Sanderson 1983). In broadness of distribution among the woody chenopods it ranks next to fourwing saltbush and winterfat and frequently grows in association with both. It grows at elevations from 1,500 to 7,000 ft (460 to 2,100 m) usually on fine textured alkaline soils but also on coarser, sandier soils (Blaisdell and Holmgren 1984; Branson 1966; McArthur and others 1978b).

It occurs in nearly pure stands and in mixtures with winterfat, budsage, big sagebrush, black sagebrush, rabbitbrush, spiny hopsage, black greasewood, gray molly, horsebrush, juniper, other saltbushes, and several species of grass. It endures alkaline soils better than most of these associates and can be found growing with such halophytes as glasswort (Hall and Clements 1923). West, Caldwell, and their colleagues, (Caldwell and others 1977; Moore and others 1972; West 1985; West and Gasto 1978) showed how the synecological and physiological relationships of shadscale and winterfat growing in a mixed stand give insight on why subtle environmental differences are important in the distribution patterns of these and other desert shrubs. A number of ecotypes grow on a wide range of sites including highly alkaline soils. Shadscale has a relatively short life span and can be killed by drought and high water (Blaisdell and Holmgren 1984; McArthur and others 1978b).

Plant Culture

Although shadscale readily spreads naturally from seed, it is difficult to establish from seed. Only under the most favorable climatic conditions do stands become established from artificial seeding (McArthur and others 1978b; Monsen and Richardson 1984). It can be successfully transplanted when moisture conditions are right in the spring or fall (Luke and Monsen 1984). Fruit remains on the ground 1 year or more before germinating and establishing. Understanding the riddles in shadscale germination and stand establishment requires more research. Warren and Kay (1984) demonstrated that dormancy in shadscale is difficult to overcome by traditional mechanical and chemical methods. Young and others (1984e), following a Stutz (1978) and Stutz and Sanderson (1983), scenario of shadscale's evolution in a pluvial lake regime, suggested that a great deal of ecotypic variation in shadscale germination should occur. Oaks, Stutz, and Sanderson (unpublished) have found ecotypic germination variation to be common. Garvin and others (1996) using eight shadscale accessions concluded that the species germinates in a long-term temporally staggered fashion, suggesting the operation of multiple dormancy mechanisms. A few populations lack the species' characteristic seed dormancy. Insects can cause severe damage to shadscale (Haws and others 1984; Hutchings 1952).

Low seed fill often compounds low seed germination problems. Seed is usually acquired from wildland stands growing under arid conditions. Seed quality varies from year to year and even among bushes. Most commercial lots of seed are collected from upland foothill ranges that receive higher amounts of precipitation. Harvested seed crops are produced about every 3 to 5 years, yet some sites are more reliable than others.

Seed or utricles are normally hand collected but can be efficiently harvested with vacuum, rill, or strip-type machinery (see discussion under fourwing saltbush). Seed usually ripens in late fall or early winter. Utricles must be dry before they detach from the bush. Early winter storms can interfere with seed harvesting. Once harvested, the wings are usually removed from the utricle with a hammermill or flail-type beater. Seeds can be stored for a number of years without loss of viability. However, unless stored in cold chambers and treated with an insecticide, seed borne insects can destroy stored lots. Good quality seed has between 40 to 50 percent "filled" utricles. However, a considerable amount of lower quality seed is sold. Seed viability should be retested if stored over 1 year.

Because seed germination is often erratic and varies among ecotypes, fall seeding is recommended to aid in overcoming natural dormancy and breakdown of the utricle. Seed must be placed 0.25 to 0.5 inch (6.4 to 12.7 mm) deep to ensure germination and seedling establishment. Shadscale is often planted on heavy-textured salty soils. Soil particles may be flocculated, which creates a rough surface that aids in seed burial. However, soils may crust easily, and shadscale seedlings may not be able to emerge through the surface crust. Shadscale seedlings grow slowly and are not able to compete with herbs, particularly cheatgrass. Consequently, planting sites must be cleared of weeds, and the shrub should be seeded alone in separate rows from other species. Once seedlings reach 2 years old, losses to competition are low. The plant has done well on barren mine wastes, particularly infertile soils (Ferguson and Frischknecht 1985).

Broadcast seeding with no followup measure to cover the seed has not been very successful. Either direct drilling or interseeding is recommended. Seed should be planted at approximately 2 to 4 lb PLS/acre (2.2 to 4.5 kg PLS/ha). Most conventional seeders can be used to seed this shrub. Dewinged seeds are relatively small and flow freely through most seeding devices. Seeds are relatively heavy and can be used in seed mixtures to facilitate the planting of more fluffy or trashy seeds through the seeder (Monsen, unpublished). Seeding rates can be easily regulated. Seed germination may begin quite early in the spring and continue until early summer.

Natural spread of shadscale occurs erratically, although large stands frequently develop. New seedlings normally require 3 to 8 years to attain a mature status. Some ecotypes, however, from north-central Nevada and northeastern Wyoming grow fast. Undoubtedly other collections have similar traits.

Transplants of shadscale can be successfully reared as container or bare root stock. Even under favorable conditions, shadscale seedings grow rather slowly. The 1 year old stock usually are 3 to 7 inches (7.6 to 17.8 cm) in height but have a moderately diverse root system.

Seedlings do not survive field planting well unless extra care is given in handling and planting. Seedlings must be dormant when planted. Because some leaves tend to remain on the plant, it is difficult to determine if plants are clearly dormant. Seedlings also require a growth medium that is similar to the original soil. Bare root seedlings are particularly sensitive to overwatering. Maintaining plants as 2-0 stock result in much larger materials, but has not improved field survival. Transplants do not survive if planted amid herbaceous competition. Clearings of 30 inches (76.2 cm) in diameter are required to reduce competition sufficiently. Field survival of 60 to 80 percent is considered normal for large-scale plantings. Much lower survival results if plants are planted offsite. Shadscale does not establish or persist long when planted on unadapted sites. Neither transplants nor direct-seeded seedlings persist if planted offsite. Care should be taken to assure seeding of adapted ecotypes. Unlike fourwing saltbush, shadscale seedlings and young plants are not selectively sought and grazed by rodents, rabbits, or livestock.

Uses and Management

Despite its spiny character, shadscale is grazed by livestock and game. Persistence of leaves varies greatly over shadscale habitat. Forage value improves with persistence of leaves. Spines save this species from heavier grazing than it would otherwise receive, and the spines are likely a factor in its common widespread distribution. Seeds are a preferred and nutritious part of the plant (USDA Forest Service 1937). According to Sampson and Jespersen (1963), as the leaves and fruits drop in the autumn, they often accumulate around the parent shrubs. Livestock readily seek this accumulation. In some areas shadscale is an increaser and becomes dominant as more palatable species such as budsage and black sagebrush are killed by grazing (Blaisdell and Holmgren 1984). Because shadscale is generally more salt-tolerant than fourwing saltbush and several other shrubby chenopods, it may be used to better advantage on the more salty areas for range rehabilitation and soil stabilization (McArthur and others 1978b). Existing stands of shadscale should be managed rather than mechanically manipulated because the species usually occurs on areas that are difficult to manipulate (Bleak and others 1965; Plummer 1966). This is because shadscale normally grows in semiarid conditions, often occupying sites that receive less than 10 inches (25.4 cm) annual moisture. When disturbed these areas are usually invaded by cheatgrass or other weeds. The competition must be controlled to allow survival of naturally or artificially seeded shadscale. Large extensive areas can be direct seeded if no competition exists. Otherwise, some means of site preparation is required to reduce competition.

Shadscale often occurs as near pure stands void of most other shrubs. Plants from these pure stands do not grow in mixtures with many other shrubs. Consequently, they are usually planted alone. Ecotypes that extend into pinyon-juniper woodlands and big sagebrush communities have been more successfully seeded in diverse habitats. These ecotypes, the diploid races (see Varieties and Ecotypes section), when seeded compete favorably with other species but are best adapted to sites similar to those from where they have been collected. Ecotypes collected from more arid salt desert conditions, the higher polyploids, are less adapted to foothill upland communities but appear more drought tolerant.

Varieties and Ecotypes

Shadscale comprise chromosome races ranging from diploid (2n = 18) to decaploid (2n = 90). The chromosome races are distributed, in general, with the high ploidy levels occurring in uniform stands on valley floors and lower ploidy forms progressively larger and more morphologically variable and occurring in more diverse communities (Sanderson and others 1990; Stutz and Sanderson 1983). Little attention has been paid to differential adaptation of these forms for revegetation purposes. However, the most robust erect forms produce more seed and have generally been used more for seeding. More attention should be paid to this feature because some of the higher polyploids are narrow genetically and adaptively. Consequently, these are poorly adapted to many sites for which the more diverse diploids and tetraploids are adapted (Stutz 1982; Stutz and Sanderson 1983).

Atriplex corrugata

Mat Saltbush

Mat saltbush is a low shrub that forms dense, extremely prostrate (6 inches [15.2 cm] tall) nearly white mats five to 20 times wider than they are tall (fig. 6). The prostrate branches often produce adventitious roots where they contact the soil. The bark is soft, spongy, and white. The evergreen sessile leaves are opposite on the lower parts of the stems, and alternate above. The blades are densely scurfy and measure 7 to 18 mm wide (Blauer and others 1976; McArthur and others 1978b). Bushes are commonly dioecious, but some are monoecious. The sexual system appears to operate much like that of fourwing and shadscale (Freeman and McArthur 1984; Pope 1976). The yellow to light-brown staminate flowers are borne of glomerules 3 to 6 mm wide on nearly naked spikes. The pairs of fruiting bracts that enclose the pistils of the female flowers are sessile or subsessile, 3 to 5 mm long, 4 to 6 mm wide, united along seven-tenths of their length and usually densely tuberculate on the lower one-third. Mat saltbush flowers from April to June, and the fruit ripens 6 to 10 weeks later.

Ecological Relationships and Distribution

Mat saltbush is distributed mainly on soils derived from the Mancos shale formation in eastern Utah, southwestern Wyoming, western Colorado, and northwestern New Mexico at elevations from 4,000 to 7,000 ft (1,200 to 2,100 m). It tolerates up to 13,000 ppm soluble salts and is often the only perennial plant present where such high concentrations of salt occur (Hanson 1962). Mat saltbush is probably the most halophytic shrub in the genus, but it is frequently found in areas where the salt concentration is not so high. In these areas, it may be associated with shrubs such as winterfat, cuneate saltbush, shadscale, fourwing saltbush, black greasewood, budsage, and gray molly. Young plants have been successfully transplanted into a former greasewood type in the Great Basin (Blauer and others 1976).

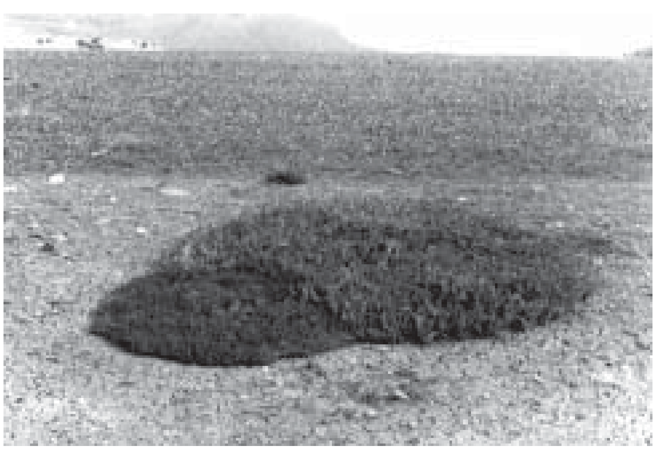


Figure 6—Male mat saltbush (left) and female Castle Valley clover saltbush (right) growing along highway near Fremont Junction, Emery County, UT.

Plant Culture

The seed or utricle does not require hammermilling. The seed is usually screened with a fanning mill to remove debris, and then seeded with most conventional equipment. Cleaned seed can be stored for several years without serious loss in viability. Most native stands produce between 40 to 60 percent filled utricles.

Seed production is often quite low, yet even during serious drought and prolonged use, some shrubs produce seed. Seed fill or quality is usually low. Some stands, particularly those in south-central Wyoming, produce unusually abundant crops yearly. Large fields are machine harvested and sold each year. Hand collection is quite slow, yet field combines are able to harvest seed easily.

Uses and Management

The plant is important as a winter forage. It often grows interspaced with other plant communities at mid to high elevations. Under these circumstances it is encountered on exposed shaley outcrops with few other plants. These sites are often windblown slopes that are accessible to winter grazing. The shrub withstands heavy use, even under unstable soil conditions. Plants may be heavily browsed and seriously trampled. Big game animals often concentrate on these exposed sites during periods of deep snow accumulation. The shrubs are able to recover from serious abuse without noticeable loss of vigor.

Fall seeding is normally recommended. Where possible, midwinter planting is successful. Seedlings are susceptible to early spring frosts. If serious frosts are expected, spring seeding can be used. Seeds should be planted near the soil surface or not more than 0.5 inch (1.3 cm) deep. Seeding is usually done on sites that once supported the shrub. These areas usually are not infested with annual weeds, consequently, direct seeding without other preparatory measures is all that is necessary.

Seedlings usually emerge rapidly and grow rather vigorously the first year. If moisture remains available, seedlings normally continue growth all summer. Mat saltbush has been seeded with selected grasses including Russian wildrye, tall wheatgrass, and crested wheatgrass. Although these herbs may improve the forage production, they usually do not persist in dense stands throughout the site. Young grass seedlings and mature plants do suppress shrub establishment. However, grasses interseeded into established shrub stands do not decrease shrub density or vigor.

Mat saltbush can be broadcast seeded and covered with a drag or harrow if planted alone. When seeded with herbs, the shrub seeds should be planted in separate rows or spots. Between 2 to 4 lb PLS/acre (2.2 to 4.5 kg PLS/ha) is recommended. However, satisfactory stands have developed from lower rates. When seeding on the heavy clay soils that normally support this shrub, care must be taken to avoid surface compaction and crusting.

Transplanting either nursery-grown bare root stock, wildings, or container materials is successful. Wildings can be dug from native stands and transplanted directly on disturbances. Wildings and bare root stock survive abusive treatment, but should not be unnecessarily mistreated. Transplants should not be allowed to “heat up,” and roots must be placed in a moist soil. When transplanted on unstable and seemly infertile soils, the transplants survive remarkably well. Natural enlargement of the crown occurs soon after planting, providing excellent soil protection even under adverse conditions.

Mat saltbush has performed well from either direct seeding or transplanting disturbed sites. It is particularly useful as a shrub for seeding mine disturbances, road construction sites, and similar areas where heavy textured soils and substrata are exposed. It has established, persisted, and grown well when planted on pinyon-juniper and big sagebrush sites if soils are quite basic and heavy.

Small seedlings normally are not destroyed by grazing or insect attack. The shrub should be seeded in areas where remnant plants remain. Attempting to convert mat saltbush communities to fourwing saltbush, winterfat, or blackbrush is not advised. Although these and other shrubs may be more palatable, converted communities usually do not remain.

Varieties and Ecotypes

Little study has been accomplished in this area. Hanson (1962) and Pope (1976) have demonstrated some populational differences. Mat saltbush will hybridize with other saltbush species (Blauer and others 1976; Stutz 1978, 1984).

Atriplex cuneata ________________

Castle Valley Clover or Cuneate Saltbush

Castle Valley clover saltbush is a low shrub 0.3 to 1.5 ft tall (9.1 to 45.7 cm) with a more or less prostrate, woody, much-branched base and erect branches (fig. 6). The light grey-green, spatulate to broadly elliptic evergreen leaves are 2 to 6 cm long and 0.5 to 2.5 cm wide (Hall and Clements 1923). In common with some other woody saltbush species, this species is apparently trioecious (Freeman and McArthur 1984). Its yellow to brown staminate flowers are borne in glomerules arranged in panicles. The pistillate flowers are borne in axillary clusters and consist of pistils enclosed by wingless bracts. At maturity, the bracts are 5 to 9 mm wide, irregularly toothed along their margins, and have numerous, flattened, crestlike tubercles on their sides (fig. 4d). Blooming occurs from mid-April to July, depending on elevation and climatic conditions. Ripening of the fruit follows about 7 weeks later (Hanson 1962).

Ecological Relationships and Distribution

The species occurs in high to moderately alkaline soils in eastern Utah, southwestern Colorado, and northern New Mexico. In these areas, Castle Valley clover saltbush is often dominant or is codominant with shadscale and mat saltbush.

Plant Culture

Seed production of Castle Valley clover saltbush is similar to that of other woody saltbushes. Annual yields are erratic, and only about 50 percent of all utricles produce viable seeds. Seed germination is also erratic and varies among ecotypes. Seeds or utricles are relatively small and can be planted with most equipment. Seedlings are quite vigorous and grow moderately rapidly. Young plants are competitive but can be suppressed by perennial grasses and annual weeds. Plants invade open disturbances, yet success from artificial seeding is not consistent. The plant should not be seeded directly with herbaceous plants but is able to compete favorably when seeded with fourwing saltbush, big sagebrush, green ephedra, and spiny hopsage.

The shrub should not be seeded on areas other than sites naturally occupied by this shrub. The species is not well adapted to the big sagebrush and upland communities, but can be used throughout most salt desert shrublands. Like other woody saltbushes, the shrub does well on fresh disturbances and can be used to treat exposed substrata created from mining, road construction, and so forth.

Uses and Management

Castle Valley clover saltbush, so named by stockmen because of the high livestock preference in all seasons, remains green and succulent throughout the winter. The shrub shows particular promise in artificial restoration of certain winter game ranges and on disturbed sites having saline-alkaline soils.

It grows through a wide range of salinity and may be associated with any of the other shrubby chenopods and many of the sagebrush species. It grows well with a variety of desert grasses and forbs. Its protein content helps to provide a balanced diet for livestock and game, particularly in the winter when much of the associated vegetation is dry (McArthur and others 1978b).

Varieties and Ecotypes

Castle Valley clover saltbush hybridizes readily with a number of the saltbushes, but particularly so with fourwing saltbush, both naturally and artificially (Blauer and others 1976; Stutz 1984). A stabilized hybrid of these could be a boon to our winter ranges. Such a plant would be taller than Castle Valley clover saltbush and retain more green foliage than fourwing. A stabilized, widely adapted hybrid might be found in nature.

Atriplex gardneri

Gardner Saltbush

Gardner saltbush is a low subshrub, usually less than 12 inches (30.5 cm) (fig. 7). The lower one-fourth to three-fourths of the plant is slightly woody and the rest is herbaceous. Its habit varies from decumbent creeping forms to rounded forms three to five times broader than they are high. The spineless decumbent branches usually produce adventitious roots where they contact the soil. The lightly scurfy leaves are evergreen spatulate to oblaceolate to obovate 15 to 55 mm long, and 5 to 12 mm wide. Plants of this species are dioecious or sometimes monoecious (Hanson 1962; Pope 1976). The brown staminate flowers are borne in glomerules 3 to 5 mm wide on nearly naked one-branched terminal panicles. The pistillate flowers are borne on leafy spikes. Fruiting bracts that enclose the female flowers are 3 to 6 mm long, 2.5 to 5.0 mm wide, and are sessile. Their surfaces range from smooth and free of tubercles to densely tuberculate. The apex of the bract ends in an oval terminal tooth subtended by two slightly smaller lateral teeth. Gardner saltbush flowers from mid-May to the first of July and intermittently following heavy rains. The fruit ripens about 7 weeks after flowering.

Figure 7—Gardner saltbush (right) growing with budsage (left) in the Red Desert, Sweetwater County, WY.

Ecological Relationships and Distribution

Gardner saltbush is abundant throughout much of Wyoming and Montana on clay and occasionally sandy soils. It is tetraploid, 2n = 36 (Stutz and others 1979). It is useful year-around forage for big game and livestock (McArthur and others 1978b).

Plant Culture

Field establishment may be difficult because of low seedling vigor (Ansley and Abernethy 1984a,b). Ansley and Abernethy (1984b) demonstrated that plants are best established in a field situation when seeds are scarified and stratified.

For production fields and commercial harvest, Carlson and others (1984) recommend direct seeding on a firm weed-free seedbed with 36 inch (91.4 cm) rows in the fall at a rate of 20 pure live seed per foot (66 per m). Once the plants are established and producing seed, the plants can be cut by hayswather, windrowed, and the utricles collected by conventional grain combine.

Uses and Management

Gardner saltbush can be successfully seeded on mine disturbances and rangelands. Although initial establishment is often erratic, a slow but general improvement normally results. When seeded in areas free of weedy competition, seedling survival is usually adequate. Shrub seedlings grow quite favorably and are able to survive normal grazing pressure.

Gardner Saltbush Relatives

Atriplex buxifolia, *Atriplex falcata*, *Atriplex tridentata*

Much of the literature dealing with Gardner saltbush is confusing in that there are several related species considered as a species complex. The taxonomic complexity has not been completely unraveled. The species complex has been alternatively treated as the *A. gardneri* or the *A. nuttallii* complex. These suffrutescent shrubs exhibit population variability, hybridization between populations of the same and different taxa, and polyploid chromosome races (Stutz 1978; Sanderson and Stutz 1994b). *Atriplex nuttallii* is a name that has recently been lectotypified from the northern Great Plains (Saskatchewan) by Bassett and others (1983); that name (*A. nuttallii*) had been without standing prior to then (Fosberg 1941; Stutz and others 1979). We believe the plants of the Intermountain area including *A. buxifolia*, *A. falcata* (falcate saltbush), and *A. tridentata* (tridentate saltbush) are best referred to as part of the *A. gardneri* complex reserving *A. nuttallii* for plants of the northern Great Plains. Drs. Howard Stutz and Stewart Sanderson (n.d.) are actively working on this group of plants from a cytogenetic and morphological standpoint. They propose the name of *A. canadensis* as an alternative name for *A. nuttallii*.

Atriplex buxifolia is similar to *A. gardneri* in habitat preference (heavy clay soils) and in morphology (Hanson 1962; McArthur and others 1978b). Stutz (personal communication) believes that there is no good reason to maintain the two as separate species but to refer both to *A. gardneri*. Plants that have been referred to as *A. buxifolia* were larger than *A. gardneri* (up to 50 cm; 19.7 inches) and distributed more to the north and east (northern Nebraska to southern Saskatchewan) (Hanson 1962; McArthur and others 1978b).

Both *A. tridentata* and *A. falcata* are generally larger statured than *A. gardneri*. *Atriplex tridentata* plants may be from 4 inches to 3 ft tall (10.2 to 91.4 cm). They root sprout profusely (fig. 8). This is the plant referred to as *A. gardneri* by Nord and others (1969) (see Stutz and others 1979). *Atriplex tridentata* can tolerate salt concentrations of over 30,000 ppm and grows with iodine bush and inland saltgrass (Hanson 1962). It is distributed mostly in the Lake Bonneville Basin of western Utah, eastern Nevada, and southern Idaho, but also in eastern Utah and southern Wyoming (Hanson 1962; Stutz and others 1979). *Atriplex falcata* grows up to 20 inches (50.8 cm) tall. It is distributed through the northern Great Basin extending northward to eastern Idaho and eastern Oregon. It grows in soils with 9 to 50 percent sand often between or in association with shadscale, Wyoming big sagebrush, and winterfat communities (Hanson 1962; Yensen and Smith 1984). *Atriplex tridentata* is mostly hexaploid, but tetraploids are also known (Stutz 1978; Stutz and others 1979). All the saltbushes treated in this section are useful year-around forages as is *A. gardneri* itself. They may prove useful in rehabilitation of disturbed saline sites. The edaphic adaption of each taxa should be borne in mind in rehabilitation efforts.

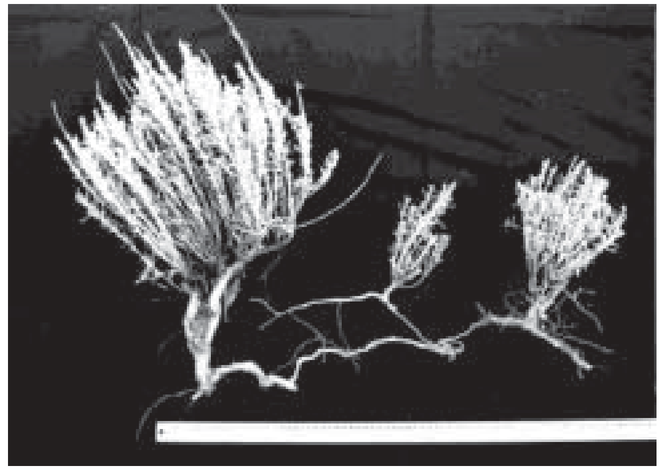


Figure 8—Example of root sprouting in trident saltbush from west Sanpete Valley near Ephraim, Sanpete County, UT.

Research with *A. tridentata* and *A. falcata* have been hampered by poor seed production. Although both species are capable of good seed yields, concentrated efforts have not been developed to acquire adequate samples. Both species have been successfully established by fall seeding. The shrubs appear capable of growing over a wide range of sites, including areas naturally occupied by fourwing saltbush.

The erect growth habit of *A. tridentata* and *A. falcata* can be grown as bare root or container transplant stock. They survive field planting quite well. Individual plants grow well under nursery conditions and may require pruning to reduce plant size.

Atriplex tridentata and *A. falcata* often lack a herbaceous understory. This is often due to heavy grazing. Both shrubs persist under intense use, although seed production is reduced. Both shrubs are capable of growing with a diverse understory. These shrubs have the unique ability to persist with various forage species, and yet remain quite productive themselves.

Other Saltbushes

Atriplex lentiformis (quailbush), *Atriplex obovata* (broadscale saltbush), *Atriplex polycarpa* (allscale saltbush), *Atriplex hymenelytra* (desert holly saltbush)

Some other saltbush species occur in parts of the Intermountain area—especially in the southern parts. Quailbush (*Atriplex lentiformis*) is a large shrub up to 11.5 ft (3.5 m) tall and 24.5 ft wide (7.5 m) (fig. 9). Its leaves are evergreen, alternate, gray-green, scurfy. The distinctive utricles are small flat discs about 3 to 4 mm in diameter. The similar species,

Figure 9—A large quailbush saltbush near St. George, Washington County, UT.

Torrey saltbush differs by being smaller, up to 10 ft (3.0 m) tall and 16 ft (4.9 m) wide, and in having anled stems (versus terete for quailbush). Both species occur in the St. George area of Utah and in other southern and western margins of the Intermountain area (Brown 1956; Hanson 1962). One selection, 'Casa', of quailbush has been released for upland game use and erosion control (Carlson 1984). In contrast to some other *Atriplex* species, quailbush utricles require burial for effective plant establishment (Young and others 1980).

Three other southern saltbush species are broadscale saltbush, allscale saltbush, and desert holly saltbush. Broadscale saltbush is a subshrub 0.6 to 1.5 ft (0.15 to 0.45 m) in height with a woody, spreading base that produces numerous ascending to erect branches (fig. 10). The silvery, scurfy, deciduous leaves are elliptical to obovate, 1 to 3.5 cm long, 1 to 2 cm wide, with a short petiole. This species has yellow staminate flowers borne in small glomerules and arranged 500 to 5,000 to a panicle. The fruiting bracts are broadly cuneate or obovate, 4 to 5 mm long, 5 to 9 mm broad, with smooth or sometimes slightly tuberculed surfaces (Blauer and others 1976). Broadscale saltbush tolerates salinity from 165 to 4,900 ppm soluble salts (Hanson 1962). It is commonly associated with such halophytes as black greasewood, seepweed, and alkali sacaton, and other saltbushes (McArthur and others 1978b; Wagner and Aldon 1978).

Figure 10—Broadscale saltbush growing in Hamblin Wash, Coconino County, AZ. Ruler is 12 inches (30 cm) long.

Broadscale saltbush is an important browse plant in alkaline areas (Edgar and Springield 1977; Hall and Clements 1923). It grows rapidly and is most succulent in the spring. Within areas of adaptation, this species should be useful for stabilizing disturbed sites. Frischknecht and Ferguson (1984) reported that broadscale saltbush was the most successful of seven chenopod shrubs transplanted into a processed oil shale matrix in eastern Utah. After 6 years, over 80 percent of the shrubs survived in both irrigated and nonirrigated plots. Broadscale saltbush seed germinates best following an after-ripening period (Edgar and Springfield 1977). It has been observed to invade the disturbed margins of newly constructed highways.

Allscale saltbush is an intricately branched, rounded shrub to 5 ft (1.5 m) tall. Its twigs are delicate, even approaching spininess. Leaves are obovate to linearly obovate. It occurs in the Sonoran and Mohave Deserts and in drier portions of the San Juaquin and Owens Valleys of California. This species has value as browse and as upland game habitat (Brown 1956; Chatterton and others 1971; Hall and Clements 1923; Sankary and Barbour 1972). Chatterton and others (1971) reported that allscale saltbush is an excellent nutrient source for browsing animals especially late in the year. Graves and others (1975) reported that allscale saltbush was useful for revegetating Mohave Desert land. For successful reseedings, they suggested that allscale saltbush be drill seeded in the early winter. Sankary and Barbour (1972) reported that November is the time of natural seed dispersal and seedling establishment for allscale saltbush. Mixing activated carbon directly with utricles in the seedbox enhances germination by inactivating inhibitory substances found in the utricles (Graves and others 1975).

Desert holly saltbush is a compactly branching, rounded shrub to 3 ft (91.4 cm) tall. The twigs are brittle but not spiny. Its leaves are obicular in outline, but leaf margins are irregularly undulate or coarsely toothed and as long as 1.6 inches (4 cm). Desert holly is distributed on dry alkaline alluvial fans and hills from Owens Valley, California, to southwestern Utah and south to Mexico (Brown 1956).

Ceratoides lanata

Winterfat

Winterfat is an erect or spreading subshrub that shows wide variation in stature from dwarf forms less than 8 inches (20.3 cm) in height to larger forms to 4 ft (1.2 m) (fig. 11). The dwarf forms are herbaceous above a woody base. Taller forms tend to be woody throughout. Branches and leaves are covered with a dense coating of stellate and simple hairs that are white when young but become rust colored with age. The leaves are alternate, linear, 5 to 50 mm long, with entire, strongly revolute margins. Winterfat is predominately monoecious, but dioecious plants also may occur. The flowers are borne in dense paniculate clusters along the upper portion of the branches. The pistillate flowers are below the staminate flowers on monoecious plants. Staminate flowers lack bracts and petals. They have four sepals and four stamens borne opposite the sepals. Pistillate flowers lack both sepals and petals. Pistils are enclosed by a pair of bracts that are united more than half their length. The bracts are covered and often obscured by long, silky hairs (fig. 4i). These long hairs distinguish winterfat from species of *Atriplex*. Site and climate permitting, winterfat blooms between May and August. The fruit ripens from September to November and is dispersed by wind in late fall and winter. Seed production is extremely variable. A scant crop is produced in most years under arid circumstances. Sources from foothill ranges usually produce an adequate crop each year. A heavy seed crop can be produced in years of good summer storms coupled with the absence of summer grazing. Such productive crops on dry desert ranges may occur but once in a decade (Blauer and others 1976).

Figure 11—'Hatch' winterfat growing at Bell Rapids, Gooding County, ID.

Ecological Relationships and Distribution

Winterfat is remarkably resistant to drought, and even on dry sites will produce seed in the third and fourth years after establishment. On favorable sites, plants have produced some seed in their first year of growth. The species has a deep taproot and numerous extensive lateral roots. The plant may appear dead after unusually dry years, but it normally recovers after rain. It exhibits strong reproductive qualities; however, establishment from artificial seeding is hindered because seedlings are highly sensitive to frost damage (Stevens and others 1977a).

Winterfat stands often attain old ages. For example, in southern Idaho a stand of winterfat had plants thought to be an average of 72 years old, whereas the corresponding figure for falcate saltbush was 24 years (Yensen and Smith 1984). Determining the ages of chenopod shrubs is difficult and imprecise (Stewart and others 1940; Yensen and Smith 1984).

Winterfat is most abundant on lower foothills, plains, and valleys with dry subalkaline soils in Utah, Nevada, Wyoming, Arizona, and New Mexico (Riedl and others 1964; Stevens and others 1977). In the Great Basin, it often occurs in pure stands over thousands of acres (Benson and Darrow 1945) and is an important component over millions of acres of the salt desert shrub type. It also grows intermixed with basin big sagebrush, pinyon-juniper, and ponderosa pine. The ecotypes for these upland communities have been used to seed areas often lacking this shrub. Winterfat ranges from Canada through the Great Basin and Rocky Mountain States to Mexico, from California and eastward to Texas and North Dakota (Branson 1966; fig. 1). It also grows over a wide range of altitudes. In Utah, it occurs from the lower Sonoran zone to the alpine ridges. Dwarf forms usually occur on desert floors, on areas of high salt concentration, and on high mountain tops. The larger forms occur on alluvial fans, foothills, and mesas on ponderosa pine and juniper-pinyon sites.

Plant Culture

Winterfat can be established in seed production fields. To do so requires a firm, weed-free seedbed. Carlson and others (1984) recommended direct seeding at a depth of 0.12 inch (3.2 mm) in 36 inch (91.4 cm) rows. Fields require cultivation or hoeing and may require irrigation. Seeds can be combine harvested, usually from late October to mid-November. See chapter 24 for additional information on seed harvest.

Seed is often hammermilled to remove the fluffy utricles (Carlson and others 1984). Booth (1982), however, reported better establishment by seeding whole fruits on the soil surface. Hammermilling also damages many fruits. However, a problem with not hammermilling is that fruits may be difficult to separate from stems, leaves, and litter collected in the field. Seed should be cleaned using a barley debearder to detach separate utricles from the flower head, and then processed with a fanning mill to separate utricles from debris.

Winterfat can be successfully seeded and transplanted in rehabilitation plantings (Clary and Tiedemann 1984; Frischknecht and Ferguson 1984; Luke and Monsen 1984; Plummer 1977; Shaw and Monsen 1984; Stevens and others 1981b). When seeded alone, winterfat seed does not flow through a drill or other seeding equipment. If mixed with heavier seed or a carrier, the winterfat seed is forced through the machinery. Even when mixed with heavier seeds, winterfat debris can cause bridging and clogging. Seed must be carefully cleaned to facilitate seeding. Sticks and other debris should be removed by screening. Chopping or hammermilling leaves a considerable amount of material that restricts seeding operation. Pelleting the seed has improved seeding without reducing seed germination. The heavy coated seed can also be broadcast seeded with less chance of drift. However, coated or pelleted seed must be properly cleaned prior to treatment, or sticks and leaves can still impede seeding.

Winterfat seed maintains viability only for relatively short periods (6 months to 4 years) without special treatment (Kay and others 1977d; Stevens and others 1977, 1981a). Special treatments—such as use of desiccants, sealed containers, and cold storage—can prolong viability up to 8 years (Kay and others 1977d; Springfield 1974). Winterfat seed requires an after-ripening period for maximum germination and germinates best at warm temperatures (77 to 80 °F [25.0 to 26.7 °C]) (Springfield 1968, 1972b; Young and others 1984a). Current research seeks ways to better establish winterfat by seeding because seedlings are generally vulnerable to spring frosts (Stevens and others 1977a).

Winterfat seed is usually cleaned to a purity of between 20 to 50 percent. Seed viability normally ranges between 20 to 50 percent. Approximately 1 lb (PLS) per acre (1.1 k/ha) is recommended for drill seeding. Seeds can be successfully established by broadcast seeding, if lightly covered with a drag, harrow, or pipe harrow. Seeds should be covered with not more than 0.25 inch (6.4 mm) of soil. Some seedlings establish from surface seeding, but failure to cover the seed is a major reason for poor stands on semiarid sites. Because spring frosts seriously weaken young seedlings, spring plantings are recommended in areas where spring frosts are expected.

Winterfat germinates quickly and seedlings grow rapidly. These traits, coupled with early germination, cause the plant to be highly competitive with herbs. Seedlings of few other shrubs survive and grow as well as winterfat amid competition. However, seedlings can be weakened by competition, and weedy annuals and established perennials can and do reduce seeding survival. Winterfat can be established by broadcast seeding directly with herbs and other shrubs. When drill seeded it is best to plant winterfat in separate furrows from the herbs to reduce competition and to set the furrower depth for proper seed placement. Winterfat establishes well when seeded with a cultipacker seeder. Although seeds need only shallow coverage, planting in a firm seedbed is recommended. Young plantings are extremely persistent and are able to withstand heavy grazing, trampling, and drought.

Winterfat is unusually well-adapted to mixed seedings, particularly when planted in pinyon-juniper communities. Although desert types normally grow alone, the tall robust ecotypes do well when seeded in mixtures. However, to encourage spread, openings must be created to allow seedling survival.

Winterfat is easily grown as container or bare root nursery stock. Seedlings are susceptible to damping off organisms, and entire plantings can be eliminated in a few days. Maintaining clean, disease-free conditions is the best control measure, although soil drenches and fumigation can be helpful. Young seedlings transplant well. Plants are difficult to “harden-off” prior to field planting. Transplants that are not hardened are susceptible to stress by drought and freezing. Spring planting is usually recommended, yet transplants are extremely hardy and survive even midsummer planting. The stems of young seedlings become quite brittle and can be easily broken off during lifting and transplanting.

Uses and Management

Winterfat is a superior nutritious winter browse for livestock and big game. Sheep, cattle, antelope, elk, deer, and rabbits consume it. Except for the woody base and larger stems, the plant is edible (McArthur and others 1978b; Riedl and others 1964). Overgrazing has greatly reduced and even eliminated winterfat in some areas, even though it is relatively tolerant to grazing (Stevens and others 1977a). Rasmussen and Brotherson (1986b) demonstrated that late winter grazing of winterfat by cattle reduces the vigor of winterfat stands and opens those stands to less desirable forage species. Winterfat is potentially one of the most useful shrubs for planting to increase cover and forage on alkaline soils of desert ranges in Utah and adjacent States where the average annual precipitation is less than 10 inches (25.4 cm). It is one of a few shrubs that can be reliably seeded under arid circumstances. A great deal of winterfat is planted on Western ranges. Plummer (1984) estimated that 20,000 lb

(9,100 kg) of seed were sold annually. Winterfat ecotypes from upland communities have proven useful for improving deteriorated pinyon-juniper game winter ranges.

Sampson and Jespersen (1963) give winterfat a browse rating of excellent to good for cattle and sheep, excellent to fair for goats, good to fair for deer, and fair for horses. Shaw and others (1984) showed that some winterfat ecotypes have potential as upland game cover. Ostyina and others (1984) reported that winterfat is useful in increasing range productivity for fall and winter use of grass pastures. The species is a good natural increaser and should be highly useful for stabilization in areas where it naturally occurs. Some good stands have resulted from broadcasting utricles on such areas (McArthur and others 1978b).

Varieties and Ecotypes

The different ecotypes of winterfat not only show wide variation in stature but also in seed production, seed size, seedling germination and vigor, pubescence on fruit and seed, and tolerance to varying pH in soils. These ecotypes maintain character differences when planted in uniform gardens (Riedl and others 1964; Stevens and others 1977a). A more woody, somewhat spinescent form of winterfat (*C. lanata* ssp. *subspinosa*) referred to as foothills winterfat occurs on rocky hills in southern Utah, Arizona, California, and Mexico. It apparently is the only form present in southern Arizona. This subspecies shows intergradation in all characteristics with typical winterfat (Kearney and Peebles 1960). Six other species of *Ceratoides* are confined to the old world (McArthur and Sanderson 1984).

Some controversy still exists as to whether the long standing name of *Eurotia* retains its validity in Eurasia and in North America (Committee for Spermatophyta 1978; Howell 1971; Reveal and Holmgren 1972; Robertson 1982). There is also some discussion that the proper generic name is *Krascheninnikova*. Robertson (1982) suggested that south-central Asian winterfat, also known as Pamirian winterfat (*Ceratoides latens* or *Eurotia ceratoides*) has value as a forage plant on North American ranges.

'Hatch' winterfat is a recently released selection that is suitable for its ability to establish, persist, and provide forage in sagebrush and pinyon-juniper communities (Monsen and others 1985a; Stevens and Monsen 1988). 'Hatch' is a large ecotype capable of providing winter forage available above the snow (fig. 11). This selection also has potential for upland game habitat (Shaw and others 1984).

Grayia brandegei

Spineless Hopsage

Grayia, like *Atriplex*, has staminate flowers of four or five sepals, four or five stamens, and pistillate flowers that lack both sepals and petals but have pistils enclosed by pairs of bracts. The margins of each pair of bracts are united from base to apex except for a minute apical opening. Pendleton and others (1988) have shown that spineless hopsage has the unusual monoecious floral system of heterodochogamy. In that system protandrous ("male" first) and protogynous ("female" first) plants are synchronized and reciprocal ensuring cross fertilization. On the basis of a morphological, embryological, and chromatographic study, Collotzi (1966) recommended that *Grayia* be reclassified as *Atriplex*. Welsh (1984) made an alternate suggestion that *G. brandegei* be transferred to *Zuckia* as *Z. brandegei* var. *brandegei*. We favor retaining *Grayia* as a genus including both the species *G. brandegei* and *G. spinosa*. McArthur (unpublished) analyzed Collotzi's (1966) chromatographic data, which shows *G. brandegei* and *G. spinosa* to be most similar among the 10 chenopod taxa. *Zuckia* was not included in Collotzi's (1966) study. More work is required to resolve the *Grayia*-*Atriplex*-*Zuckia* taxonomic question.

Spineless hopsage is a subshrub to 3.5 ft (1.1 m) tall (fig. 12) with linear-oblanceolate to obovate leaf blades 1.5 to 4.5 cm long (Collotzi 1966; fig. 13). The flowering period varies between mid-June and mid-August. Seed matures in late September through early October. Utricles persist on the plants until January and some may last through the winter. These are often removed by small mammals and birds.

Ecological Relationships and Distribution

Spineless hopsage is generally restricted to shale formations of the Upper Colorado River Drainage (Stutz and others 1987) in southwestern Wyoming, western Colorado, northwestern New Mexico, northeastern Arizona, and eastern Utah. Other populations occur in central Utah. It favors silty clay loam soil derived from shales. It grows on tough sites that few other plants occupy (Pendleton 1986; Pendleton and others 1988). Collotzi (1966) noted it occurred under mildly alkaline (pH 7.4 to 7.7) conditions.

Plant Culture

Seed viability and production is similar to saltbush species. Low viability is often encountered due to the arid conditions at the native sites. It germinates and produces seedlings readily, but unless protected, these are quickly taken by rodents and rabbits.

Figure 12—Spineless hopsage growing in Antelope Valley, Sanpete County, UT.

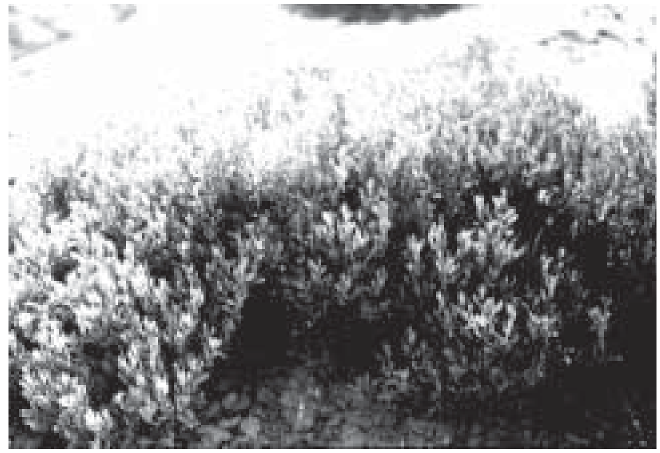


Figure 13—Spineless hopsage growing in Antelope Valley, Sanpete County, UT.

Uses and Management

This species may be used as browse by livestock and big game. Small mammals have shown a high preference for seedlings established at several locations. The shrub should be particularly useful for stabilizing disturbed shaley soils. It provides forage for livestock and game, especially in the spring when it is full leaf (McArthur and others 1978c). Kingsbury (1964) listed spineless hopsage as possible secondary or facultative selenium absorber. As such, it could be mildly poisonous in areas where the soil contains selenium. Some ecotypes demonstrate the ability to grow on heavy soils within pinyon-juniper and basin big sagebrush communities. Stands establish best from fall plantings. To date the shrub has not grown well with other herbs or shrubs. However, it is well suited to harsh situations. Seedlings grow quickly and can be reared as transplant stock quite easily.

Varieties and Ecotypes

Stutz and others (1987) showed that diploid (2x = 2n = 18) and tetraploid (2n = 36) populations differ in phenotype and distribution. In general, the diploids are restricted to the more central portion of the species range, are smaller (x = 13 inches tall and 29 inches wide; 33.0 by 73.7 cm) than tetraploids (x = 16 inches tall and 37 inches wide; 40.6 to 94.0 cm) and have narrower leaves (x = 3.8 mm versus x = 11.2 mm) than tetraploids (Stutz and others 1987).

Grayia spinosa

Spiny Hopsage

Spiny hopsage differs markedly from spineless hopsage in many respects, but the fruits and flowers are similar. It has small, inconspicuous, unisexual flowers. The sexual system appears to be temporally monoecious to allow the species to more efficiently occupy stressful, heterogeneous, patchy environments (McArthur and Sanderson 1984). Spiny hopsage is an erect, diffusely branched, spinescent shrub from 1 ft (30.5 cm) to 4 ft (121.9 cm) high. Its leaves are fleshy in the spring but usually dry before midsummer. Fruits (fig. 4k) generally mature just before leaf fall (Ackerman and others 1980). Unusual ecotypes in northeastern Utah and southwestern Idaho retain a considerable percentage of their leaves throughout the growing season (Blauer and others 1976).

Ecological Relationships and Distribution

Spiny hopsage occupies plains, desert valleys, and foothills over much of the Western United States (eastern Washington south to southern California and east to western Wyoming and northwestern New Mexico) at elevations ranging from 2,500 to 6,900 ft (760 to 2,100 m) (Blauer and others 1976; Collotzi 1966; Shaw 1992). It generally grows on well-drained soils of loamy to rocky or gravelly textures, but it may occasionally be found on clay soils. Soils usually range from neutral to alkaline; its adaptation to salinity may vary ecotypically (McArthur and others 1978b; Shaw1992; Stark 1966). It often grows in soils high in calcium (McArthur and others 1978b).

Spiny hopsage may occur in pure stands but more often is a component of communities dominated by other shrub species (Shaw 1992). It occurs in both sagebrush and salt desert shrub communities in association with Wyoming and basin big sagebrush, blackbrush, black greasewood, shadscale, winterfat, and pinyon and juniper species (Sampson and Jespersen 1963; Welsh 1984).

Plant Culture

Seed production is highly variable between years, populations, and individual plants. During favorable moisture years some shrubs produce large quantities of fruits, but during dry years few flowers or fruits are produced (Shaw 1992). Under warehouse conditions seed maintains viability up to 6 years (Shaw 1992; Smith 1974a). Kay and others (1984) demonstrated that seed life can be extended by drying seed at 35 °C (95.0 °F) for 6 days and storing them in glass jars with a desiccant at room temperature. This procedure has maintained full seed viability for over 9 years.

Viable seeds germinate rapidly. For field establishment late fall seeding is best because moisture levels are high (Shaw and others 1994). Bracts of spiny hopsage are probably important for seed dispersal and seedling establishment (Shaw and others 1996). In some cases, however, removal of the bracts may be preferred for seeding depending on the equipment used. Most drills are unable to seed the large fruits unless seeded alone.

Young seedlings grow quite rapidly but become dominant during the early summer. The plant often grows without an understory of herbs, and the shrub seedlings are not highly competitive with herbs. To be successful, seedlings must be made in prepared seedbeds free of competition. Small seedlings are vulnerable to weedy annuals.

Broadcast seedings have erratic success. Natural seeding is episodic; success depends on the availability of soil water (Shaw and others 1994). When hand seeded in pits or favorable sites and covered with soil, moderate success has been achieved. Rodents appear to forage upon young seedlings, but the extent of their damage is not fully understood. When seeded with herbs, small seedlings emerge and survive until about midsummer. Seedlings then appear to become dormant, yet few recover the following season.

Field grown transplants also demonstrate early summer dormancy even when irrigated. However, greenhouse reared stock do not senesce prematurely. Field survival of bare root transplants have been satisfactory when planted on mine disturbances and native sites. Neither container or bare root stock do well when planted offsite.

Uses and Management

Spiny hopsage is a valuable forage for livestock and game from early May to midsummer while foliage persists. It receives little use during its dormant period (McArthur and others 1978b; Sampson and Jespersen 1963; Welsh 1984). Spiny hopsage furnishes good cover for upland game in all seasons. The plant has potential for use in revegetation but has received little use in that capacity. Glazebrook (1941), Wood and others (1976), and Kay and others (1977c) have all recommended its use for rehabilitation plantings. However, additional work on site requirements is needed to better assure artificial seeding success.

Varieties and Ecotypes

No improved varieties have been developed. Spiny hopsage is, however, composed of numerous ecotypes. Use of these for various management purposes and genetic improvement should both be possible. The species is known only at the tetraploid (4x) level (Sanderson and Stutz 1994b).

Kochia americana ________________

Gray Molly

Gray molly is a small, woody-based subshrub to 20 inches tall (50.8 cm) (fig. 14). Its numerous, annual, erect branches and leaves are covered with long, silky hairs. The linear, fleshy, more or less terete leaves are 5 to 30 mm long. Hairy perfect or pistillate flowers are borne singly or in small clusters in the axils of leaves along almost the full length of the branches. At anthesis, the hooded calyx lobes are about 1.5 mm long and closely cover the ovary. At maturity, the fruit is largely concealed in the persistent calyx, which develops conspicuous, horizontal, fanlike papery wings to 3 mm long. This species blooms from June to August (Blauer and others 1976).

Gray molly usually occurs in saline or alkaline clay on plains and foothills between 4,500 to 6,000 ft (1,400 to 1,800 m). Its range extends from southern Montana and eastern Oregon to New Mexico and California. Gray molly summer cypress is quite widely

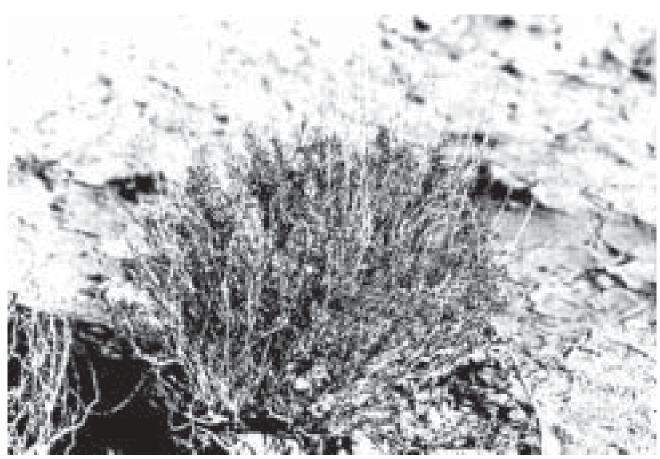


Figure 14—Gray molly growing near Faust, Tooele County, UT.

used as winter forage by livestock when it is sufficiently abundant (Blauer and others 1976). It appears to have usefulness in revegetation of areas with a high salt concentration.

Varieties and Ecotypes

Both diploid (2x) and tetraploid (4x) populations are known to exist but their characteristic differences, if any, are poorly understood (Sanderson and McArthur, n.d.; Sanderson and Stutz 1994b).

Kochia prostrata ________________

Forage Kochia

Forage kochia is generally a long-lived, highly variable, woody-based subshrub (fig. 15). However, some ecotypes may be definite upright shrubs. It ranges from less than 12 inches to over 40 inches (30.5 to 101.6 cm) in height. Ascending branches are covered with short to long woolly hairs. Leaves are flat, linear to filiform, and hairy. Flowers are borne in small clusters (glomerules) in the axils of slightly reduced leaves on the upper part of the stem. As the fruit develops, the calyx forms dorsal appendages around it that are rounded, flat, and tuberclelike, or oblong and winglike (Shishkin 1936). Blooming occurs from July to September (Blauer and others 1976).

Ecological Relationships and Distribution

Forage kochia is native to arid and semiarid regions of central Eurasia extending to the Mediterranean basin and northeastern China. It grows on alkaline, stony, and sandy steppes and plains (Francois 1976; Shishkin 1936). Forage kochia tends to be evergreen. Seeds of accessions from several types including both subspecies of forage kochia were introduced into the United States during the 1960's (Keller and Bleak 1974). The species is well adapted to the climate and soils of the Intermountain area. This is especially so for the pinyon-juniper, sagebrush, and salt desert shrub communities (Blauer and others 1976; Keller and Bleak 1974; McArthur and others 1974; Stevens and others 1985a). It grows at elevations in its native range from 0 to 8,000 ft (0 to 2,400 m) (Balyan 1972; McArthur and others 1974).

Figure 15—Forage kochia growing on a roadcut near the mouth of Salina Canyon, Sevier County, UT.

Plant Culture

Seed, under uncontrolled storage conditions, loses viability rapidly in about 6 months (Balyan 1972; Jorgensen and Davis 1984). Seed viability can be maintained up to 4 years by drying seed to 7 to 9 percent moisture levels and storing in airtight containers (Balyan 1972; Jorgensen and Davis 1984; Young and others 1981c).

In seeding forage kochia, best results occur when the seed is surface sown and not covered (Stevens and Van Epps 1984). Aerial seedings have been successful. Seeding at a rate of 0.25 lb (PLS) per acre (0.28 k/ha) is usually sufficient. If drilled, seeds should be no deeper than 1⁄16 inch (1.6 mm) (Stevens and others 1985a). The species can be transplanted with good results in spring or fall when the ground is moist. Once established forage kochia is a good natural spreader. In concentrated stands, forage kochia attracts large populations of lygus bugs, but such concentrations do not occur in mixed plant communities (Moore and others 1982).

Uses and Management

In its native habitat, forage kochia is a drought-resistant, salt-tolerant species and is highly valued as a forage plant (Nechaeva and others 1977). The plant has high nutritive value with a high protein and carotene content (Balyan 1972; Davis 1979; Welch and Davis 1984). Forage kochia has its highest nutritive content in midsummer through fall when its crude protein and carotene levels are high (Davis 1979; Davis and Welch 1984). Frischknecht and Ferguson (1979), McKell and others (1979), and Ferguson and Frischknecht (1985) have shown forage kochia to be an effective mine spoil stabilizing plant. Sheep, goats, camels, and horses all consume it (Shishkin 1936). In Utah this species is sought out by mule deer. Davis and Welch (1985) showed some accessions are more palatable to mule deer than others. Forage kochia readily establishes from seed and grows rapidly, and under favorable conditions, reaches sexual maturity in 1 year (McArthur and others 1974). It spreads well, naturally, from seed. It is a useful component in shrub-grass pastures (Otsynia and others 1984). Once established, forage kochia will compete with annuals such as halogeton and cheatgrass (McArthur and others 1990a; Monsen and Turnipseed 1990; Stevens and McArthur 1990; Stevens and others 1985a). One desirable characteristic for competing with cheatgrass is its fire tolerance (McArthur and others 1990a).

Forage kochia shows considerable potential for becoming a valuable forage and cover plant on arid Western ranges. In arid shrublands, it is among the most desired species to seed. Concern over possible poisonous properties is unnecessary (Davis 1979; Williams 1980). Russian workers have been seeding forage kochia on ranges since 1921 (Balyan 1972).

Ecotypes and Varieties

Although forage kochia is not native to North America, it is well adapted to many areas in Western North America (McArthur and Stevens 1983; Stevens and others 1985a). A near relative, *Kochia americana*, is widespread but less robust and aggressive than *K. prostrata* (Blackwell and others 1978; Blauer and others 1976).

Forage kochia comprises two subspecies and two varieties with separate habitat preferences (Balyan 1972):

Clay habitats; *Kochia prostrata*	ssp. *virescens* (green)
Sandy habitats; *Kochia prostrata*	ssp. *grisea* (grey) var. *canescens* (densely pubescent)
Solonetzes (salty clay soils)	var. *villosocansa* (white-villous)

Each of the above taxa has a relatively wide tolerance to soil types; however, in general, the green subspecies (ssp. *virescens*) grows best in clay soils. It has both mountain and lowland ecotypes (Balyan 1972). Variety *canescens* of the grey subspecies (ssp. *grisea*) is adapted best to sandy habitats, whereas variety *villosocansa* is best adapted to salty clay soils (Balyan 1972).

The species is a polyploid complex based on $x = 9$ with diploid, tetraploid, and hexaploid populations (Davis and Welch 1985; Herbel and others 1981; Pope and McArthur 1977). One selection, 'Immigrant', has been released (Stevens and others 1985a). This selection (ssp. *virescens*), originally from Stavrapol Botanical Gardens in Russia, has shown superior performance in longevity, forage production and quality, palatability, and competitiveness with annuals. It is adapted to sandy loam to heavy clay soils with best adaptation to heavier soils. 'Immigrant' has demonstrated its adaptability to the pinyon-juniper, basin and Wyoming big sagebrush, and greasewood-shadscale shrub vegetative types. McArthur and others (1996) recently confirmed the outstanding performance of 'Immigrant' forage kochia in an adaptation and performance test across an environmental gradient. Another accession (ssp. *grisea*) also performed well.

Sarcobatus vermiculatus ________

Black Greasewood

Black greasewood is an erect, spiny-branched shrub up to 10 ft (3.0 m) tall (fig. 16). The deciduous, bright-green leaves 1 to 4 cm long are usually narrowly linear and often semi-terete. The shrub is usually monoecious.

Black greasewood had traditionally been considered as a member of the chenopod family. However, recent studies on chloroplast DNA and sieve element plastids provide evidence that it should be separated from that family (Behnke 1997; Downie and others 1997). Behnke (1997) reviews the taxonomic history of *Sarcobatus* and concludes that this genus is distinct enough to merit its own family, Sarobataceae. We have included it here because of its traditional place in the Chenopodiaceae.

Ecological Relationship and Distribution

Black greasewood grows from Alberta south into Mexico with stands occurring in all the Western States. A smaller species, Bailey greasewood (*Sarcobatus baileyi*), occurs in western Nevada in association with shadscale and other desert shrubs. Shadscale often grows with black greasewood as well. In the more saline areas of its range, black greasewood may be found in nearly pure stands. On such sites, minor components of shadscale, Castle Valley clover saltbush, and Gardner saltbush may occur. In less saline areas, it may grow with threadleaf and whitestem

Figure 16—Black greasewood growing near Tuba City, Coconino County, AZ.

rubber rabbitbrushes, spiny hopsage, basin big sagebrush, fourwing saltbush, winterfat, black sagebrush, and broom snakeweed. Greasewood often occurs in valley bottoms where subsoil moisture is high. Often inland saltgrass, alkali sacaton, Nuttall alkaligrass, alkali muhly, and basin wildrye grow with black greasewood, they may form grassy understories. Russian wildrye, tall wheatgrass, and quackgrass have been successfully planted into black greasewood stands to make these stands more versatile grazing areas (McArthur and others 1978b).

Plant Culture

Like other chenopod shrubs, black greasewood produces erratic seed crops that usually have low viability. Seed is more difficult to collect because of the spiny, brittle nature of the stems. Poor seed quality has decreased planting success. Seeds ripen in the fall and respond best to fall or winter seeding. Establishment by natural or artificial seeding is unpredictable. Seeding with grasses is not recommended unless the shrub can be seeded in separate rows.

Black greasewood often exists on sites with clay-textured surface soils. Soils compact and crust easily, often reducing seedling survival. Black greasewood has done well when seeded or transplanted on mine disturbances. Under these conditions it establishes well on fresh exposures and infertile soils. It competes well with herbs under these circumstances unless the sites are fertilized heavily.

Uses and Management

Black greasewood contains soluble oxalates that will sicken and kill hungry livestock that consume large amounts of the foliage (Kingsbury 1964). However, where there is a good assortment of other species, this danger is negligible. It is often eaten by livestock (sheep and cattle) and wildlife in the spring. It is usually not regarded as an important forage plant although it furnishes cover and habitat. It is especially important on sites that flood, and it forms an important zone within various riparian habitats. It is highly important as cover to upland game birds and big game animals. Sites that are burned, disked, or plowed and seeded to herbs receive heavy use. When seeded on mine and related disturbances, the shrub is often heavily grazed.

Varieties and Ecotypes

Black greasewood exhibits considerable variation both in natural stands and plantations. Roos (1984), in a study involving 18 populations, concluded that *Sarcobatus vermiculatus* was rich in genetic variation. Sanderson and others (1999) have documented an interesting distribution of chromosome races in *Sarcobatus*. *Sarcobatus vermiculatus*, black greasewood, is widely distributed in Western North America (fig. 1). Tetraploid ($x = 9$, $4x$ populations) occur only on the periphery of the distributional range to the north (southern Alberta, southern Manitoba, northern Montana, eastern North Dakota), to the west (northeastern and east-central California and south-central Oregon), and to the south (southern Arizona and northwestern Sonora). Throughout the rest of the species vast range including the central portion of that range, *S. vermiculatus* is octoploid (8x). It is apparently an old plant; no diploids are known (Sanderson and Stutz 1994b; Sanderson and others 1999). *Sarcobatus baileyi* is dodecapoid (12x) throughout its more limited range (western and south-central Nevada) (Sanderson and Stutz 1994b; Sanderson and others 1999).

Other Chenopod Shrubs

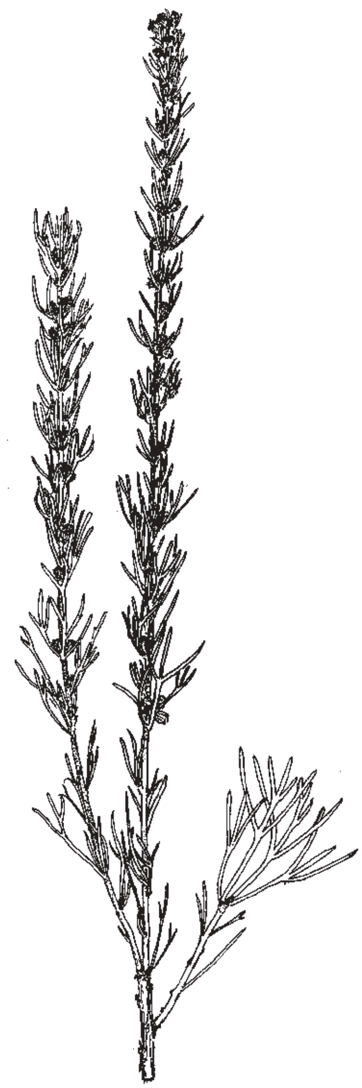
Allenrolfea occidentalis (iodine bush), *Camphorosoma monspeliaca* (Mediterranean camphorfume), *Suaeda torreyana* (desert sumpbush or desert blite)

Iodine bush and desert sumpbush are two species that grow in areas where salt concentrations are so high that they are the only forms of higher plant life that survive (McArthur and others 1978b). In so doing, they provide a valuable soil-binding service. Perhaps these species could be used more for rehabilitation work. Another species, an introduction from Eurasia, Mediterranean camphorfume, has been shown to be useful in rehabilitating mine spoil materials (Ferguson and Frischknecht 1985). This species is similar in growth habit to forage kochia, and like forage kochia, it is a useful forage plant in south-central Asia (Nechaeva and others 1977).

E. Durant McArthur
Richard Stevens

Chapter 21

Composite Shrubs



The sunflower family (Compositae or Asteraceae) is the largest family of flowering plants. Its many species occur around the world as annual and perennial herbs and as shrubs and trees (Benson 1957; Cronquist 1968; Wagenitz 1977). Three shrubby genera of the family—sagebrush (*Artemisia*), rabbitbrush (*Chrysothamnus*), and matchbrush (*Gutierrezia*)—make plants of this family among the most common and important plants of the Intermountain area (McArthur and others 1979a; table 1). Shrubs of these genera provide critically needed ground cover on arid Western ranges, are important sources of browse for domestic livestock and big game, and serve as cover and forage for many wildlife species. A number of sagebrush and rabbitbrush species are important as cover for small birds, game birds, and mammals, and as browse plants for big game animals, especially on winter and early spring ranges. Some species also provide forage for livestock (sheep and cattle). Horsebrush and matchbrush also contribute more forage than is generally believed; however, both plants may, under certain conditions, be harmful to domestic livestock (Benson and Darrow 1945; Johnson 1974a; McArthur and others 1979a) and cause allergies in humans (Lewis and Elvin-Lewis 1977; Rodriguez and others 1976).

Chapter Contents by Species

Various forms of sagebrush and rabbitbrush may also be directly seeded or transplanted for landscaping, stabilizing, and beautifying disturbed landscapes and may have potential for supplying industrial chemicals. Young wildings of both sagebrush and rabbitbrush transplant easily. Usually within 3 to 7 years, direct seeded or transplanted plants are established sufficiently to reproduce naturally from seed. Both establish well when properly aerially or drill seeded (McArthur and others 1974; Plummer 1977; Plummer and others 1968).

In this chapter, we prefer to limit the term sagebrush to members of the subgenus *Tridentatae* (McArthur 1979; McArthur and others 1981). Other woody members of the genus *Artemisia* then become “sage” or “wormwood.” However, in the broad sense in this chapter, use of sagebrush alone may refer to any woody, native North American *Artemisia* species.

Sagebrush and rabbitbrush species that are especially important on low elevation Intermountain area ranges include big sagebrush (*A. tridentata*), black sagebrush (*A. nova*), threetip sagebrush (*A. tripartita*), low sagebrush (*A. arbuscula*), budsage (*A. spinescens*), fringed sage (*A. frigida*), sand sage (*A. filifolia*), early sagebrush (*A. longiloba*), rubber rabbitbrush (*C. nauseosus*), low rabbitbrush (*C. viscidiflorus*), Greene’s rabbitbrush (*C. greenei*), spreading rabbitbrush (*C. linifolius*), and Parry’s rabbitbrush (*C. parryi*). Some of these species, for example, threetip sagebrush and Parry’s rabbitbrush, are usually found on ranges at higher elevations than the others.

Virtually all of these species include an array of ecotypes. Some are large taxonomic units that include several subspecies (big sagebrush, rubber rabbitbrush, low rabbitbrush, and Parry’s rabbitbrush) (McArthur and others 1979a). These shrubs, especially under conditions of heavy grazing, may form closed stands. However, in many locations they mix with grasses and forbs. Big sagebrush often occurs with the grasses, bluebunch wheatgrass, western wheatgrass, the

Table 1—Important Composite shrubs of the Intermountain area.

Common name	Scientific name
Oldman wormwood[a]	*Artemisia abrotanum*
Low sagebrush	*Artemisia arbuscula*
Bigelow sagebrush	*Artemisia bigelovii*
Silver sagebrush	*Artemisia cana*
Sand or oldman sage	*Artemisia filifolia*
Fringed sage	*Artemisia frigida*
Longleaf sage	*Artemisia longifolia*
Alkali sagebrush	*Artemisia longiloba*
Black sagebrush	*Artemisia nova*
Birdsfoot sage	*Artemisia pedifida*
Pygmy sagebrush	*Artemisia pygmaea*
Stiff or scabland sagebrush	*Artemisia rigida*
Budsage	*Artemisia spinescens*
Big sagebrush	*Artemisia tridentata*
Threetip sagebrush	*Artemisia tripartita*
Alkali rabbitbrush	*Chrysothamnus albidus*
Dwarf rabbitbrush	*Chrysothamnus depressus*
Spreading rabbitbrush	*Chrysothamnus linifolius*
Greene's rabbitbrush	*Chrysothamnus greenei*
Rubber rabbitbrush	*Chrysothamnus nauseosus*
Parry rabbitbrush	*Chrysothamnus parryi*
Vasey rabbitbrush	*Chrysothamnus vaseyi*
Low rabbitbrush	*Chrysothamnus viscidiflorus*
Small headed matchbrush	*Gutierrizia microcephala*
Broom snakeweed	*Gutierrizia sarothrae*
Gray horsebrush	*Tetradymia canescens*
Littleleaf horsebrush	*Tetradymia glabrata*
Nuttall horsebrush	*Tetradymia nuttallii*
Spiny horsebrush	*Tetradymia spinosa*

[a]Introduced species.

introduced crested wheatgrasses and desert wheatgrasses, and intermediate wheatgrasses, Idaho fescue, sheep fescue, Indian ricegrass, Sandberg bluegrass, Thurber needlegrass, bottlebrush squirreltail, and others.

A rich array of forbs also grow in the sagebrush-grasslands, including species of aster, lupine, locoweed or milkvetch , balsamroot, Agroseris, wild buckwheat, and goldenrod. Sagebrush species are the dominant and codominant species of over 40 described habitat types of the American West (Blaisdell and others 1982). Passey and others (1982) published a classic study on sagebrush habitats of the Intermountain West. Their statement of the importance of sagebrush:

> Opinions differ among plant scientists as to the place of sagebrush in plant communities on semiarid rangelands (Ellison 1960). Historical accounts of the amount and distribution of sagebrush are also often contradictory. As noted, the relative amount and distribution of sagebrush species or subspecies have been observed and evaluated on the several hundred tracts examined in this study. One or more species of sagebrush were present on every area examined except where there was unmistakable evidence of recent burning, tillage, or mechanical or chemical treatment. Many of these observations were made on rangelands where the plant community was judged to be in near-climax condition. Some areas, in fact, had no evidence of use or disturbance of any kind except by native fauna. On all study sites supporting subspecies of big sagebrush, annual growth rings of the largest stems were counted to determine the age of the plants and to establish the length of time during which there had been no fires. The oldest plants found were about 120 years old, and several locations supported plants at least 100 years old. Many of the older plants had split and nearly decayed stems on which the growth rings could not be accurately counted; so some plants may have been even older. With few exceptions, the oldest (not necessarily the largest) plants grew on stony or gravelly soils, and were of the Wyoming big sagebrush subspecies. On disturbed relic areas, subspecies of big sagebrush typically grew in open stands with individual plants or small clumps of plants uniformly distributed. Where it grew, big sagebrush made up five to 20 percent of the total annual production on the study site.

Woody *Artemisia*, called wormwood in North Africa and Eurasia, are principal components of the steppes of those regions. There (Larin 1956), as in North America (Blaisdell and others 1982; Laycock 1979; McArthur and Plummer 1978), many range managers regard them as a mixed blessing. They are aggressive and increase on overgrazed land; on the other hand, they provide much forage for wildlife and domestic animals. This group of plants (*Artemisia*) may number 400 species and is divided into four subgenera based on floral, anatomical, chemical, karyotypical, and distributional characteristics (McArthur 1979; McArthur 1983b; McArthur and others 1981; table 2). Rabbitbrushes are equally as widespread as sagebrush (= N. American *Tridentatae*) but are generally less dominant (McArthur and Meyer 1987). There are 17 rabbitbrush species with 40 subspecies divided into five sections (table 4).

Seed of most composite shrubs can be collected by hand stripping, beating into a container, and, in some cases, with vacuum harvesters (chapter 24). For seed to pass through most seeders, plumes and other flower parts need to be partially removed. This can be done by passing the seed through a barley debearder followed by screening and fanning. Seeds are rather brittle; consequently, care must be taken to ensure that they are not cracked or broken during cleaning and seeding. Seed of most composites can be stored no more than 1 to 3 years before seeding—otherwise, considerable viability will be lost (Stevens and others 1981a).

A principal trait of sagebrush and rabbitbrush is the ability to persist under heavy abuse and poor management, and yet, be able to recover with proper management. Few other shrubs can recover in a reasonable period without special management, including seeding. Most plants of this group can compete with weedy herbs, and many species occupy arid sites where few other shrubs persist.

Important characteristics of a number of composite shrubs are listed in the Introduction to section VII. Seeding recommendations for principal vegetative types and conditions are discussed in chapter 17. Composite shrubs adapted to these vegetative types and conditions are included in the seeding recommendations. Seed characteristics are found in chapters 24 and 26.

We include in this chapter a brief species description, ecological relationships, distribution, culture requirements, use, improved varieties, and management of each of the species appearing in the chapter contents list.

General Sagebrush Culture

Intermountain sagebrush species all have small seed (see chapter 24). The smallest seeds are those of fringed sage, with over 4.5 million seeds per lb (9.9 million per kg) (100 percent purity). Pygmy sagebrush has relatively large seeds with about 500,000 per lb (1.1 million per kg). In big sagebrush, seed size varies among subspecies. Basin big sagebrush has just over 2.5 million seeds per lb (5.5 million per kg), Wyoming big sagebrush just under 2.5 million (5.5 million per kg), and mountain big sagebrush has about 2 million (2.2 million/kg). Seed size, no doubt, influences the depth at which seeds should be planted. Seed of most sagebrush species should not be planted deeper than 1⁄16 inch (1.6 mm). Good results can be obtained when seeds are broadcast on top of disturbed soils and not covered.

Adequate covering usually occurs from natural soil sluff. Sagebrush seed can be placed on top of the seedbed using drills that have had their seed drops or tubes pulled out between the disk-furrow opener and placed behind. Seeds then drop on the soil disturbed by the disk furrow openers. Several effective methods of planting sagebrush seed include broadcasting (aerial or by ground rigs), and placing through a seed dribbler, thimble seeder, or browse seeder onto disturbed soil. Drill seeding is a low priority option.

Table 2—Taxonomic subgenera of *Artemisia* (McArthur and others 1979a).

Classical section[a]	Modern subgenera[b]	Distinguishing characteristics	Distribution	Species mentioned in this chapter
Absinthium	Artemisia	Pistillate ray flowers perfect disc flower, predominantly herbaceous, but	Eurasia North Africa North America	*A. abrotanum* *A. absinthium* *A. frigida*
Abrotanum		a few are woody		*A. longifolia* *A. ludoviciana*
Drancunculus	Drancunculus	Pistillate ray flowers staminate disc flowers herbacious and woody.	Eurasia North America	*A. filifolia* *A. pedatifida* *A. spinescens*
Seriphidium	Seriphidium	Ray flowers lacking, perfect disc flowers; herbaceous and woody.	Eurasia, North Africa[d]	
	Tridentatae	Ray flowering lacking, perfect disc flowers, woody.[c]	North America	*A. arbuscula* *A. argillosa* *A. bigelovii* *A. cana* *A. longiloba* *A. nova* *A. pygmaea* *A. rigida* *A. rothrockii* *A. tridentata* *A. tripartita*

[a]De Candolle 1837; Hooker 1840; McArthur and Plummer 1978; McArthur 1979.
[b]Rydberg 1916; Beetle 1960; Polyakova 1961; McArthur 1979; McArthur and others 1981.
[c]The single exception, *A. bigelovii*, has zero to two pistillate ray flowers on otherwise discoid heads.
[d]Two anomalous American species have been referred to Seriphidium: *A. palmeri* of southern and Baja California and *A. mendozana* Argentina.

Seeding sagebrush with most ground equipment requires that the seed be cleaned to at least 60 percent purity. Most sagebrush seed is collected between 10 to 15 percent purity. To increase purity, the collected material is run through a hammermill or barley debearder followed by fanning and screening. Barley debearders are preferred (Booth and others 1997; Welch 1995). Hammermills tend to ball up the collected materials, rendering it almost impossible to seed mechanically.

As seed purity increases, volume of material decreases. Seed cleaned to more than 30 percent purity requires being mixed with a carrier such as rice hulls or screened sawdust. Range seeders and drills are not equipped to handle seed the size of sagebrush seed. Small seed size requires that volume of material be increased to help ensure proper seed metering. Plant materials and floral parts that are collected with sagebrush seed will not flow through and will plug most ground rig seeding devises.

Most sagebrush seed matures and is dispersed October through December. This is also the most ideal time to seed. We do not recommend spring seedings. Sagebrush seedlings are susceptible to frost damage and are intolerant of short drought. Many sagebrush seedlings that establish are located in, under, and next to downed and dead plant materials and next to rocks—all areas that provide some protection from adverse climatic conditions and grazing animals. When seeding sagebrush in a mixture with other species through ground equipment, we recommend that sagebrush seed be separated in the seeding device from seed of more competitive species (those with strong seedlings and fast rate of growth; most grasses fall in this group). Individual compartments in drill seed boxes can be constructed with cardboard partitions and duct tape. This will allow sagebrush and compatible species to be seeded separately but at the same time as seeding the noncompatible species another compartment. Seeding sagebrush aerially generally results in the seed of the various species in the mixture being separated so they are not in competition with each other.

When dried and stored in an open, untreated, uncooled warehouse, seed of most sagebrush species will retain good viability for up to 3 years following collection (Stevens and others 1981a).

Most sagebrushes transplant well. When standard bareroot and container stock handling, planting, site condition, requirements, principles, procedures, and methods are followed, excellent establishment success can be expected (Richardson and others 1986; Stevens and others 1981b).

A majority of sagebrush seed is hand collected by stripping or beating the seed into some type of container. Seed of some species can be collected with a mechanical seed stripper.

Artemisia abrotanum

Oldman Wormwood

Oldman wormwood, also called southernwood, is a shrub 1.5 to 6 ft (0.5 to 1.8 m) tall (Grieve 1931; Hall and Clements 1923; Plummer 1974b). Stems are much branched, erect or somewhat spreading, and form a rounded bush (fig. 1). The species has a pleasing aromatic fragrance and bright green, finely divided, pinnately dissected leaves giving the shrubs a feathery appearance. It has a deep and extensive root system allowing the plant to obtain nutrients and water from considerable distances (Plummer 1974b). This characteristic also allows the plant to establish in raw subsoils. Principal leaves are 3.0 to 6.1 cm long, two or three times pinnately dissected with revolute margins, glabrous or sparsely puberulent on upper surfaces, but lightly tomentulose on the lower surfaces (Hall and Clements 1923). The inflorescence is an elongated terminal panicle, leafy at the base, 6 to 15 inches (15.2 to 38.1 cm) long and 1.5 to 6 inches (3.8 to 15.2 cm) broad. Heads are heterogamous, short

Figure 1—Oldman wormwood plants growing from stem cuttings along Ephraim Canyon Road, Sanpete County, UT.

peduncled, and nodding, and are about 2.0 to 2.5 mm high, 2.5 to 3 mm broad. There are five to 15 ray flowers with 1.5 mm long corollas and 10 to 20 five-toothed disk flowers with campanulate corollas, 1.5 to 2 mm long. There are eight to 18 bracts. The receptacle is naked.

Ecological Relationships and Distribution

Oldman wormwood is native to the Mediterranean areas of Europe, Asia, and Africa (Hall and Clements 1923). Its alternate common name, southernwood, distinguishes it from common wormwood (*A. absinthium*). The latter is common and adapted in northern Europe including Great Britain, whereas oldman wormwood was recognized as an introduction in these areas (Grieve 1931). In Britain, oldman wormwood rarely flowers, perhaps because of the high latitude. In North America, the plant is occasionally adventive in the Eastern United States as a garden escape. In the Intermountain area, however, it occurs only where it has been planted. Few viable seeds are produced and only rarely are seedlings found (Plummer 1977). A dwarf form, var. *nana* 1 ft (30.5 cm) tall, and another regular sized ecotype have long been maintained by the USDA-ARS High Plains Research Station at Cheyenne, WY. Although seed production remains rare, a higher frequency of viable seed production has occurred with these additional plant genotypes growing in proximity to the formerly near sterile ecotype. This suggests that outcrossing facilitates seed production in oldman wormwood. It can be established by cuttings in many soil types including raw subsoils in various vegetation types big sagebrush to the subalpine, 5,000 to 10,500 ft (1,500 to 3,200 m) elevation, 12 to 40 inches (30.5 to 101.6 cm) precipitation (Plummer 1974b, 1976, 1977). It can tolerate moderately alkaline to moderately acidic soils (Plummer 1974b). Although this species is adapted to subsoils such as roadcuts it is not universally adapted to mine disturbances. Plants are apparently sensitive to heavy metals or other mine waste materials. Plants have not persisted more than 5 years on acidic soils of the Idaho Batholith (Monsen, unpublished).

Plant Culture

This species is, in essence, maintained vegetatively in the Intermountain area. It is easily propagated by stem cuttings. The process for establishing the plant in a nursery or in outplantings is the same. Place cuttings in the ground in spring when and where soil is moist. Plummer (1974b) gave instructions for cuttings. Stems 10 to 18 inches (25.4 to 45.7 cm) and up to 0.5 inch (12.7 mm) in diameter give good results. Smaller cuttings root well but are difficult to stick in the ground. For best results, leaves and small twigs should be removed from the cuttings. Sharpening the large end of the cutting will facilitate penetration of a hard soil surface and minimize damage to the cuttings. The cuttings perform best if planted within 48 hours after being taken. However, cuttings have rooted after 6 weeks in cold storage (32 to 40 °F; 0 to 4.4 °C). Cuttings should be kept moist and cool until planted. In general, roots are forming and new buds leafing out about 2 weeks after planting. Plants should be placed about every 2 to 4 ft (0.6 to 1.2 m) for good stands. Nursery plants remain vigorous and disease-free for years (Nelson and Krebill 1981).

Uses and Management

Oldman wormwood is useful for stabilizing subsoil sites (Plummer 1974b, 1977). Its deep extensive root system makes the plant especially useful for erosion control. Plants placed in staggered rows about 2 to 4 ft (0.6 to 1.2 m) apart make good ground cover. It is especially useful on steep sites such as roadcuts and fills. On such sites, new roots are produced on freshly covered stems with each earth movement, thus providing additional stabilization. This species is useful as a nurse crop in that it helps stabilize and modify raw soils so that natural invasion of plant materials from the surrounding areas can occur. Individual plants may persist for 15 to 25 years or more, but eventually they will go out without reproducing themselves. By that time, however, they have usually served their purpose. Plants are consumed by small animals (at times girdling the bark under snow) and insects, but are not often eaten by large animals. Plants do provide excellent cover for upland game species. Formerly the plant was much used in herbal medicine as a tonic, anthelmintic, emmenagogue, and antiseptic (Grieve 1931). It is also used in ornamental plantings (Hall and Clements 1923; Plummer 1974b).

This plant requires little management. Nurseries can be maintained as a source of cutting stock with only routine maintenance. Occasional weed control and supplemental water on dry sites is all that is required. At outplanting sites where the plant has been put in to help with soil stabilization no care is necessary. These sites, however, often provide additional cutting stock.

Varieties and Ecotypes

Two varieties exist, the common one (var. *abrotanum*) and a dwarf one (var. *nana*). We know of no plant improvement work or ecotype comparisons. The common variety is best, in most cases, for raw soil stabilization planting because of its more vigorous growth.

Artemisia arbuscula ______________

Low Sagebrush

Low sagebrush (fig. 2) is a low spreading, irregularly branched shrub up to 20 inches (50.8 cm) high. The slender, erect twigs are densely canescent but may become nearly glabrous and thus darker green in late summer. The plant layers infrequently. Leaves are broadly cuneate, or fan shaped, 0.5 to 1.5 cm long, 0.3 to 1 cm wide, and are usually three-toothed (occasionally four to five in ephemeral leaves) or cleft at the apex (fig. 3). Leaves on the upper part of the flowering shoots may become entire. Flowerheads are grouped into elongated, narrow racemose panicles. The heads usually contain five to 11 disc flowers with corollas 3 to 4 mm long. The 10 to 15 involucral bracts are canescent. Flowering occurs August to September, depending upon strain and elevation. Seed ripens in October and November (McArthur and others 1979a).

Figure 3—Two subspecies of low sagebrush: (A) *A. arbuscula* ssp. *arbuscula*; (B) *A. arbuscula* ssp. *thermopola* (Shultz 1986).

Ecological Relationships and Distribution

Low sagebrush grows on dry, sterile, often rocky and alkaline, usually clay, soils between 2,300 and 11,500 ft (700 and 3,500 m) on approximately 39,112 mi^2 (101,300 km^2) in 11 Western States (Beetle 1960; McArthur and Plummer 1978; Ward 1953). In the warmer, drier parts of its range, particularly in southwestern Utah and Nevada, it may grow well into the mountains above 9,800 ft (3,000 m). In some areas, for example, east-central Idaho, low sagebrush occurs on disjunct low and high elevation bands (McArthur and others 1979a). Low sagebrush ranges from southern Colorado to western Montana and west throughout Utah and Idaho to northern California, Oregon, and Washington. Normally its sites are drier and more rocky than those on which big sagebrush occurs. It may grow in mosaics with big sagebrush where each is confined to a particular soil type. Low sagebrush and black sagebrush only rarely occur in intermixed stands, for example, Lost River-Lemhi Range area of Idaho (McArthur and others 1979a). In areas where the distribution of these two species overlap, low sagebrush is usually found in the more moist habitats or at slightly higher elevations than black sagebrush (Tisdale and Hironaka 1981; Ward 1953; Zamora and Tueller 1973).

Figure 2—Low sagebrush growing on shallow, stony soil in Logan Canyon, Cache County, UT.

Plant Culture

Plants can be established on adapted sites by direct seeding, broadcasting, and drilling. Seeding should be conducted in the fall on disturbed soil. Care must be taken to ensure that seeds are not covered more than $\frac{1}{16}$ inch (1.6 mm). Wildings of this species can be transplanted in the spring or fall. Experimental nursery plantings have successfully reproduced. Plants of low sagebrush established at the Snow Field Station were more vigorous than most other sagebrush plantings there (Nelson and Krebill 1981). Plants establish well by direct seeding. Seedlings emerge rapidly and grow quickly, although few attain large stature at first. Roots develop rapidly, and plants are able to survive dry surface conditions. Low sagebrush recovers quickly after burning and other disturbances. It persists and invades sites seeded to perennial grasses. It expresses good seedling vigor and can be seeded with herbs. Seeds should be planted at a shallow depth with a firm seedbed. Seed lots of low sagebrush usually contain less inert or floral materials than processed seed lots of big sagebrush. Thus, seeds can be more easily planted. Seed of low sagebrush is more difficult to collect than the more robust big sagebrush. Seed prices are, thus, somewhat higher, and lower quality seed is often sold. Low sagebrush may often occur with little understory. When seeded with herbs, a mixed community normally develops, but the understory often weakens and recedes. The relationship with introduced and native herbs is not well understood.

Uses and Management

On winter ranges, and to a limited extent on summer ranges, low sagebrush is browsed by big game and livestock (Kufeld and others 1973; McArthur and others 1979a). Considerable variation exists in how animals browse it in different locations. In Nevada a gray-green form may be heavily browsed, while the green form is only lightly browsed (Brunner 1972). In addition to the direct browsing use of the plant, its communities are important as habitat for a wide range of domestic and wild animals (Dealy and others 1981). Low sagebrush grows on difficult sites and is, therefore, not often a candidate for manipulation. Because low sagebrush grows on exposed sites it is important to wintering animals. Few other shrubs are adapted to similar conditions. Consequently, maintenance of the species is often critical. Attempts to maintain low sagebrush on sites not similar to its origin have proven unsuccessful. Seedlings usually establish when planted "offsite," and plants may attain maturity. However, plants usually succumb after a few years with little or no regeneration.

Varieties and Ecotypes

We are not aware of any substantial plant improvement work on this species. There are numerous ecotypes (Brunner 1972; McArthur and others 1979a) and three subspecies (fig. 3a,b shows two of these subspecies). Low sagebrush can apparently hybridize with its *Tridentatae* relatives (McArthur and others 1979a). Beetle (1959, 1960) named a dwarf form hotsprings sagebrush. This form occurs in the Stanley Basin area of Idaho, Jackson Hole area of Wyoming, east-central Oregon, and perhaps other locations. Beetle speculated that this form arose as a result of hybridization between typical low sagebrush and threetip sagebrush. Another important low sagebrush is Lahonton low sagebrush (Winward and others 1986; Winward and McArthur 1995). This plant occurs in western Nevada. We believe that it is a stabilized hybrid between low and big sagebrush. The big sagebrush parent is probably Wyoming big sagebrush (Winward and McArthur 1995).

Artemisia bigelovii

Bigelow Sagebrush

Bigelow sagebrush is a low shrub 8 to 16 inches (20 to 40 cm) high with numerous spreading branches (fig. 4). It is also known as flat sagebrush (Hall and Clements 1923). The flowering stems are slender and erect and bear inflorescences that are long, narrow panicles with short, recurved branches (fig. 5). New growth is covered with a silvery-canescent pubescence. The leaves of vegetative branches are similar to those of big sagebrush. They are narrowly cuneate, 1 to 2 cm long, 2 to 5 mm wide, and normal tridentate, but may show various abnormal tips. The odor of crushed leaves is mild and pleasant. The heads are arranged into elongated, narrow panicles and normally contain one, but occasionally zero to two, ray flowers and one to three, usually two, disc flowers. The turbinate involucre consists of eight to 12 short, densely tomentose, bracts 2 to 4 mm long and 1.5 to 2.5 mm broad. Flowering occurs August to October. Bigelow sagebrush closely resembles, and is often mistaken for, low forms of big sagebrush produced by overgrazing. In contrast to big sagebrush, it has ray flowers. Furthermore, lobes of Bigelow sagebrush's vegetative leaves are always more shallow and more sharply dentate than those of big sagebrush (McArthur and others 1979a).

Figure 4—Bigelow sagebrush growing at the Snow Field Station. The ruler is 12 inches (30 cm) long.

Figure 5—Bigelow sagebrush (McArthur and others 1979a).

Ecological Relationships and Distribution

Bigelow sagebrush has a more southerly distribution than other sagebrushes. It is one of the most drought-resistant of the sagebrushes. It occurs over approximately 34,010 mi^2 (88,086 km^2) through western Texas, southern Colorado, New Mexico, Arizona, Utah, Nevada, and California in canyons, gravelly draws, and dry flats (fig. 6) from 3,000 to 7,900 ft (900 to 2,400 m) (Beetle 1960; Kearney and Peebles 1960; Ward 1953). This species is often found mixed with big sagebrush, black sagebrush, leafless green rabbitbrush, shadscale, and especially broom snakeweed. It is also characteristic in rocky soils of the southern portion of the pinyon-juniper woodlands (Hall and Clements 1923). Bigelow sagebrush is normally free of the common rust diseases and insect galls common on other *Tridentatae* taxa (Beetle 1960). However, in common with other *Tridentatae*, it is susceptible to a wilt disease (Nelson and Krebill 1981). Seedlings of Bigelow sagebrush spread well naturally. Seedlings grow rapidly and are robust and vigorous. Direct seeding of this shrub has been limited to experimental plantings. Where seeded, the shrub responds favorably and natural spread normally occurs around the parental plant. Plants appear to have good drought tolerance, even as young seedlings. Direct seeding should not be a handicap to the use of this species.

Plant Culture

Wildings can be successfully transplanted in the spring or fall. Nursery plantings successfully reproduce. Seedlings grow in the wild, suggesting that Bigelow sagebrush can be successfully direct seeded.

Uses and Management

Bigelow sagebrush is palatable to livestock and game in all areas where it occurs. Its twigs are less woody, the odor milder, and taste less bitter than most of the big sagebrush complex (Hall and Clements 1923). This species can withstand considerable browsing; generally more than other sagebrushes. However, the plants are usually scattered, and consequently, not an abundant forage source except for some large stands in the Four Corners area.

Varieties and Ecotypes

Ecotype variation has not been documented although it exists in chromosome races from 2x to 8x (McArthur and others 1981; McArthur and Sanderson 1999). Bigelow sagebrush occupies a taxonomic position between the true sagebrushes (subgenus *Tridentatae*) and the *Artemisia* (subgenus *Artemisia*) species. We have chosen to treat it as a member of the *Tridentatae* because of its characteristic growth habit, woody anatomy, leaf form, chromosomal karyotype, and RAPD molecular genetic markers (McArthur and others 1981; McArthur and others 1998a). The confusion arises because its flowers have zero to two ray flowers as well as the characteristic disc flowers of the *Tridentatae*.

Figure 6—Bigelow sagebrush, foreground, growing with fourwing saltbush in a gravelly draw near Bicknell, Wayne County, UT.

Artemisia cana

Silver Sagebrush

Silver sagebrush is an erect, freely branched, rounded shrub up to 5 ft (1.5 m) tall. Older branches have dark brown, fibrous bark while younger branches are covered with a dense white to yellowish-green tomentum. Leaves on the vegetative branches are 1 to 10 mm wide and 2 to 8 cm long, linear to linear-oblanceolate, entire or occasionally with one or two irregular teeth or lobes, silver-canescent becoming slightly viscid with age (fig. 7). Leaves on the flowering stems are similar, but they may be slightly smaller, especially on the upper parts of the stems. The foliage emits a mild to pungent aromatic odor when crushed. Numerous heads are arranged into dense, narrow, leafy panicles, sometimes reduced to a raceme or spikelike inflorescence. Stems layer when in contact with the soil, thus producing additional root systems. Each head contains four to 20 disc flowers. Ray flowers are lacking. Achenes are granuliferous. Blooming occurs during August and September. Seed ripens in October and November.

Figure 7—Mountain silver sagebrush on Targhee National Forest, Sublette County, WY, showing leaves and flower heads.

Ecological Relationships and Distribution

Aside from big sagebrush, silver sagebrush is the most widely distributed sagebrush. It occurs over approximately 53,221 mi^2 (137,842 km^2) in British Columbia and Saskatchewan in the north, south to Arizona and New Mexico, and west to Oregon and California (Beetle 1960; McArthur and Plummer 1978). It grows on soils that are less mature, with less phosphorus, potassium, nitrogen, organic matter, and lower cation exchange capabilities than do soils that support big sagebrush (Hazlett and Hoffman 1975). However, it may grow on a variety of soils (Morris and others 1976).

Plant Culture

Wildings of silver sagebrush can be transplanted in the spring or fall. Establishment by direct seeding has also been successful (Kelsey 1986), especially when done in the fall on the soil surface or at shallow depths (Wasser 1982). In most natural situations, however, few seedlings survive (Walton and others 1986). The species can also be propagated from hardwood cuttings. Harvey (1981) successfully rooted 87 percent of the cuttings of plains silver sagebrush. He used 6 inch (15.2 cm) cuttings with the basal, 1.5 inch (3.8 cm) stripped of leaves, dipped in "rootone" and placed in a misting propagation bench with a growth medium of 50 percent sand, 25 percent vermiculite, 15 percent peat, and 10 percent perlite. Monsen (personal communication) has had excellent success seeding silver sagebrush on mine disturbances on semiarid ranges in southern Idaho and Wyoming and under nursery conditions. Seedlings develop rapidly often attaining a larger stature than plants of basin big sagebrush. Seedlings respond dramatically to moist conditions and may reach 15 to 20 inches (38.1 to 50.8 cm) in 1 year. Plants are usually quite uniform in size and form. Young plants grow well with understory herbs. In undisturbed sites, conditions often support a diverse understory. Plants appear well adapted to harsh disturbances when artificially seeded, but initially are slow to invade raw sites.

Use and Management

Silver sagebrush is important through its range as a browse shrub and is used quite extensively by livestock and big game, particularly when other food is scare (Kufeld 1973; Kufeld and others 1973; Wasser 1982). Bolander silver sagebrush was among the most preferred of the sagebrush taxa offered to mule deer and sheep in winter and fall feeding trials (Sheehy and Winward 1981). Mountain silver sagebrush is grazed by sheep in the fall after grasses and forbs dry. In the Western Great Plains, silver sagebrush is an important antelope survival food. Like big sagebrush, this species has been used by white settlers and Native Americans for fuel (McArthur and others 1979a). Silver sagebrush is not as susceptible to fire as many other sagebrushes (Wright and others 1979; White and Currie 1983). In efforts to manage stand densities by prescribed burning, White and Currie (1983) reported that on both fall and spring burns fire intensity was directly related to plant mortality and inversely related to subsequent growth. In general, fall burns are more effective, as a silver sagebrush control measure, than are spring burns. Internal water stress in silver sagebrush is greater as the season progresses and soils dry out, and that stress is compounded in thick stands where there is interplant competition (White and Currie 1984). An ecotype from the Sheridan, WY, area shows promise as a fire resistant competition to cheatgrass (Monsen, unpublished).

Varieties and Ecotypes

No plant improvement work has been pursued on silver sagebrush. The species, however, hybridizes with other sagebrushes (Beetle 1960; McArthur and others 1979a; Ward 1953). It is, in all likelihood, a parent along with mountain big sagebrush for spicate big sagebrush, which we believe to be a widely adapted stabilized hybrid in Intermountain areas (Goodrich and others 1985; McArthur and Goodrich 1986). It has also been proposed that silver sagebrush is one of the parents, along with early sagebrush, of the narrowly endemic coaltown sagebrush (Beetle 1960). Silver sagebrush is differentiated into three subspecies (fig. 8) separated from one another geographically, ecologically, and morphologically (Beetle 1960, 1977; Harvey 1981; McArthur and others 1979a; Shultz 1983; Walton and others 1986). RAPD genetic markers confirm both the relationship between and the integrity of subspecies (McArthur and others 1998a,c).

Plains silver sagebrush is an erect, round, canescent, freely branched shrub up to 5 ft (1.5 m) tall. It layers whenever conditions are suitable. This subspecies may spread rapidly, particularly after burning, by rootsprouting and by rhizomes (Beetle 1960). Leaves of the vegetative branches are linear-oblanceolate, entire or rarely with one or two irregular teeth or lobes, 1 to 10 mm wide, 2 to 8 cm long, and are densely silky-canescent. Crushed foliage emits a pungent turpentine odor (Beetle 1960; Ward 1953). Flowerheads are usually arranged into dense, leafy panicles and may contain one to 20 disc flowers. Blooming occurs during September, and the seeds ripen during October and November. It is octoploid, 8x (McArthur and Sanderson 1999). Putative natural hybrids between plains silver sagebrush and big sagebrush subspecies have been found (Beetle 1960; Ward 1953). This subspecies has a more eastern distribution than the other two silver sagebrush subspecies. It occurs southern Canada southward, but mostly east of the Continental Divide, through Montana, the Dakotas, Wyoming, western Nebraska, and northern Colorado. It grows particularly well on the well watered, deep soils of the northern Great Plains, especially along stream bottoms and drainageways (Johnson 1978; McArthur and others 1979a; Walton and others 1986).

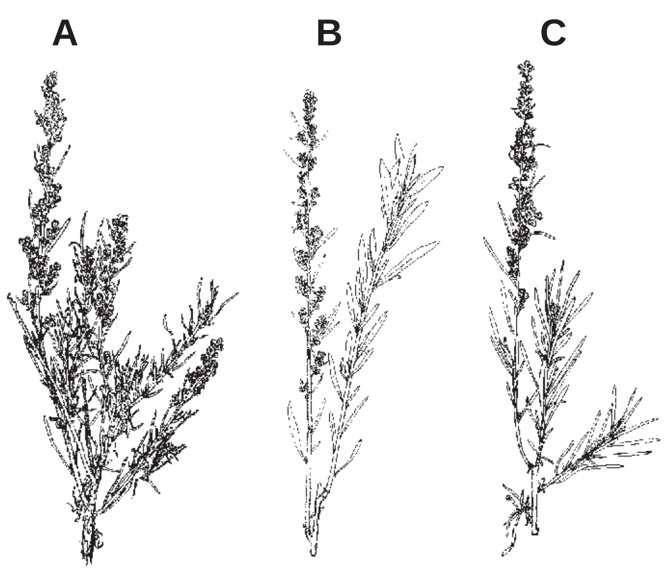


Figure 8—Silver sagebrush subspecies: (A) *A. cana* ssp. *cana*; (B) *A. cana* ssp. *bolanderi*; (C) *A. cana* ssp. *viscidula* (Shultz 1986).

Mountain silver sagebrush (*A. cana* ssp. *viscidula*) is an erect shrub that readily layers. It usually is not more than 3.3 ft (1.0 m) tall. Leaves on the vegetative branches are 1 to 5 mm wide, up to 7 cm long, and are often crowded in dark green clusters. The leaves typically are simple and entire, but occasionally are variously toothed or lobed. This subspecies varies in appearance but is always darker green than mountain big sagebrush with which it is often growing (Beetle 1960). Mountain silver sagebrush is distinguished from plains silver sagebrush by its smaller, darker green leaves, its lower stature, and more western distribution. Flowerheads are arranged into dense, short racemes or spikelike inflorescences 1 to 3 cm long. Each head contains four to 15 disc flowers. Flowers bloom during August and September. Seed matures during October and November. Mountain silver sagebrush occurs in mountainous regions around 5,500 ft (1,800 m) and above. It is usually found in areas of heavy, lingering snowpack from the southwestern corner of Montana, south along the Continental Divide to New Mexico, and west to Arizona, Nevada, and Oregon (Beetle 1960, 1977; McArthur and others 1979a; Tisdale and Hironaka 1981; Winward 1980). It occurs as both diploid, 2x, and tetraploid, 4x, populations (McArthur and others 1981).

Bolander silver sagebrush (*A. cana* ssp. *bolanderi*) has narrow leaves like mountain silver sagebrush, but they are canescent like plains silver sagebrush. It is distributed in poorly drained, alkaline soils from central Oregon to eastern California (Beetle 1960; McArthur and others 1979a; Tisdale and Hironaka 1981; Winward 1980). It is known only as diploid, 2x (Ward 1953).

Artemisia filifolia ________________

Sandsage or Oldman Sage

Sandsage is a round, freely branching shrub up to 5 ft (1.5 m) tall (fig. 9). Young branches are covered with a canescent pubescence while the older stems are covered by a dark-gray or blackish bark. Leaves are long, filiform, and silvery-white canescent; 3 to 8 cm long, less than 0.5 mm wide, entire or alternately divided into filiform divisions, and are often fascicled (fig. 10). Numerous, nodding heads containing two or three fertile, pistillate ray flowers and one to six perfect, but sterile, disc flowers are arranged into leafy, narrow panicles. Each head is subtended by five to nine canescent involucral bracts. Both the receptacle and achenes are glabrous. Flowers bloom during August and September. Seed ripens from October to December (McArthur and others 1979a). Other seed characteristics are given in tables in chapters 24 to 26.

Ecological Relationships and Distribution

Sandsage is an excellent indicator of sand. It is probably the most widespread shrub on sand dunes and sandhills the southern Black Hills of South Dakota southward to Texas and Chihuahua and westward to Arizona and Nevada (Hall and Clements 1923; McArthur and others 1979a; Rasmsussen and Brotherson 1986). In a study in southwestern Utah, Rasmussen and Brotherson (1986a) found that sandsage communities were floristically less diverse than adjacent plant communities, but that there was a higher density of plants in the sandsage communities. In the same study, they reported that despite the poor relative quality of the sandsage community soil profile, sandsage nutrient quality was not affected. Sandsage accumulates mineral nutrients well above levels found in the soils in which it grows. At the study locations, at least, sandsage is adapted to soils of low fertility.

Figure 9—Sandsage growing near Moccasin, Mohave County, AZ.

Figure 10—Sandsage (McArthur and others 1979a).

Plant Culture

Wildings can be transplanted in the spring or fall. Plants can be easily reared from seed. Seeds are smaller than those of most other sagebrushes but grow well once established. Plants mature quickly even when planted offsite. Survival is reduced, however, when the species is planted out of its natural range (Nelson and Krebill 1981). It grows well on infertile soils. It has been seeded alone in most plantings but appears to develop rapidly and can be seeded with herbs adapted to arid sandy sites. It has been easy to grow as bareroot stock and survives well when field planted. It does not require special media for rearing (Monsen n.d.).

Uses and Management

The browse value of sandsage depends on where it grows. It is seldom eaten in grasslands where other food is adequate, but in more arid, desert regions it is consumed by cattle, sheep, and big game. It is particularly important in dry years (Hall and Clements 1923; McArthur and others 1979a). Sandsage is habitat for some small nongame birds. This species helps prevent wind erosion by helping to stabilize light sandy soils. It is an important candidate for harsh sandy sites but often grows in such arid sites that seed production is quite low. It is particularly useful in blackbrush and pinyon-juniper sites where sandy outcrops occur.

Varieties and Ecotypes

No ecotypic differentiation has been documented, but it may well occur. It does have some cytological and chemical similarities with the true sagebrushes (subgenus *Tridentatae*) although it is assigned to the subgenus *Dracunculus* and differs from the *Tridentatae* in floral characteristics and wood anatomy (Kelsey and Shafizadeh 1979; McArthur and Pope 1979; Moss 1940).

Artemisia frigida ________________

Fringed Sage

Fringed sage is a fragrant, aromatic, mat-forming perennial subshrub 8 to 24 inches (20.3 to 61.0 cm) tall (fig. 11). The lower woody stems are spreading and often much branched. Adventitious rooting may occur when stems contact the soil. The upper herbaceous stems are erect and leafy. The whole plant is densely silver-canescent. The numerous small, silky, canescent leaves are 6 to 12 mm long and are two or three times pinnately divided (fig. 12). This species has a deep perennial taproot with numerous extensive laterals that help it withstand drought. Numerous small flowerheads are borne in nodding racemes or open panicles. Small, densely hairy involucral bracts occur in several series around each flowerhead. Each head contains 10 to 17 outer, seed-producing, pistillate ray flowers and numerous (25 to 50) tubular, funnelform, perfect seed-producing disc flowers. Flower receptacles are densely villous. Fringed sage blooms from June at high elevations and latitudes, to November at lower elevations and latitudes. Seed matures between September and December (McArthur and others 1979a).

Ecological Relationships And Distribution

Fringed sage is probably, on a worldwide basis, the most widely distributed and abundant species of *Artemisia*. Its range extends from Mexico northward through most of the western United States and Western Canada into Alaska, then on to Siberia, Mongolia, and Kazakhstan (Harvey 1981; USDA Forest Service 1937). Fringed sage is a common plant of the high plains along the eastern slope of the Rocky Mountains, but also occurs in valleys and mountains. In the United States, it is most abundant in the eastern and northern parts of its range. This species ranges from low semidesert valleys to more than 11,000 ft (3,400 m) elevation throughout the Rocky Mountain, Intermountain, and adjacent plains regions. Fringed sage inhabits a wide variety of sites. Most typically, it grows in full sunlight in dry, coarse, shallow soils. On winter ranges in western Utah and eastern Nevada, fringed sage may occur in dense stands along shallow depressions that collect moisture from summer rains. In such areas, it is frequently associated with winterfat, shadscale, and rabbitbrushes. On plains, foothills, and mountain slopes, this species may be associated with a variety of grasses and forbs as well as with various shrubs such as big sagebrush, Bigelow sagebrush, sandsage, and especially in overgrazed areas, with broom snakeweed. It is a common understory plant in ponderosa pine in several Western States (McArthur and others 1979a).

Figure 11—Fringed sage growing at Black Mesa, Gunnison County, CO.

Plant Culture

Fringed sage can be established by seed or by transplanting young plants or segments of old plants. Surface seeding on disturbed soils is recommended (Wasser 1982). It produces an abundance of small seeds, approximately 1,000 seeds per inch (2.5 cm) of inflorescence (Harvey 1981). There are 4.5 million seeds per lb (9.9 million per kg) (see chapter 24). In a nursery, plants require little care and maintain reasonable vigor (Nelson and Krebill 1981). Individual plants are susceptible to overgrazing, but on a populational basis, fringed sage seems to be stimulated and increases plant numbers with heavy grazing pressure (Cooperrider and Bailey 1986).

Uses and Management

The forage value of fringed sage varies considerably with location and season (Dietz 1972). Its value as browse is highest in late fall, winter, and early spring on western ranges where it is eaten readily by big game and livestock (Cooperrider and Bailey 1986; Kufeld 1973; USDA Forest Service 1937; Wasser 1982). It is also important food for sage-grouse (Wallestad and others 1975). Nutritive quality is highest in the spring, but remains adequate for animals for much of the year (Cooperrider and Bailey 1986; Rauzi 1982). In other areas, such as the grasslands of the Northwest and Great Plains, fringed sage may be less palatable and occasionally invades deteriorated grasslands. However, on the Great Plains, fringed sage is an important winter antelope food and is used to a lesser extent the year round (McArthur and others 1979a).

It is well suited for growth with grasses and broadleaf herbs. Its seedlings are competitive and can be direct seeded into areas with herbaceous competition. It is adapted to mine disturbances, perhaps better than any other *Artemisia*. It can be used to control the rapid influx of weeds on large disturbances.

This species has strong reproductive qualities and is a good pioneer shrub for stabilizing disturbed areas. It is often used in seeding western strip mines, especially coal areas. It has excellent reproduction by seed, and young plants or segments of old plants are readily transplanted in early spring (McArthur and others 1979a). Its strong taproot and numerous lateral roots make it effective in stabilizing gullies and reducing soil erosion. These rooting characteristics make the species capable of withstanding considerable grazing and trampling use. Fringed sage has some value as a medicinal plant (Hall and Clements 1923). It can be controlled when it is too abundant (Alley 1972).

Figure 12—Fringed sage (McArthur and others 1979a).

Varieties and Ecotypes

Undoubtedly, fringed sage, with its wide geographical and altitudinal distribution, has considerable genetic variation. However, no subspecific taxa are recognized and no plant improvement work is under way. Unlike several other widespread *Artemisia* species, fringed sage is known only at the diploid (2n = 2x = 18) chromosome level (McArthur and Pope 1979).

Artemisia longiloba

Alkali Sagebrush

Alkali sagebrush has also been called early sagebrush and low sagebrush. Alkali sagebrush is a misnomer because it grows mostly on neutral rather than on alkaline soils (Passey and Hugie 1962b; Tisdale and Hironaka 1981). It, however, is adapted to drought conditions (Robertson and others 1966; Zamora and Tueller 1973).

Alkali sagebrush is a low shrub up to 18 inches (45.7 cm) tall (fig. 13). It has lax, spreading stems that frequently layer. The bark is dark brown to black on the older stems. The whole plant has a dark gray-green appearance (Beetle 1960). Leaves on the vegetative stems are broadly cuneate, up to 2 cm long, and are deeply three-lobed (fig. 14). Leaves of the flowering stems are similar but smaller. This species is

Figure 13—Alkali sagebrush growing at Wasatch Station, Summit County, UT. Note the abundant, large flower heads.

readily distinguished from other low statured sagebrushes by its large heads and early blooming (Beetle 1959). Its heads contains six to 11 disc flowers and are 3 to 5 mm broad as opposed to 3 mm or less for other short statured sagebrushes (low sagebrush and black sagebrush). It flowers during mid-June to early August and its seed ripens in August and September. Beetle (1960) points out that this species has in the past been confused with silver sagebrush because of its large heads; with big sagebrush because of its broadly cuneate, 3 lobed leaves; and with low sagebrush because of its dwarf size.

Ecological Relationships and Distributions

Alkali sagebrush characteristically grows in heavy, highly impermeable soils generally with dense "B" horizons (Passey and Hugie 1962b; Tisdale and Hironaka 1981). It is, however, also found on lighter soils (McArthur and others 1979a). It occurs at elevations from 6,000 to 8,000 ft (1,800 to 2,400 m) along foothills and in basins of the ranges forming the Continental Divide in southwestern Montana, south through Wyoming to northwestern Colorado, and scattered westward through northern Utah and Idaho to Nevada and Oregon (Beetle 1960; Winward 1980).

Plant Culture

Little is known except the plant can be transplanted. Natural seeding occurs rapidly following fires and other disturbances, yet mechanical tillage can limit seedling establishment if seeds are buried too deep or the seedbed is disrupted (Monsen and Shaw 1986).

Uses and Management

The habitat of some stands of alkali sagebrush, when in good condition, supports a mixed understory of perennial grasses and annual and perennial forbs providing forage and cover for sage-grouse, antelope, and other wildlife as well as livestock (Dealy and others 1981; Monsen and Shaw 1986). Other stands are quite depauperate of associated vegetation and provide little forage and habitat for animals. Alkali sagebrush itself provides, depending on the site, browse for sheep (often preferred), and habitat and food for small animals (Dealy and others 1981; McArthur and others 1979a). The plant should be useful in rehabilitation plantings, particularly on heavy, seasonally dry soils. It has been observed invading roadcuts in Echo Canyon, UT, and barrow pits near Kemmerer, WY, (McArthur and others 1979a). Monsen and Shaw (1986) reported that decadent stands can be rejuvenated by mechanical means. Sites that lack a satisfactory understory remain closed stands unless these shrubs are reduced in number by fire or mechanical means.

Varieties and Ecotypes

Alkali sagebrush has not been studied sufficiently enough to make substantial comments here. However, because of its relatively broad and scattered distribution and its differential use by animals, we suspect it harbors considerable genetic variation. Beetle (1960) considered it to be a parent to the restricted endemic coaltown sagebrush.

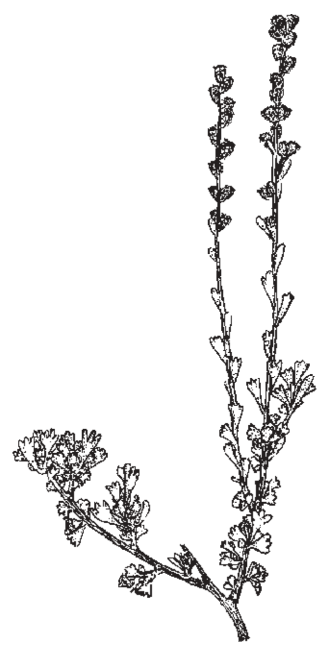


Figure 14—Alkali sagebrush (Shultz 1986).

Artemisia nova

Black Sagebrush

Black sagebrush is a small spreading, aromatic shrub 6 to 8 inches (15.2 to 20.3 cm) or occasionally to 30 inches (76.2 cm) tall with a dull grayish-tomentose vestiture that causes most populations to appear darker than big sagebrush and low sagebrush (fig. 15). However, some forms may be as light in color as those species (Beetle 1960; Brunner 1972). Numerous erect branches arise from a spreading base (fig. 16). This shrub had not been observed to layer or stump sprout (Beetle 1960; Tisdale and Hironaka 1981). However, some layering of black sagebrush on a roadcut near Kolob Reservoir, Washington County, UT, has been noted (McArthur and others 1979a). Typical leaves are evergreen, cuneate, viscid from a glandular pubescence, 0.5 to 2 cm long, 2 to 8 mm wide, and three-toothed at the apex. The uppermost leaves, particularly on the flowering stems, may be entire. Flowerheads are grouped into tall, narrow, spikelike panicles that extend above the herbage. The inflorescence stalks are red-brown and persistent. The heads usually contain three to five disc flowers with corollas 1.8 to 3 mm long. The eight to 12 involucral bracts are greenish-yellow and nearly glabrous. The principal difference between black sagebrush and low sagebrush is that low sagebrush has five to 11 flowers per head, 10 to 15 canescent involucral bracts, and is light in color. Also, the flower stalks of black sagebrush are denser, much darker, and more persistent than those of low sagebrush (McArthur and others 1979a; Ward 1953). Black sagebrush is characterized by the presence of leaf hairs readily visible at 10x magnification when compared to its relatives low sagebrush, alkali sagebrush, threetip sagebrush, and the subspecies of big sagebrush (Kelsey 1984). Three-fourths of a large sample (n = 152) of black sagebrush plants across the species range showed this characteristic conspicuously, whereas, no other taxa exceeded a 4 percent display (n = 1,849).

Figure 15—Black sagebrush, with dark flower stalks, and Wyoming big sagebrush growing at ecotone near Gabbs, Nye County, NV.

Figure 16—Black sagebrush (Shultz 1986).

Ecological Relationships and Distribution

Black sagebrush covers approximately 43,301 mi^2 (112,150 km^2) in the 11 Western States (Beetle 1960). It is most abundant at elevations from 4,900 to 7,900 ft (1,500 to 2,400 m) and normally grows on drier, more shallow stony soil than basin, mountain, or Wyoming big sagebrushes or low sagebrush (Beatley 1976; Tisdale and Hironaka 1981). Zamora and Tueller (1973) reported root restricting layers at depths of 11 to 27 inches (28.0 to 68.6 cm) in half of their black sagebrush study sites. Other soils in which black sagebrush commonly occurs are usually underlain by gravelly and sandy loam strata. Most, but not all, soils supporting black sagebrush are calcareous. Most black sagebrush stands do not burn because of their sparseness (Tisdale and Hironaka 1981). However, we have observed large burns of black sagebrush stands in central Utah. Insect galls are numerous on black sagebrush, but rust diseases are less common (Beetle 1960). Nelson and Krebill (1981) found black sagebrush to be less susceptible to a wilt disease than most other *Artemisia* taxa growing at the Snow Field

Station in Ephraim, UT. Clary (1986) reported that winter livestock grazing (principally sheep) has had a significant and often severe effect on black sagebrush. Some large areas in Nevada formerly occupied by black sagebrush have been invaded recently by Utah juniper and singleleaf pinyon pine.

Plant Culture

Black sagebrush has been successfully transplanted (Luke and Monsen 1984). Seed production in nurseries is often good. It should be seeded in fall or early winter. Seeds should be covered lightly up to 0.25 inch (6.4 mm) deep. Once established, black sagebrush can spread rapidly (Stevens 1986b).

Seeds of black sagebrush are larger than those of most sagebrushes (see chapters 20 and 24). Seeds tend to remain attached to the flower but can be processed easier than seeds of other sagebrush. Seedlings are vigorous, and young plants often grow rapidly. However, even under favorable conditions, young plants do not grow as rapidly as big sagebrush. Once established, small seedings persist well even under adverse conditions. Plants are able to establish amid rocky exposed surfaces. Under these conditions the shrub seedlings persist and usually exclude weedy annuals. Black sagebrush can be established when seeded on sites other than its origin. It grows well on areas normally occupied by big sagebrush and may persist and reproduce. Young stands grow well with seeded herbs, but as stands mature a reduction in understory herbs occurs. Black sagebrush establishes well from direct seeding. The larger seed is not as likely to be seeded too deep as smaller seeded species of sagebrush. Under favorable moisture conditions, mature plants produce abundant seed crops. Natural spread occurs quickly, consequently interseeding or other techniques can be used to establish a seed source and allow natural spread to populate large areas.

Use and Management

Black sagebrush is usually held in high regard as a palatable forage for wildlife and livestock, especially sheep, antelope, and deer (Clary 1986; McArthur and Plummer 1978). However, it, like big sagebrush, has populations that differ dramatically in mule deer preference (Behan and Welch 1985; Welch and others 1981). Welch and his colleagues (Behan and Welch 1985; Welch and others 1981) have shown that some accessions are not eaten whereas others are highly preferred—one accession had 60 percent of its current annual growth eaten in 1978 and 82 percent in 1982. Scholl and others (1977) also reported accessional differences of mule deer preference between black sagebrush accessions. In comparison with other sagebrushes, black sagebrush was preferred by mule deer (Nagy and Regelin 1977); however, Smith (1950) and Sheehy and Winward (1981) found no such preference. Striby and others (1982) reported that mule deer and elk preferred black sagebrush over basin big sagebrush, but not over Wyoming and mountain big sagebrushes. However, Wambolt (1996) found that elk and mule deer preferred black sagebrush least in comparison with mountain, basin, and Wyoming big sagebrush. In the preference tests it should be remembered that there are considerable intraspecific variations as well as interspecific ones being compared. Black sagebrush has good winter nutritive quality (Welch 1983b); not as good as big sagebrush, but the two are adapted to different habitats. Black sagebrush is a good conservation plant for dry, shallow, stony soils. The plant is an aggressive natural spreader from seed. Because it usually grows on dry rocky sites, it is usually not a candidate for plant control.

Varieties and Ecotypes

Welsh and Goodrich (1995) recently described a new variety, *A. nova* var. *duchesnicola* to go with the longstanding typical taxon, *A. nova* ssp. or var. *nova*. Typical black sagebrush occurs in two color morphs (Beetle 1960). The gray-green form is generally browsed more than the darker glossy-green form (Brunner 1972; Stevens and McArthur 1974; Winward 1980). Welch and others (1981) and Behan and Welch (1985) have shown that an accession Pine Valley Ridge in Millard County, UT, is a fine candidate for wider planting because of browsing animal preference. That accession has been transplanted and survived in several locations. It has been released as a germplasm (Welch and others 1994). Black sagebrush has many ecotypes that deserve additional attention. Black sagebrush may have had a role in the parentage of Wyoming big sagebrush (McArthur 1983a; Winward 1975). Beetle and Johnson (1982) reported that some forms of black sagebrush approach Wyoming big sagebrush in appearance. We have made similar observations on the Kaibab foothills in northern Arizona.

Artemisia pygmaea ________________

Pygmy Sagebrush

Pygmy sagebrush (fig. 17) is a dwarf, depressed, evergreen, cushionlike shrub less than 8 inches (20.3 cm) tall. Bark on older stems becomes dark brown and fibrous. On young branches the bark is nearly white to straw-colored and somewhat puberulent. Leaves on the vegetative stems are green, nearly glabrous, viscidulous, 2 to 4 mm wide, 2 to 8 mm long, and are pinnatified with three to 11 lobes, or sometimes may be only toothed (fig. 18). Leaves on the flowering branches are usually reduced and may be

Figure 17—Pygmy sagebrush growing at the Snow Field Station, Sanpete County, UT.

entire. Heads with three to five disc flowers are arranged into spikelike inflorescences. Ray flowers are lacking. Twelve to 18 greenish-yellow bracts subtend each head. Achenes are glabrous. Flowers bloom in August and September, and seed matures in October. Seeds are large for *Artemisia* (McArthur and others 1979a; see chapter 24).

Pygmy sagebrush is limited to calcareous soils in desert areas over approximately 21 mi^2 (54 km^2) eastern Utah to western Nevada and northern Arizona (Beetle 1960; McArthur and Plummer 1978; Ward 1953). In Nevada, this species is often associated with halophytic threadleaf rubber rabbitbrush. Some fairly large stands occur with black sagebrush in Utah.

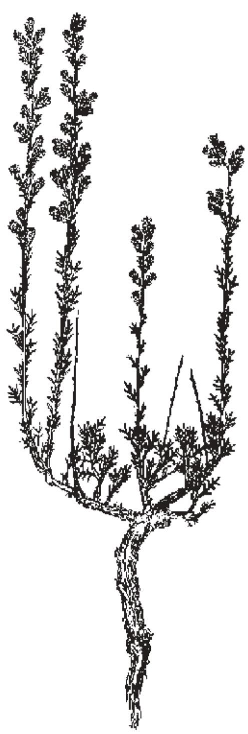


Figure 18—Pygmy sagebrush (Shultz 1986).

Because of its scarcity and small size, this species has little value as browse although it is eagerly taken when available. It does, however, provide important ground cover in the dry, alkaline areas where little else will grow. It establishes readily by transplanting divided plants. Although it spreads well from naturally dispersed seed, artificial planting of seed has not, as yet, been successful. This is due probably to poor quality seed and not the inability to establish by artificial planting. It is a good candidate to plant in heavy soils. It may be of considerable value for mine and roadway disturbances. Natural spreading has occurred when plants have been established in research plantings.

Artemisia rigida

Stiff or Scabland Sagebrush

Stiff sagebrush is a low, pungently aromatic shrub with thick, rigid, somewhat brittle branches up to 16 inches (40.6 cm) high (fig. 19). It is not known to resprout or layer. The wider deciduous, silvery-canescent, spatulate leaves are mostly 1 to 4 cm long and deeply divided into three to five narrowly linear lobes (fig. 20). Occasionally some leaves are linear and entire. The inflorescence is a leafy spike with heads sessile or in small clusters in the axils of their subtending leaves, which generally are all longer than the heads. The campanulate involucre is 4 to 5 mm long with numerous, canescent bracts. Each head consists of five to 16 perfect disc flowers. Flowering occurs from late August to early October; seeds ripen in October and November (see chapters 20 and 24). This species resembles threetip sagebrush somewhat in its small size, silvery pubescence, and the deeply, narrowly lobed leaves, but may be distinguished by the spikelike inflorescence, large leafy bracts that subtend the heads, and the deciduous leaves.

Stiff sagebrush occurs in dry rocky scablands in the Columbia and Snake River basins and spills over into the northern end of the Great Basin. It occurs primarily, if not exclusively, over basaltic bedrock (Daubenmire 1982; Tisdale and Hironaka 1981). It grows at elevations from 3,000 to 5,000 ft (910 to 1,500 m) in Idaho, central and eastern Oregon, and central and eastern Washington. Otherwise its ecological niche is similar to that of low sagebrush (Ward 1953). The report of this species growing in Montana are apparently in error (Morris and others 1976; McArthur and others 1979a).

Figure 19—Stiff sagebrush growing at the Snow Field Station, Sanpete County, UT. The ruler is 30 cm long.

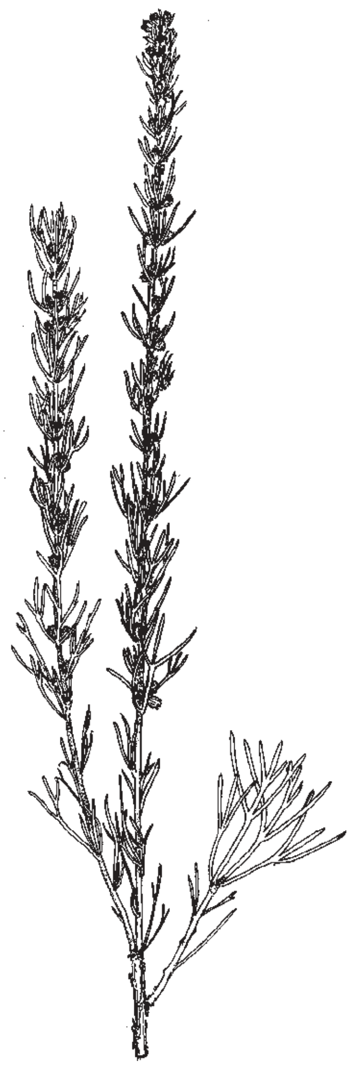


Figure 20—Stiff sagebrush (Shultz 1986).

Because of its scant foliage and stiff branches, stiff sagebrush has been considered of little value for browse, except for sheep (Hall and Clements 1923). It provides forage on the dry sites on which it grows in the midsummer when herbaceous plants are dry. This species provides cover on the poor rocky soils where it grows. It appears to have a wider range of adaptation than is indicated by its present natural range of occurrence, thus giving it potential use in reclamation of some harsh disturbed sites.

Seed production is normally quite low and seed quality is questionable (Monsen, unpublished). Attempts to seed and transplant this species in arid sagebrush ranges near Boise, ID, have not been successful. In most cases plantings were made on sites where cheatgrass and other annuals had invaded the shrublands. Stiff sagebrush seedlings were not able to compete with the weeds. Plants grow slowly and appear to require 2 to 4 years to establish and attain reasonable size. The invasion of cheatgrass undoubtedly limits the natural distribution and occurrence of this shrub. However, it is an important plant for harsh rocky sites. Plantings have successfully established on prepared seedbeds. It is able to seed naturally on harsh sites and has been able to survive wildfires.

Artemisia spinescens ____________

Budsage

Budsage is a low, spinescent, pungently aromatic, rounded shrub 4 to 20 inches (10.2 to 50.8 cm) high (fig. 21). It is profusely branched from the base and has white-tomentose pubescence on young twigs and leaves. This pubescence is grayish and stiff on older branches. Leaves are small, mostly 2 cm or less in length, including the petiole. Leaves are three to five palmately parted, with the divisions again divided into three linear-spatulate lobes. Leaves are crowded on the short stems, with those near the apex being smaller and more entire (fig. 22). Unlike most species of *Artemisia*, budsage is deciduous, with the leaves falling by midsummer. Early in the spring, when budsage first shows signs of breaking dormancy, but before the buds elongate, the bark the last season's growth can easily be pulled off. At this developmental stage, budsage is sought out by big game and livestock. Sheepmen refer to this condition as "slipping." As early as February or March, new bright-green leaves are produced.

Budsage is well adapted to xeric conditions. It has an extensive root system that grows primarily in the top 6 to 22 inches (15.2 to 55.9 cm) of soil. Interxylary cork is formed annually over the last year's wood in both the roots and the stem. This layer of cork restricts

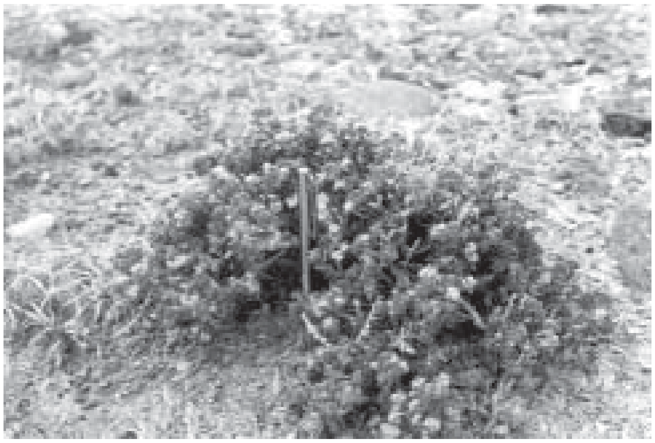


Figure 21—Budsage growing near Sevier Lake, Millard County, UT.

the upward movement of water to the narrow zone of wood formed by the current year's growth. The corky tissue develops during early summer and thus helps to prevent excessive water loss during the dormant season (Wood 1966). Many other xerically adapted woody *Artemisia* also have interxylary cork (Moss 1940). Budsage bears small flowerheads, 3 to 5 mm long, in glomerate racemes of one to three heads in leaf axils of the flower branches. Each head contains two to six fertile, pistillate ray flowers and five to 13 perfect, but sterile, disc flowers with aboritive ovaries. The loose flowerheads are held together by long, matted hairs that cover the corolla and especially the achenes. The heads often fall off the plant intact, without breaking apart to release the seed. However, some seeds are usually dispersed independently. In some instances, seeds germinate while still in the head (Wood 1966). Seeds mature by early June. Good seed production occurs infrequently. The flowers bloom so early in the spring that developing embryos frequently are frozen. Abundant reproduction occurs in years of plentiful seed and favorable moisture.

Figure 22—Budsage (McArthur and others 1979a).

Terminal and lateral buds of budsage generally expand and begin to elongate in late March and early April during the latter part of the "slipping" period. Blooming normally occurs the last week in April through the last week in May, although it has been found in bloom as early as late March and as late as mid-June (Wood 1966). Although budsage ordinarily begins growth early in the spring and then becomes dormant by early or midsummer, it occasionally may break dormancy in response to late summer storms. The plants then remain green all winter to provide succulent forage throughout the winter and spring.

Ecological Relationships and Distribution

Budsage is a drought-resistant shrub quite common in semiarid valley bottoms, benches, and foothills over much of the interior Western United States (Hall and Clements 1923; Wood and Brotherson 1986). It occurs from Wyoming through southwestern Montana, southern Idaho, and eastern Oregon south to northwestern New Mexico, northern Arizona, and southeastern California. It is often associated with shadscale, winterfat, and other salt-tolerant shrubs (McArthur and others 1979a; Wood and Brotherson 1986).

Plant Culture

Summer dormancy can be broken by supplemental water. Wood and Brotherson (1986) reported that supplemental water advanced the beginning of growth by 2 weeks, but did not increase total productivity by the time of the onset of cold weather. Seed quality is usually low, but during infrequent years, natural seeding occurs. Some sites have improved well through protection from livestock grazing. Blaisdell and Holmgren (1984) reported significant recovery of budsage on areas protected from spring grazing. Artificial seeding has been hampered by the use of low quality seed, not the inability of the plant to establish from direct seeding. Plants do not reach maturity quickly, but seedlings and young plants are competitive. They persist under adverse conditions where few other species exist. Plants grow well with winterfat and scattered amounts of grass. Disking is detrimental to the survival of budsage, but anchor chaining usually has little effect upon the shrub.

Uses and Management

Budsage is a palatable, nutritious forage plant for upland birds, small game, big game, and sheep in the winter. It is especially high in calcium, magnesium, phosphorus, and protein (Wood and Brotherson 1986). Generally, it is more palatable in the late winter than during the early winter (Holmgren and Hutchings 1972). During this time it is of tremendous value to the welfare of grazing animals, especially where there is an abundance of dry grass. Care must be taken in grazing budsage in late winter and early spring. Even light grazing during this period is detrimental, and continual heavy grazing may eliminate budsage from areas (Holmgren and Hutchings 1972).

Varieties and Ecotypes

Despite its wide distribution and isolated population, little morphological variation has been described in budsage. However, polyploidy is known (McArthur and Pope 1979).

Artemisia tridentata ______________

Big Sagebrush

Big sagebrush (*Artemisia tridentata*) is a highly polymorphic species with numerous ecotypes and biotypes (fig. 23). Three subspecies—basin, Wyoming, and mountain (*tridentata*, *wyomingensis*, and *vaseyana*) big sagebrush—are generally recognized (Beetle 1960; Beetle and Young 1965) (see chapter 21). Additional subspecies, spicate big sagebrush (*spiciformis*) and xeric big sagebrush (*xericensis*), have recently been proposed (Goodrich and others 1985; Rosentreter and Kelsey 1991). Subspecies will be discussed in the Varieties and Ecotypes section. Big sagebrush is composed of aromatic, evergreen shrubs ranging from dwarf to tall, arborescent forms up to 15 ft (4.6 m) tall (fig. 24). The lower forms generally have several main stems arising from the base, whereas the tall forms often have a single short trunk. Older branches are covered with a gray to brown to black shredded bark. Younger branches and leaves have a white to gray tomentum that gives the plants a silvery cast. Typical leaves are narrowly cuneate or oblanceolate and terminate with three blunt teeth at their truncate apexes. However, considerable variation occurs, ranging from linear, entire leaves with rounded to acute apexes (fig. 25) to broadly cuneate leaves with varying numbers of teeth or shallow lobes. The leaves also range in size from 2 mm to 2 cm broad and 1 cm to 6.5 cm long. Normally, leaves of vegetative shoots are more characteristic and less variable than those on flowering shoots. Also, persistent, that is overwintering, leaves are less variable than leaves of the spring growth flush (Miller and Shultz 1987; Winward 1970, 1980), which are shed by midsummer. Heads of this species contain three to eight disc flowers, (except spicate big sagebrush, which may have up to 12 flowers per head) and are arranged into leafy panicles with erect or sometimes drooping branches. In some forms, the inflorescence becomes spikate. Blooming occurs from July to October. Seeds mature in October, November, and December. Big sagebrush plants often live 70 to 100 years or more. Specimens from several sites were found to be more than 200 years old (Ferguson 1964). Usually, however, a high rate of individual plant turnover occurs within a 20 year period (Stevens 1986b). Characteristics of big sagebrush are detailed in table 3.

Figure 24—Large basin big sagebrush near Meeker, Rio Blanco County, CO.

Figure 23—Individual big sagebrush plants of basin, mountain, and Wyoming subspecies. Plants of each subspecies are randomly placed at the Gordon Creek Wildlife Management Area, Carbon County, UT. Plants are even aged.

Ecological Relationships and Distribution

Big sagebrush is the most widespread and common shrub of Western North America. It is especially common in the Great Basin. Beetle (1960) reports the species as covering approximately 226,374 mi^2 (586,309 km^2) in the 11 Western States. Beetle's estimate of coverage for this and other species is probably too high, because it includes areas where *Artemisia* are partial dominants (McArthur 1981, 1983b; McArthur and Ott 1996). Nevertheless, his figures show how extensively sagebrush is distributed and the relative abundance of each *Artemisia* species when compared to related species. Big sagebrush grows in a variety of soils on arid plains, valleys, and foothills to mountain slopes from 1,600 to 11,200 ft (490 to 3,400 m) and is frequently associated with such shrubs as shadscale, saltbush, rubber rabbitbrush, low rabbitbrush, fourwing saltbush, spiny hopsage, spiny horsebrush, winterfat, broom snakeweed, antelope bitterbrush, snowberry, and serviceberry. Although it is tolerant of quite alkaline as well as quite acidic soils, its optimum growth is in deep, fertile, alluvial loams (Sampson and Jesperson 1963).

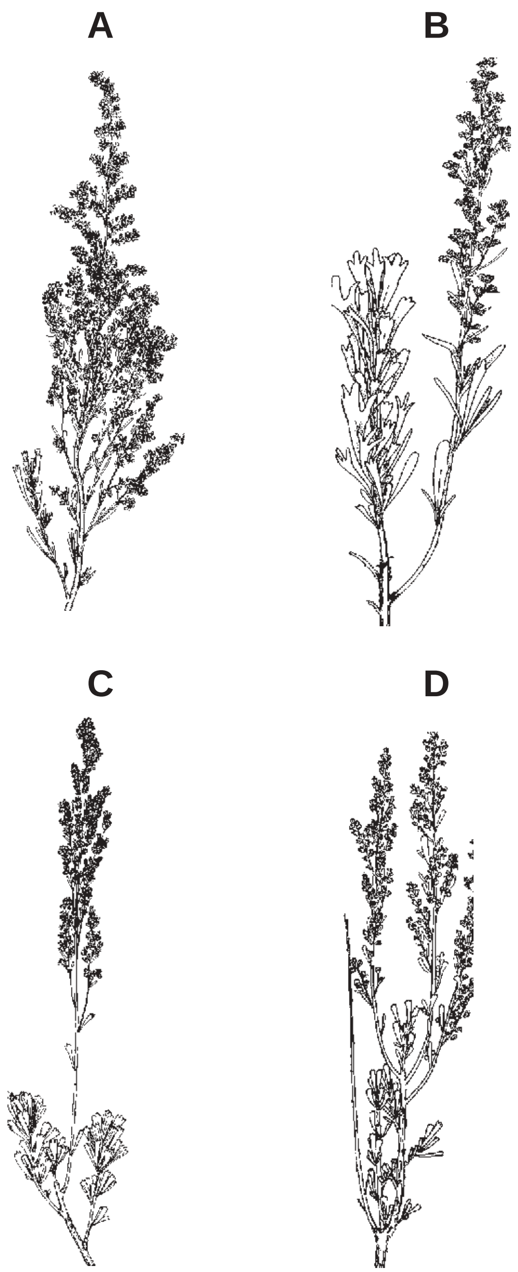


Figure 25—Four subspecies of big sagebrush: (A) *A. tridentata* ssp. *tridentata*; (B) *A. tridentata* ssp. *spiciformis*; (C) *A. tridentata* ssp. *vaseyana*; (D) *A. tridentata* ssp. *wyomingensis* (Shultz 1986).

Although big sagebrush has spread with settlement of the West (Cottam 1961; Christensen and Johnson 1964; Hull and Hull 1974), it was clearly an important and widespread plant before this settlement. Vale (1975), quoting early pioneer and explorer diaries, has shown it was a common Western plant prior to 1850. Johnson (1986) presented photographic evidence showing sagebrush as a widespread dominant in the 1870's. As early as the Pleistocene Epoch, sagebrush was already an important part of the Intermountain flora. Some 80,000 to 10,000 years ago, sagebrush dominated large tracts of land in areas where it is still found (Tidwell and others 1972; Van Devender 1977). Big sagebrush is an indicator of site quality (Kearney and others 1914; McArthur and Welch 1982; Passey and others 1982; Stevens and others 1974). Some populations, especially basin big sagebrush, have been taken out and the land they occupied put into agriculture.

Big sagebrush and its subgenus *Tridentatae* relatives are subject to insect and microbial pests and benefactors—most notably the sagebrush defoliator moth (*Aroga websteri*) (see chapter 21). Wide ranging and periodic outbreaks of this insect have caused extensive sagebrush mortality over much of the range of *A. tridentata* and its relatives (Hall 1965; Henry 1961; Hsiao 1986; McArthur and others 1979a). However, except on some critical winter game ranges, *Aroga websteri* is not believed to have serious, long-term effects. The moth is subject to insect parasites and predators and does not completely kill entire sagebrush stands (Hall 1965; Hsiao 1986). In time, sagebrush naturally reinvades its old sites that in the meantime have become more diverse plant communities. During drought, grasshoppers have been known to defoliate big sagebrush (Schlatterer, personal communication). Galls of many kinds of flies (*Diptera*) are found on sagebrush (Hall 1965; Jones 1971). The effect of the galls is not known. Sagebrush hosts many others insects of various orders (see Graham and others 1995; Messina and others 1996). Some of these may protect the plant disease vectors. Several microbial-induced diseases are known (Krebill 1972).

Table 3—Characteristics of subspecies of *Artemisia tridentata* (adapted from McArthur 1983b).

Characteristics	Subspecies *tridentata*	*vaseyana*	*wyomingensis*	*spiciformis*	References
Habitat and range	Foothills and valley floors. 4,000 to 7,000 ft (1,220 to 2,135 m). British Columbia and Montana to Baja California and New Mexico.	Foothills and mountains. 3,000 to 19,000 ft (915 to 5,790 m). British Columbia and Alberta to California and New Mexico.	Foothills and valley floors. 2,500 to 7,000 ft (760 to 2,135 m). Montana, Washington to Arizona.	High mountain areas. 7,000 to 12,000 ft (2,135 to 3,660 m). Oregon and Montana to Nevada and Colorado.	Beetle and Young 1965; Morris and others 1976; Winward and Tisdale 1977; McArthur and Plummer 1978; McArthur and others 1979a; Dealy and others 1981; Winward 1980; Harvey 1981.
Smell	Biter pungent	Pleasant	Bitter pungent	Pungent, not bitter	McArthur and others 1974.
Essential oil	x = 1.4 percent	x = 2.2 percent	x = 1.1 percent	x = ?	Welch and McArthur 1981.
Leaf shape	narrowly cuneate	Cuneate to spatulate	Cuneate	Cuneate to narrowly cuneate	Marchand and others 1966; McArthur and others 1974; McDonough and others 1975; Winward and Tisdale 1977.
Common height ranges	3 to 13 ft (0.9 to 4 m)	2 to 5 ft (0.6 to 1.5 m)	1.5 to 3 ft (0.5 to 0.9 m)	2 to 5 ft (0.6 to 1.5 m)	McArthur and others 1979a; Winward 1980.
Sesquiterpenes compounds	4 to 7	3 to 6	2	5	Kelsey and others 1973.
Ultraviolet visible coumarins	Trace	Abundant	Trace, but often more than *tridentata*.	Abundant	Shafizdeh and Melinknoff 1970; Stevens and McArthur 1974; Brown and others 1975; McArthur and others 1981.
Tendency to layer	None	Mild	None	Very strong	Beetle and Young 1965; Winward 1980; Goodrich and others 1985.
Palatability to deer and sheep	Low	Usually highest	Highest for sheep sometimes high for deer.	High for sheep in late summer and fall. Sometimes under snow in season of use.	Hanks and others 1973; Sheehy and Winward 1981; Welch and others 1981; Striby and others 1982; Welch and McArthur 1986; unpublished; Welch and others 1987.
Protein content	High	Low	Low	?	Welch and McArthur 1979b.
Seed germination prior to stratification	High	Low	Intermediate	?	Harniss and McDonough 1976.
2*n* chromosome	Commonly 18, some 36	Commonly 18, some 36	Consistently 36	18, 36	Ward 1953; Taylor and others 1964; Winward and Tisdale 1977; Kelsey and others 1975; McArthur and others 1981; McArthur and Sanderson 1999
Flower and seed phenology	Late	Early	Late-intermediate	Early	Marchand and others 1966; Hanks and others 1973; Winward and Tisdale 1977.
Flower stalk to vegetative shoot length ratios	x = 1.8	x = 3.4	x = 2.2	x = 3.1	Winward and Tisdale 1977.
Flower per head	3 to 6	4 to 8	3 to 8	6 to 12	Beetle and Young 1965; Winward and Tisdale 1977; Goodrich and others 1985.
Effect of fire on seed germination	Negative	Positive	Neutral	Positive?	Chaplin and Winward 1982.
Leaf and stem water potential differences	Lower	Higher	Lower	Higher?	Miller and others 1982; Shumar 1984; McArthur and others 1998b
Shrub shape	Uneven topped	Even topped (usually)	Uneven topped	Even topped	Winward 1980; Goodrich and others 1985.
Position of flower stalks	Throughout crown	Above crown	Throughout crown	Above crown	Winward 1980; Goodrich and others 1985.
Seedling growth	Longest sustained root growth rate	Slowest root growth rate	Both above ground and root growth is initially more rapid than other ssp.	?	Welch and Jacobson 1988; Booth and others 1990.

Some of these are widespread and may be locally destructive; however, sagebrush populations are resilient and generally are not significantly affected in the long run. Nelson and Krebill (1981) isolated several fungal species of the genera *Gliocladium*, *Fusarium*, and *Rhizoctonia* from dying sagebrush in uniform gardens. Similar symptoms (dying desiccated plants) have been observed in natural populations (McArthur and others 1979a). Nelson and Sturges (1986; Sturges and Nelson 1986) reported that snowmold disease can be serious in mountain big sagebrush populations. Diseases induced by these fungi may be among the most serious sagebrush diseases. Some microbes are likely useful for the vigor and growth of sagebrush. Wallace and Romney (1972) found preliminary evidence that big sagebrush formed symbiotic relationships with microbial endophytes to fix atmospheric nitrogen. Williams and Aldon (1976) found endomycorrhizae within big sagebrush roots and abundant spores around the roots. Endomycorrhizae, in general, have a beneficial influence on plant growth by promoting nutrient absorption through infected roots (Williams and Aldon 1976). For sagebrush, the beneficial effect has recently been demonstrated (Allen 1984).

Plant Culture

Big sagebrush is one of few shrubs with potential for easy establishment by artificial seeding. Seedlings grow rapidly and compete well with herbaceous plants. The plant establishes well from broadcast planting on irregular but firm seedbeds. Consequently, plants can be established by broadcast seeding even when seeded in mixtures with herbs. Natural seeding often takes place amid established stands of seeded grasses. Because natural spread generally occurs, sagebrush can be planted at low rates and allowed to spread. This has been successful.

Sagebrush seed is difficult to separate from the chaff. Large stalks and debris are usually removed and seed is sold and seeded at a purity of 10 to 20 percent. Seeds are small and planting rates of 0.10 PLS (1 lb bulk per acre or 1.1 kg per ha) can produce adequate stands from broadcast or drill seeding. Seeds require minimal coverage but must be planted on a firm seedbed. Planting on a loose surface is not advised. Seeding should be delayed until early winter when soil surfaces are moist and firm. Seeds require afterripening and stratification to attain uniform germination. Small seedlings are not frost tolerant, and extensive losses occur from spring frosts.

Sagebrush often establishes better from broadcast seeding than drill seeding, as seed are placed too deep with conventional drills. Seedings using the cultipacker seeder are successful as seeds are not placed more than 0.25 inch (6.4 mm) deep and the soil surface is compacted or "firmed up" with this machine.

Although established stands of big sagebrush can reduce the productivity of associated herbs, young sagebrush plants do not diminish the density or vigor of developing herbs. Consequently, sagebrush can be directly seeded with herbs to provide a mixed composition of plants. Big sagebrush is also compatible with numerous shrubs, so mixed seedings can be done even though young sagebrush plants develop more rapidly than serviceberry, snowberry, Martin ceanothus, green ephreda, and Wyeth eriogonum.

Big sagebrush wildings can easily be transplanted into nurseries and field locations when they are relatively dormant and moisture conditions are right—fall and early spring. Wildings about 6 to 8 inches (15.2 to 20.3 cm) tall transplant best. McArthur and Plummer (1978) reported that of the 829 big sagebrush plants transplanted to the Snow Field Station in Ephraim, UT, in 1969 to 1970, 590 established (71.2 percent). Five years later 421 plants were vigorous and growing. Luke and Monsen (1984) reported high success in transplanting sagebrush on a Wyoming mine spoil site. Individual big sagebrush plants can be propagated by the rooting of stem cuttings (Alvarez-Cordero and McKell 1979). Tissue culture propagation is also possible (Neville and McArthur 1986).

Big sagebrush can be successfully drill (fig. 26, 27), or broadcast seeded (fig. 28). Care should be taken that seeds are not covered too deeply, 1/8 inch (3.2 mm) or less is preferred (Monsen and Richardson 1984; Richardson and others 1986; Young and Evans 1986b). Seeding should be done in the fall. Planting in subsoil substrates has had mixed success. Luke and Monsen (1984) and Monsen and Richardson (1984) were not successful, but Stevens and others (1981b) successfully seeded big sagebrush in subsoil scalps (fig. 29).

Figure 26—Drill seeded big sagebrush with grass mixture in southern Idaho. Sagebrush seed was separated from grass seed in seed boxes and drill rows.

Figure 27—Seeded big sagebrush in subsoil scalps in an intermediate wheatgrass seeding, Millard County, UT.

Matching seed source with planting site habitat is important for emergence and survival of big sagebrush (Meyer and Monsen 1991). In general, regardless of subspecies, big sagebrush seed germination is adapted to climate of collection sites (Meyer and others 1990b). A wilt disease can be troublesome in nurseries (Nelson and Krebill 1981). Symptoms of this disease are present also in natural populations. Snowmold can also cause lack of vigor and death in sagebrush (Nelson and Sturgess 1986; Sturgess and Nelson 1986). During cold winters with little snow cover, winter injury and death has been documented for large stands of sagebrush (Nelson and Tiernan 1983).

Uses and Management

Big sagebrush is one of the more nutritious shrubs on Western winter livestock and game ranges. Basin big sagebrush has higher protein levels than the other subspecies (Welch and McArthur 1979b). Palatability of the different populations of this shrub to mule deer and other animals varies widely. For deer, basin big sagebrush is generally less palatable than Wyoming big sagebrush; both are generally less palatable than mountain big sagebrush (Hanks and others 1973; Scholl and others 1977; Sheehy and Winward 1981; Wambolt 1996; Welch and McArthur 1986; Welch and others 1981). However, Striby and others (1982)

Figure 28—Plant establishment from aerial seeding of big sagebrush with crested wheatgrass, alfalfa, and Utah sweetvetch in south-central Utah.

reported that Wyoming big sagebrush was most palatable to deer and elk at their Montana study site. Wyoming big sagebrush is generally most palatable to sheep (Welch and others 1987). Palatability of spicate big sagebrush has not been studied to any great extent. It is browsed by sheep in the late summer and early fall and by big game when available in winter. Palatability of xeric big sagebrush is good for mule deer and sheep. Sagebrush is important food and cover for upland birds. For example, sagebrush comprised 62 percent of the annual diet of sage-grouse in Montana (Wallestad and others 1975). Big sagebrush is an important component of antelope diet. Olsen and Hansen (1977) found sagebrush comprised 78 percent of the annual diet for antelope in Wyoming's Red Desert. Even though sagebrush is a valuable forage, it is generally a less preferred browse for deer and other

Figure 29—An even-topped mountain big sagebrush.

browsers than many rosaceous shrubs such as the mountain mahoganies, bitterbrush, and cliffrose (McArthur and others 1978b; Smith and Hubbard 1954; Smith and others 1965). Because of its widespread abundance, its ability to grow with associated grasses, forbs, and other shrubs and its nutritious nature, big sagebrush is the most important winter forage in foothill areas throughout much of the West for livestock and big game. Sustained heavy use can, however, result in loss of vigor and mortality of big sagebrush and other sagebrush species (Cook and Child 1971; McArthur and others 1988a; Smith 1949). It is one of the best shrubs available for use in revegetation of depleted winter game ranges in the Intermountain area (Plummer 1974a; Welch 1983a).

Meyer and colleagues showed that sagebrush seeds are site-adapted. Generally seeds from the area to be planted or a similar area will establish and perform better (Meyer 1994; Meyer and Monsen 1992; Meyer and others 1990b).

All forms of big sagebrush usually recover by naturally seeding sites that have been sprayed, burned, disked, or chained. Natural spread can be reduced if soils are plowed or deeply disked causing seeds to be deeply buried. Mountain big sagebrush recovers well even amid the presence of established herbs. However, mountain big sagebrush usually grows on sites that receive high amounts of summer moisture to sustain seedling growth. In addition, this sagebrush is able to produce good seed crops each year. Under more arid conditions, natural seed production is more erratic. Poor seed crops often occur and seed viability is diminished after 2 to 3 years of storage (Stevens and others 1981a).

Big sagebrush is aggressive and persistent and sometimes forms closed stands. These stands may require thinning and rejuvenation. These techniques are treated in chapter 17, and in Plummer and others (1955), Pechanec and others (1965), Laycock (1979), Utah State University (1979) (especially Keller's contribution), Marion and others (1986), and Whisenant (1986b). Big sagebrush stands are unexcelled in providing ground cover and forage when grazed to maintain a balance between the sagebrush and associated herbs and shrubs. Because big sagebrush has the potential to establish rapidly from both transplanting and direct seeding, it is useful for stabilizing washes, gullies, roadcuts, and other raw, exposed sites (Clary and Tiedemann 1984; McArthur and others 1979a; Monsen and Richardson 1984) and planting depleted game ranges (Plummer and others 1968). Big sagebrush, especially basin big sagebrush, has shown promise as a living snowfence (Laycock and Shoop 1986). Winward (1980, 1983) reported that associated species richness with each subspecies (see next section) varies greatly. Of the three common subspecies, the order and quantity of diversified associated species is *vaseyana* > *tridentata* > *wyomingensis*. This information should be kept in mind for carrying capacity and manipulative considerations.

Varieties and Ecotypes

Because of its plasticity and the apparent ease with which it hybridizes, there are good opportunities for developing improved forms of big sagebrush for different purposes (McArthur 1981; McArthur and others 1979a, 1985, 1988b; Noller and McArthur 1986; Welch and McArthur 1979a). One accession has been released as a named germplasm; 'Hobble Creek' is a vigorous mountain big sagebrush from near the mouth of Hobble Creek Canyon, UT. It is palatable to mule deer and sheep; it persists in relatively dry sites receiving from 13 to 14 inches (33.0 to 35.6 cm) of rain; and has good growth characteristics (Welch and others 1986). Other accessions also show promise and may qualify for later release.

Basin big sagebrush (*A. tridentata* ssp. *tridentata*) is an erect, heavily branched, unevenly topped shrub (fig. 24). Similar contrasting characteristics of basin and other big sagebrush subspecies are given in table 3. This subspecies has undivided or at least trunklike, main stems. Most shrubs range between 3 to 6.5 ft (0.9 to 2.0 m) in height. Some forms, however, may reach 15 ft (4.6 m) in suitable habitats. Mature shrubs of this subspecies are the largest members of the big sagebrush complex. The evergreen, vegetative leaves are narrowly lanceolate, up to 5 cm long by 5 mm wide, and typically three-toothed at the apex. The leaves of the flowering stems gradually become smaller and may be linear or oblanceolate and entire. Winward (1970) found the average length-to-width ratio of persistent leaves is 4.6 to 5.6. The gray-canescent foliage passes a strongly pungent, aromatic odor. Flowering stems arise through the uneven crown and bear numerous flowerheads in erect, leafy panicles. The heads contain three to six small yellowish or brownish, trumpet-shaped, perfect disc flowers. The narrowly campanulate involucre consists of canescent bracts 3 to 4 mm long and about 2 mm wide that form four to five overlapping series around each head. The outermost bracts are less than a fourth as long as the innermost bracts. Flowering occurs from late August to October. Seed matures, depending on site, from October to early December. Seed can be collected fairly easily by beating (see chapters 20 and 24). Basin big sagebrush is probably the most abundant shrub in Western North America on lowland ranges. It normally occurs on dry, deep, well-drained soils on plains, valleys, and foothills below 7,000 ft (2,100 m) elevation. Above this elevation subspecies *vaseyana* and *spiciformis*, and occasionally subspecies *wyomingensis* are more prevalent. Vigorously growing basin big sagebrush is considered indicative of productive ranges because it often grows in deep, fertile soil. This subspecies has generally been regarded as intolerant of alkali, but there are ecotypes that grow in relatively high alkalinity in association with such alkali-tolerant plants as black greasewood, shadscale, and saltgrass. A similar taxa restricted to southern California is ssp. *parishii* distinguished by its exceptionally hairy achenes. Subspecies *parishii* may only be an ecotype of basin big sagebrush.

Mountain big sagebrush (*A. t.* ssp. *vaseyana*) is normally a smaller shrub than basin big sagebrush. Its main stems are usually divided at or near the ground, and it tends to have a spreading, evenly topped crown (fig. 29). Vegetative branches are usually less than 3 ft (91.4 cm) high and occasionally layer at the base. Some lower elevation ecotypes reach about 6 ft (1.8 m) in height. The persistent vegetative leaves are broadly cuneate to spatulate and are characteristically wider than those of both basin and Wyoming big sagebrushes. When looking down at shrubs of mountain big sagebrush, terminal leaves on each twig appear to be distinctly whorled. Basin big sagebrush does not show this trait, but Wyoming big sagebrush shows the trait to some extent. Mountain big sagebrush grows in slightly acidic to slightly alkaline soils (Welch and McArthur n.d.). Unlike ssp. *tridentata*, ssp. *vaseyana* is rarely associated with any of the saltbushes. Mountain big sagebrush has larger seeds than Wyoming and basin big sagebrushes. It usually comes better from direct seeding than the other two subspecies. There are two varieties of mountain big sagebrush. Each variety occurs in large distinct populations but also integrates into other populations. The most common variety outside of the Pacific Northwest is small-headed mountain big sagebrush (Goodrich and others 1985). This is the sagebrush that Ward (1953) referred to as that of "timbered or mountainous areas in which the plants are very uniform in size, usually about 2 ft (61.0 cm) in height, and of a rather spreading, flat-topped habit of growth, with the inflorescence extending upward like plumes above the rest of the bush." The small-headed form has four to six flowers per head. The other variety, var. *vaseyana*, has seven to 11 flowers per head and has a more restricted geographical range in the upper elevational sagebrush areas of Washington, Oregon, and Idaho with only occasional small patches occurring outside of that area (Goodrich and others 1985).

Rosentreter and Kelsey (1991), on Winward's (1970) suggestion maintained that xeric big sagebrush, (*A. t.* ssp. *xericensis*) be recognized as a distinct entity. This subspecies is apparently derived from hybridization between ssp. *tridentata* and *vaseyana* (McArthur and others 1979a; Rosentreter and Kelsey 1991). It is adapted to dry sites between 2,600 and 4,600 ft (790 to 1,400 m) in southern Idaho and surrounding areas. Its introgression with ssp. *tridentata* is apparent in that plants are large and ragged topped, but chromatographically, cytologically, and phenologically it most closely resembles ssp. *vaseyana*.

Wyoming big sagebrush (*A. t.* ssp. *wyomingensis*) is somewhat intermediate in distribution, ecology, and morphology between basin big sagebrush and mountain big sagebrush, but more diminutive than either (fig. 30). It is adapted to drier sites than other subspecies by virtue of its rapid and long root growth and early, but relatively small, aboveground growth (Booth and others 1990; Welch and Jacobson 1988). The accession 'Gordon Creek' has recently been released as a named germplasm (Welch and others 1992b). It combines wide adaptability, palatability, favorable growth characteristics, and drought tolerance. Occasionally, the subspecies *tridentata*, *vaseyana*, and *wyomingensis* may be found growing together. Whenever it is found associated with ssp. *tridentata*, ssp. *wyomingensis* is growing in the poorer, more shallow soils (Beetle and Young 1965). Subspecies *wyomingensis* is a low shrub usually less than 3 ft (91.4 cm) in height. It has an uneven to round top with flower stalks arising throughout the crown like ssp. *tridentata*. Its main stem branches at or near the ground level like ssp. *vaseyana*, but it does not layer. Leaves are 1 to 2 cm long, narrowly cuneate to cuneate, and have an average length-to-width ratio of about 3:1 for the persistent leaves (Winward 1970). Flowerheads contain three to eight disc flowers and are arranged into panicles narrower than the paniculate inflorescence of *tridentata*, and is wider than the spicate inflorescence of *vaseyana* (Beetle and Young 1965; Winward and Tisdale 1977). Flowering and seed ripening take

Figure 30—Wyoming big sagebrush growing near Daniel, Sublette County, WY.

place later than *vaseyana* and earlier than *tridentata*. Wyoming big sagebrush plants have an effective near surface root system (Sturges 1977). This may be one reason why relatively few plant species grow with it. This subspecies may have arisen from hybridization between ssp. *tridentata* and *vaseyana* (Beetle and Young 1965; Hanks and others 1973) or ssp. *tridentata* and *A. nova* (Winward 1975), or a combination of all three taxa (McArthur 1983b). Wyoming big sagebrush grows throughout the Intermountain region. It is particularly abundant east of the Continental Divide in Montana, Wyoming, and parts of Colorado in dry, shallow, gravelly soil; usually from 5,000 to 7,000 ft (1,500 to 2,100 m) (Beetle and Young 1965). In Idaho, this subspecies is found from 2,500 to 6,500 ft (760 to 2,000 m) in the hotter, drier portions of the state (Winward 1970).

Timberline big sagebrush (*A. t.*ssp. *spiciformis*) has been the subject of some taxonomic confusion (see *A. rothrockii* discussion in Goodrich and others 1985 and McArthur and others 1979a, 1981). This taxon is the widespread root sprouting big sagebrush of high elevations in the Intermountain area (Goodrich and others 1985; McArthur and Goodrich 1986). Its habitat is often in openings in aspen, spruce, or fir woods or where drifting snow accumulates (fig. 31). It had formerly been confounded with Rothrock sagebrush (*Artemisia rothrockii*), a similar taxon of the Sierra Nevada (Goodrich and others 1985; Shultz 1983; Ward 1953). Rothrock sagebrush differs from timberline sagebrush by its dark resinous leaves, restricted California distribution, and high polyploidy. Timberline big sagebrush is thought to be a stabilized hybrid between mountain big sagebrush and mountain silver sagebrush (Goodrich and others 1985). In growth form, timberline big sagebrush resembles mountain big sagebrush in stem and leaf characteristics, but mountain silver sagebrush in floral characteristics (fig. 32). It has 10 to 18 flowers per head. Timberline big sagebrush flowers in August and September in native habitats, but in early June when transplanted to low elevations (4,500 to 5,600 ft; 1,400 to 1,700 m). It is a palatable sagebrush often browsed heavily in the fall by sheep and mule deer. In winter it is usually unavailable under snow. It has shown potential as a low landscape hedge (McArthur and others 1979a). Although basin, Wyoming, and mountain big sagebrush occur in distinct sites, all three of these common subspecies express a wide range of adaptation. When planted throughout the big sagebrush, pinyon-juniper, and mountain brush communities all three subspecies demonstrate adaptiveness. Although sources from high elevations are not suited to arid circumstances, and sources collected from light textured soils are not adapted to heavy clay textured soils, most selections have established and persisted when planted over a wide range of sites.

Figure 31—Timberline big sagebrush growing near Minturn, Eagle County, CO. Note the large flower heads and flowering stalks.

Figure 32—A specimen of timberline big sagebrush collected from Wolf Creek Summit, Wasatch County, UT.

The subspecies of big sagebrush as well as near relatives (=subgenus *Tridentatae*) hybridize at many of their contact points. In fact, hybridization is thought to have been a key mechanism in the evolution and speciation of the group (Beetle 1960; Hanks and others 1973; McArthur and others 1981, 1988; Ward 1953). Artificial hybridization may be useful in selecting and combining traits for management purposes such as fire tolerance and palatability (McArthur and others 1979a, 1988b,c, 1998a; Weber and others 1994). Some current studies of big sagebrush zones of hybridization are yielding results in an effort to better understand the role of hybridization in nature and to help determine the importance of the permanence and function of hybrid zones. These studies have concentrated on morphological, chemical, physiological, cytological, ecological, edaphic, and entomological characteristics (Byrd 1997; Byrd and others 1999; Freeman and others 1991, 1995, 1999; Graham and others 1995; McArthur and others 1988b,c, 1998a, 1999b; McArthur and Sanderson 1999; Messina and others 1996; Wang 1996; Wang and others 1997, 1998, 1999).

Artemisia tripartita ________________

Threetip Sagebrush

Threetip sagebrush is a round, evergreen shrub up to 6 ft (1.8 m) high. It may have a simple, trunklike main stem or several branches arising from the base. The bark on young branches is canescent but becomes shredded and grayish, light brown to dark brown or black on older stems. This species can layer, sometimes sprout back after a burn, and may sprout from the stump following herbicide treatment (Beetle 1960; Pechanec and others 1965; Schlatterer 1973; Winward 1980). Leaves of the vegetative branches are canescent, 0.5 to 4 cm long, and typically deeply divided into three linear or narrowly linear-lanceolate lobes, which in turn may be three-cleft (fig. 33). Some of the upper leaves are often entire. Crushed foliage emits a pungent odor. Flowerheads contain three to 11 disc flowers and are normally arranged into panicles. Ray flowers are lacking. Each head is subtended by eight to 12 canescent involucral bracts. Achenes are resinous-granuliferous. Blooming occurs from July to September and seed is collected from mid-October to mid-December.

Ecological Relationships and Distribution

Threetip sagebrush covers approximately 13,000 mi^2 (33,670 km^2) in the Northern Rocky Mountains and Great Basin States from British Columbia south through Montana and Wyoming to Colorado and west to Washington, Oregon, northern Nevada, and northern Utah at elevations between 3,000 to 9,000 ft (910 to 2,700 m) (Beetle 1960). In some places, particularly in Idaho, this species occurs between the lower, hot, dry sites dominated by Wyoming big sagebrush and the higher, cooler sites dominated by mountain big sagebrush (Schlatterer 1973). It usually grows on moderate to deep, well-drained, loamy and sandy loam soils (Winward 1980).

Figure 33—Threetip sagebrush (Shultz 1986): (A) *A. tripartita* ssp. *rupicola*; (B) *A. tripartita* ssp. *tripartita*.

Uses and Management

Threetip sagebrush is a vigorous seeder, but unfortunately some forms are not particularly palatable. However, Kufeld (1973) reported use by elk, and Kufeld and others (1973) reported use by deer. Beetle (1960) reported it was of low palatability for both livestock and game, and Brunner (1972) observed that it was never grazed in Nevada. However, a form near Salmon, ID, is palatable to deer. The form near Salmon may have been introgressed by a nearby population of Wyoming big sagebrush (McArthur and others 1979a). Stands of threetip sagebrush sometimes require thinning by mechanical and chemical means (Pechanec and others 1965).

Threetip sagebrush has not been difficult to establish by direct seeding, rearing, or transplanting. Usually a large amount of high quality seed is produced annually. Seeds can be harvested without difficulty from the upright bushes. Within its area of occurrence, threetip sagebrush establishes and performs well. Seedlings are able to persist within both a dense perennial and annual understory. But threetip sagebrush is not any more competitive with cheatgrass and other annuals than other species of sagebrush.

Plants grow quickly and can attain a mature stature in 3 to 5 years. The shrub frequently exists with a number of other shrubs and herbs. Seeding a mixture of species usually does not reduce the survival or productivity of this shrub.

Attempts to establish threetip sagebrush onto arid sites dominated by Wyoming big sagebrush have not been successful. Plants initially appear but fail to persist if reseeded. However, some ecotypes can be extended to drier sites.

Threetip sagebrush recovers well following extensive disturbances. However, hot summer fires can kill large stands and prevent resprouting and can significantly delay recovery by seeds.

Threetip sagebrush often grows intermixed, but as separate stands, with mountain big sagebrush, Wyoming big sagebrush, or alkali sagebrush. When disturbances have occurred in these areas, threetip sagebrush seedlings often invade into all circumstances. Natural sorting occurs, but rather slowly. Threetip sagebrush demonstrates good compatibility with many introduced and native grasses and broadleaf herbs. It survives and grows well with competitive grasses including mountain brome, slender wheatgrass, intermediate wheatgrass, and orchardgrass.

Varieties and Ecotypes

Wyoming threetip sagebrush (*Artemisia tripartita* ssp. *rupicola*) is a dwarf shrub with decumbent branches that rarely grows over 6 inches (15.2 cm) tall. It is frequently found layering and may have a crown of 12 to 20 inches (30.5 to 50.8 cm) (Beetle 1960). Leaves of the vegetative branches are often 3 cm long and deeply divided into linear lobes, each at least 1 mm wide (Beetle 1959, 1960). Flowerheads bear three to 11 disc flowers and are arranged into leafy, narrowly racemose panicles. Flowers bloom in late August and September. Seed ripens in October. Wyoming threetip sagebrush has a rather limited range. It occurs on rocky knolls from 7,000 to 9,000 ft (2,100 to 2,700 m) in elevation in central and southeastern Wyoming (Beetle 1960). Brunner (1972) reported this subspecies also occurs in southern Oregon, but had not yet been found in Nevada. It typically grows on sites adjacent to those of mountain big sagebrush.

Tall threetip sagebrush (*A. t.* ssp. *tripartita*) is a freely branching shrub up to 6 ft (1.8 m) high. It can layer easily when the conditions are right but is seldom found layering in the field. After burning, it may stump-sprout (Beetle 1960). Leaves of the vegetative branches are 1.5 to 4 cm long and deeply divided into three linear lobes less than 1 mm wide. The lobes may be further divided (Beetle 1959, 1960). Flowerheads bear four to eight disc flowers and are arranged into panicles that may sometimes be reduced to a spicate form. Flowers bloom in late August and September. Seeds ripen in October. This subspecies occurs in dry, well drained soils at 3,000 to 7,500 ft (910 to 2,300 m) elevation from British Columbia south through Washington to northern Nevada and eastward to northern Utah and western Montana.

Other Sagebrushes

Coaltown sagebrush (*Artemisia argillosa*) is a threetip form endemic to a small area in Jackson County, CO. This species is well adapted to heavy clay spoil material and may have some utility in reclamation activities (Beetle 1960; McArthur and others 1981).

Rothrock sagebrush (*A. rothrockii*) is similar in many respects to subalpine big sagebrush and would share the latter's uses. However, Rothrock sagebrush does not occur in the area of interest for this book. It is confined to the high country of California (Goodrich and others 1985; Shultz 1983).

Two other species—longleaf sage (*A. longifolia*) and birdsfoot sage (*A. pedatifida*)—are not true sagebrushes in that they don't belong to the subgenus *Tridentatae* (table 2). Both, however, may prove useful in revegetation efforts. Longleaf sage is the most robust and woody member of the mostly herbaceous Louisiana sage (*A. ludoviciana*) complex (see chapter 19 for treatment of the Louisiana sage or sagewort complex). Longleaf sage may grow up to 3 ft (91.4 cm) tall. It grows well on clay soils from Nebraska and Wyoming north to Canada (Hall and Clements 1923). Birdsfoot sage is a low perennial subshrub up to 6 inches (15.2 cm) tall with a tough woody root. It grows on alkaline flats in Wyoming and Idaho and could be used for rehabilitation of alkaline spoils (Hall and Clements 1923).

General Rabbitbrush Culture

Table 4 presents distribution and differentation of rabbitbrush taxa. Tueller and Payne (1987) and other papers in Johnson (1987) provide additional information on rabbitbrush culture, management, and use.

The fruit of rabbitbrush is a spindle shaped achene (seed). The terminal, or crown end, of each seed bears a ring or crown of hairs, known as the pappus. Seed can be wind and animal dispersed. Normally seed is produced annually. Seedlings naturally establish, especially on disturbed sites where competition is lacking or slight. Thousands of seedlings can be found in bare and disturbed soils, under and next to mature plants. Most do not, however, develop beyond the seedling stage. Seeds are relatively small (see chapter 20) with considerable variation in size between taxa. White rubber rabbitbrush seeds are among the smallest with about 700,000 per lb (1.5 million/kg) (100 percent purity). Mountain rubber rabbitbrush seeds are somewhat larger with just over 425,000 per lb (937,000 per kg).

Various rabbitbrush species have been successfully seeded. Seeding success, based on successful establishment, has ranged from 0.001 to 4.0 percent (Stevens and others 1986). The pappus has to be removed to facilitate seed being seeded aerially, broadcast, or drilled. Although seeding success theoretically could be

Table 4—Species of *Chrysothamnus* with distribution, notes, and subspecific differentiation (drawn from Anderson 1986a; McArthur and Meyer 1987; McArthur and others 1979a; and references cited therein).

Section and species	Distribution	Notes	Number of subspecies
Chrysothamnus			
C. albidus	Scattered in alkaline soils W Utah to EC California.	White-flowered very resinous	—
C. greenei[a]	Often in sandy soils SC Colorado and N New Mexico to W Nevada and E California.	Mature plants have brittle white shiny stems Involuvral bracts are acuminate and recurved.	1
C. humilis	Arid plains NW Nevada, NE California, SE Oregon, and isolated populations further N in Oregon and Washington	Blooms earlier than rabbitbrush.	—
C. linifolius	Dry arroyos and other moist, deep but usually alkaline soil sites S Montana to N Arizona and N New Mexico	Large statured like rubber rabbitbrush.	—
C. viscidiflorus	Broad distribution on dry open areas British Columbia and Montana S to New Mexico, Arizona, and E California; entire state of Utah.	Some populations have the only ray flowers in *Chrysothamnus*	5[b]
Gramini			
C. eremobius	Known from only three populations in upland S Nevada.	Related to genus *Petradoria*	—
C. gramineus	Grows in mountain canyons in S Nevada and adjacent California.	Related to genus *Petradoria*. As opposed to *C. eremobius* this species has longer involucres, unkeeled phyllaries, and glabrous achenes.	—
Nauseosi			
C. nauseosus	Broadly distributed in plains, foothills and mountains British Columbia to Saskatchewan S to Western Texas, Sonora, and Baja California.	Most common and widely distributed rabbitbrush with much diversity. Forms of ssp. *albicaulis*, *hololeucus*, and *salicifolius* are preferred by browsing animals.	22[c]
C. parryi	Dry open places in mountains and foothills Wyoming and Western Nebraska W to California and S to New Mexico and Arizona.	Shares stem tomentum character with *C. nauseosus* but has attenuate involucral bracts as opposed to acute bracts of *C. nauseosus*. Generally smaller and finer structured than *C. nauseosus*.	13[d]
Pulchelli			
C. depressus	Dry plains, hills, and rocky mountain slopes scattered over Western Colorado and New Mexico W to SE California and S Nevada.	Dwarf shrub with conspicuously keeled, sharply ranked involucral bracts. Perhaps the most palatable taxa to ruminants.	—
C. molestus	Occurs only in a few scattered populations in uplands of NC Arizona.	Rare species. Has glandular-hispid foliage.	—
C. pulchellus	An undershrub in SW desert savannas SE Utah and SW in Utah, Kansas, to W Texas and N Coahuila.	Has prominantly angled achenes.	—
C. vaseyi	Scattered populations in mountain valleys and foothills SE Wyoming to NC New Mexico W to high plateaus of Utah.	Resembles the more common *C. viscidiflorus*.	—
Punctati			
C. paniculatus	Arid often stony slopes especially in dry arroyos SW Utah and SW Nevada to SC California.	Striate stems and terete leaves.	—
C. teretifolius	Arid stony slopes in S Nevada and SE California.	Similar to *C. paniculatis* but more abundant. Has more strongly aligned involucral bracts	—

[a]Formerly ssp. *greenei* and *filifolius* were recognized, but McArthur and others (1978a, 1979a) and Anderson (1986a) see no consistent distinctive differences between the formerly recognized subspecies.

[b] A total of 25 have been named at various taxonomic ranks. Hall and Clements (1923) recognized nine; Anderson (1986a) recognized five subspecies: ssp. *axillaris*, *lanceolatus*, *planifolius*, *puberulus*, and *viscidiflorus*.

[c] A total of 62 have been named at various taxonomic ranks. Hall and Clements (1923) recognized 20; Anderson (1986a) recognized 22 subspecies: ssp. *albicaulis*, *arenarius*, *bernardinus*, *bigelovii*, *ceruminosos*, *graveolens*, *hololeucus*, *iridis*, *junceus*, *latisquameus*, *leiospermus*, *mohavensis*, *nanus*, *nauseosus*, *nitidus*, *psilocarpus*, *salicifolius*, *texensis*, *turbinatus*, *uintahensis*, and *wasinoensis*.

[d]A total of 16 have been named at various taxonomic ranks. Hall and Clements (1923) recognized 10; Anderson (1986a) recognized 12 subspecies: ssp. *affinis*, *attenuatus*, *asper, howardii*, *imulus*, *latior*, *monocephalus*, *montanum*, *nevadensis*, *parryi*, *salmonensis*, and *vulcanicus*.

enhanced where the pappus is not removed (Stevens and others 1986), there is presently no available equipment for seeding uncleaned seed.

Seeds are generally hand collected but can be harvested with various types of seed strippers, seed beaters, and vacuums. The pappus is removed by running the seed through a barley debearder or hammermill followed by screening and fanning. Seed is generally collected between 10 and 15 percent purity. Seed can be cleaned to 95 percent purity with persistent screening and fanning. Barley debearding is preferred over hammermilling. Seeds are somewhat brittle; hammermilling can result in seed breakage and cracking in the balling of the collected material. Balling hinders seeding.

Seed cleaned to less than 70 percent purity can only be seeded aerially, by hand, or through a thimble seeder. Seed cleaned to 70 percent or greater can be run through a drill, seed dribbler, or browse seeder. Where seeds are cleaned to high purities, they need to be diluted with rice hulls or screened sawdust to facilitate seeding. Seed of most rabbitbrush species should be surface seeded or covered not more than 1⁄32 inch (0.8 mm) deep. If drilled, seed drop tubes and hoses should be removed from between the disk furrow opener and placed behind them. Seed will then be deposited behind the disk furrow opener on a disturbed soil surface. Rabbitbrush seedlings are generally not competitive and may be suppressed by other species. If drilled, thimble, dribbler, or browse seeder seeded, rabbitbrush seed should be seeded individually or with less competitive species. Broadcasting results in substantially less competition between species. Late fall and early spring seeding are preferred. Rabbitbrush seed can be stored in an open, unheated, uncooled warehouse for up to 3 years following collection without too much loss of viability.

Chrysothamnus depressus ________

Dwarf Rabbitbrush

Dwarf rabbitbrush is a small, irregularly branched, depressed shrub or subshrub 1 ft (30.5 cm) high or less, with numerous short branches arising from decumbent lower stems (fig. 34). The branches are covered with a dense scabrid pubescence. The narrowly oblanceolate to spatulate leaves are 0.7 to 2 cm long, 1 to 4 mm wide, and finely puberulent or scabrous like the branches. The heads contain five disc flowers that are arranged into compact terminal cymes. Involucral bracts have mucromate to attenuate tips, are 10 to 13 mm long, and are arranged into five distinct vertical ranks. Achenes are 5 to 5.5 mm long and glabrous or obscurely pubescent toward their apex. The soft brownish-white pappus is slightly longer than the corolla. Blooming occurs from May to October; seed matures from October to December (see chapter 20).

Figure 34—Dwarf rabbitbrush growing near the mouth of Ephraim Canyon, Sanpete County, UT.

This species occurs on dry plains, hills, and rocky mountain slopes from 3,300 to 6,900 ft (1,000 to 2,100 m) in elevations scattered over western Colorado, New Mexico, Utah, Nevada, Arizona, and southeastern California (Anderson 1986a).

Dwarf rabbitbrush is often heavily browsed by sheep, cattle, and wildlife (Hall and Clements 1923; Kufeld and others 1973). It transplants readily, can be seeded, and is useful for stabilizing depleted soils on which it readily grows. This handsome shrub is a source of protein when grasses and broadleaf herbs have dried (McArthur and others 1979a).

Chrysothamnus linifolius __________

Spreading Rabbitbrush

Spreading rabbitbrush is a tall, robust shrub up to 7 ft (2.1 m) high that spreads underground (fig. 35) by lateral roots that form adventitious shoots (Anderson 1964). Of all the rabbitbrushes only Parry rabbitbrush shares the underground spreading trait and then not nearly to the extent spreading rabbitbrush does. Leaves are large, flat, green, glabrous, lanceolate to oblong-lanceolate, 2 to 5 cm long, and 8 to 16 mm wide. Heads contain four to six, usually five, disc flowers and are arranged into broad, loose cymes. The involucral bracts have obtuse tips with thickened green spots similar to those of Vasey rabbitbrush. These spots, however, dry to a brown color. Achenes are covered with dense, long, soft hair. Blooming occurs during August and September with seed ripening from October to mid-December.

Spreading rabbitbrush occurs in Montana, Wyoming, Colorado, New Mexico, Utah, and Arizona. It is most abundant in alkaline soils along roadcuts, barrow pits, ditches, streams, and washes in the Upper Colorado River drainage.

Figure 35—Root sprouts, foreground, of spreading rabbitbrush at the Snow Field Station.

Figure 36—Large rubber rabbitbrush growing at Palmetto, Esmeralda County, NV. The specimen pictured is the *viridulus* form of ssp. *consimilis*.

The species has aggressive underground spreading characteristics coupled with an ability to spread by seed that make it a valuable stabilizer of disturbed alkaline soils (McArthur and others 1974; 1979a; Plummer 1977). It transplants readily. Laycock and Shoop (1986) found spreading rabbitbrush to be an excellent living snowfence for the central Great Plains. Spreading rabbitbrush receives little browsing use. It does, however, provide year round cover for upland game and small birds.

Chrysothamnus nauseosus

Rubber Rabbitbrush

Rubber rabbitbrush is a shrub usually 12 to 80 inches (0.3 to 2.0 m) high, but it varies from dwarf forms to types over 10 ft (3.0 m) high (fig. 36). Usually, several erect stems arise from the base and these branch to form rounded bushes. Branches are covered with a green, yellow-green, gray-green to white feltlike tomentum usually infiltrated with a resinous gum, making the plant somewhat sticky. This coating is often mistaken for part of the bark but can be discerned by scraping with a knife edge or a fingernail. Leaves are nearly filiform in some subspecies to broadly linear in others. Leaves vary from 18 to 63 mm long and are covered with a tomentose vestiture. They are not twisted or gland-dotted. The heads of this species are usually arranged into a cymose inflorescence. Each head bears 20 to 25 glabrous to densely tomentose involucral bracts arranged in up to five vertical rows. Rubber rabbitbrush blooms from August to October and are among the latest bloomers of the genus. Plants at higher elevations bloom earlier than those at lower elevations. Seeds mature, depending on location and subspecies, and are collected from mid-October until the end of the year with over 500,000 cleaned seeds per lb (1.1 million/kg) (see chapter 24). Rubber rabbitbrush is normally a heavy seed producer (fig. 37).

Ecological Relationships and Distribution

We have recently discovered that galls induced by tephritid flies are differentially distributed among the subspecies of rubber rabbitbrush (McArthur 1986; McArthur and others 1979b—See Varieties and Ecotypes section later in this section for subspecies descriptions). Over much of their range, the white-stemmed subspecies *albicaulis* and subspecies *hololeucus* are infested with a persistent round stem gall, 0.3 to 1.2 cm in diameter. This gall was found restricted to these white-stemmed subspecies in our observations. Green subspecies *consimilis*, *graveolens*,

Figure 37—Rubber rabbitbrush in seed, south-central Utah.

and *turbinatus*, on the other hand, have a less persistent, fluffy stem gall reminiscent of a ball of cotton about 0.7 to 1.4 cm in diameter. This gall is found also on ssp. *hololeucus* in southern areas near Kanab, UT, and Colorado City, AZ. The round gall is absent in these areas. In areas where these green-stemmed and white-stemmed rubber rabbitbrush subspecies occur together the galls are specific. We have observed only a few cases of cross gall inoculation and then only on putative hybrid plants. Wangberg (1981) independently observed some species and subspecies specificity of tephritid galls on rabbitbrush in Idaho. He found less specificity for the round gall in Idaho than we did in Utah. He identified the tephritid flies that induce the galls as two different species of *Aciurina*. Dodson and George (1986) confirmed the genetic and ecological integrity of the two *Aciurina* species.

Rubber rabbitbrush ranges from British Columbia to Saskatchewan south to western Texas, Sonora, Baja California, and eastern California (Anderson 1986a, c). It is a common plant on plains, valleys, and foothills. It grows best in openings with the sagebrush, juniper-pinyon, and ponderosa pine zones in sandy, gravelly, or clay-alkaline soils. This species grows at elevations ranging from 500 to 9,000 ft (150 to 2,700 m). Rubber rabbitbrush is a vigorous early invader of disturbed sites such as roadcuts and overgrazed rangelands. On ranges where big sagebrush has been destroyed by fire, insects, vehicular traffic, or continued heavy grazing, rabbitbrush will increase and often become the dominant vegetation (Evans and others 1973; Rosentreter 1986). Nevertheless, in most habitats, this species is not overly competitive with herbaceous species, and on some sites, it does not suppress grass. Production of herbaceous cover percentage have been notably greater (fig. 38) when rabbitbrush is present than when it is not present (Frischknecht 1963; Plummer 1959; Plummer and others 1968). We find it of interest that rubber rabbitbrush has a high photosynthetic rate, not unlike desert-adapted C4 photosynthetic pathway species (Davis and others 1985).

Plant Culture

Rubber rabbitbrush can easily be transplanted in the fall or preferably in the spring to avoid frost heaving so long as the plants are physiologically inactive and moisture conditions are right and the transplants are small (10 inches tall; 25.4 cm or less). A less successful method—which, nevertheless, yields some results—is to divide dormant crowns (Hall and Clements 1923). Tissue culture techniques have been successfully employed to propagate rubber rabbitbrush (Upadhyaya and others 1985). Success was obtained from direct seeding, especially when seeds have been distributed on top of disturbed soil in the fall or early winter. Once established, natural spread can occur (Stevens 1986b).

Figure 38—Rubber rabbitbrush growing in association with smooth brome, Sanpete County, UT. Note vigor of grass under shrub canopy.

Seed germination of rubber rabbitbrush is usually quite high. Seeds maintain high viability (65 percent) for 3 years under ordinary warehouse storage conditions (Stevens and others 1981a). With cool night (40.5 °F; 4.7 °C) and warm day temperatures, rubber rabbitbrush seed germinates in about 2 days (Weber and others 1985). However, under standardized single cool temperature germination conditions, seeds from lower elevations and latitudes germinate in about half the time (2 weeks) that it takes for seeds from higher elevations and more northerly areas to germinate (McArthur and others 1987a; Meyer and McArthur 1987; Meyer and others 1989). Stevens and others (1986) have shown that seeding rabbitbrush is more successful when the pappus is left on the achene (the fruit that holds rabbitbrush seed) and the achenes are placed upright at the soil surface. Achene size in rubber rabbitbrush subspecies appears to be correlated to habitat; subspecies adapted to sandy sites have larger achenes (Meyer 1997).

Uses and Management

Rubber rabbitbrush is an excellent plant for controlling erosion because of its deep roots, heavy litter, and ability to establish on severe sites (Aldon and Pase 1981; Luke and Monsen 1984; Monsen and Richardson 1984; Monsen and Stevens 1987; USDA Forest Service 1937). Once established, this species reproduces easily and spreads fast from its light, plumed, wind-disseminated achenes (Young and others 1984b). It also grows vigorously when transplanted. The value of

C. nauseosus as browse varies greatly between subspecies and ecotypes. The white to grayish subspecies such as *albicaulis*, *hololeucus*, and *salicifolius* are more palatable to livestock and big game than the green subspecies, *graveolens* and *consimilis* (fig. 39) (Hanks and others 1975; McArthur and others 1974). Throughout much of the summer range, game and livestock browse the plant lightly, if at all, except under unusual conditions. During late summer and fall when rubber rabbitbrush is in bloom, most livestock and game graze the flowers and occasionally a few leaves and the more tender stems. Rubber rabbitbrush is most heavily browsed on winter ranges (fig. 40). Rubber rabbitbrush was found in 48 percent of the deer stomachs examined on a portion of winter range in Owens Valley, Inyo County, CA; however, it never amounted to more than 6 percent of the total food ingested (Sampson and Jesperson 1963). Crude protein content ranged from 9 percent during the dormant months to 11.8 percent in the spring after new leaves had formed (Sampson and Jesperson 1963). Antelope also make extensive use of rubber rabbitbrush (Yoakum 1986). Bhat and others (1990) found a wide range of winter nutritive quality in rubber rabbitbrush accessions growing in a uniform garden. Rubber rabbitbrush is resilient to browsing. Severely browsed plants often obtain full regrowth by midsummer following heavy browsing. Rubber rabbitbrush also provides cover for small mammals and birds.

The potential for this species to produce rubber and other chemicals has long been recognized (Hall and Goodspeed 1919). There has been a recent revival of interest in this potential (Hegerhorst and others 1987; Ostler and others 1986; Weber and others 1985). Some accessions produce up to 6 percent stem rubber and 20 percent resin content. The plant also has other possible industrial and horticultural uses (Weber and others 1985).

Rubber rabbitbrush can become troublesome on ranges when it invades and occupies disturbed lands at high densities. It is a difficult plant to control because of its resistance to herbicides and its crown sprouting nature (Evans and others 1973; Whisenant 1986b, 1987; Young and others 1976a).

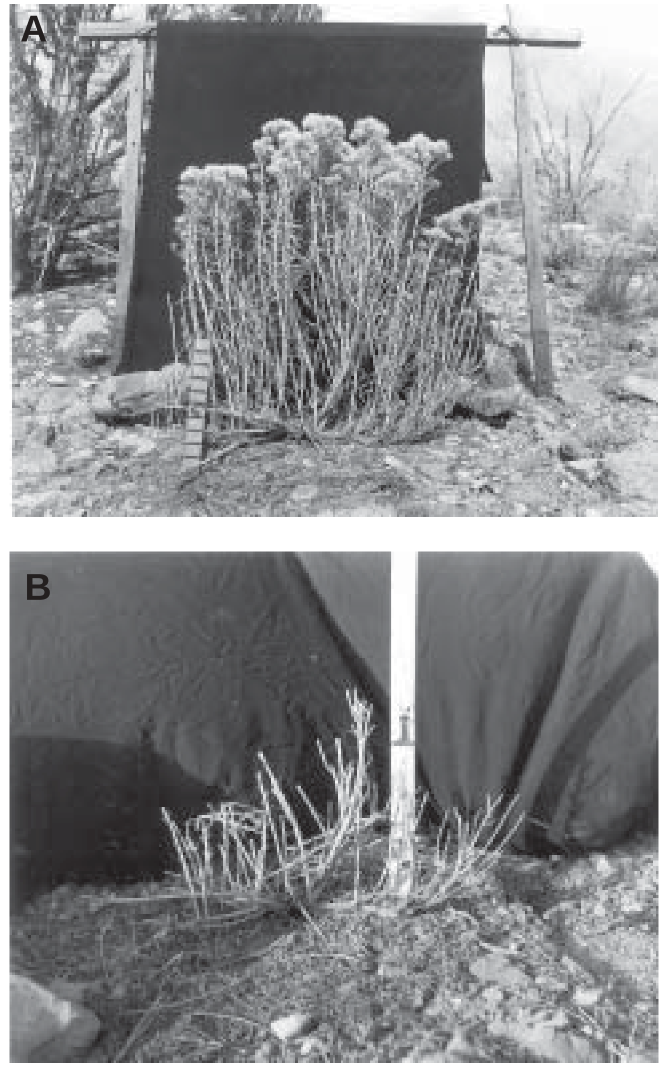


Figure 40—Heavy use of rubber rabbitbrush by deer in the winter at an experimental plot in Sanpete County, UT: (A) *C. nauseosus* spp. *salifolius* plant in the late fall; (B) The same plant after winter browsing. The stake in “A” is 1 ft tall; the mark on the stake in “B” is at 1 ft.

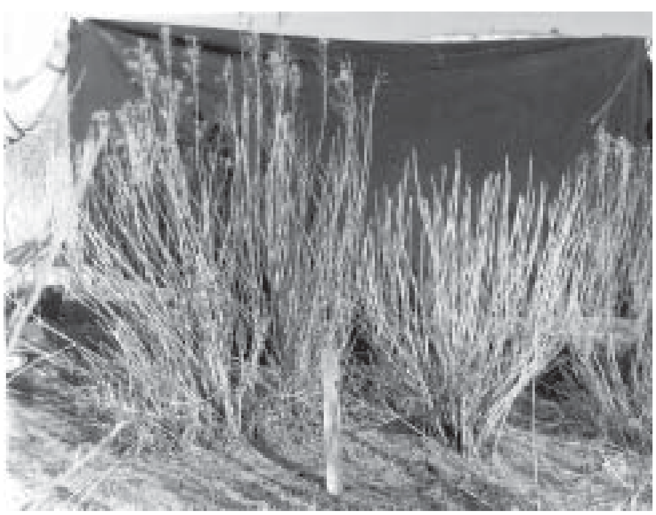


Figure 39—Differential winter-spring utilization of rubber rabbitbrush subspecies by deer in Sanpete County, UT. Left, *C. nauseosus* ssp. *consimilis* (10 percent use), right, *C. nauseosus* ssp. *hololeucus* (50 percent use).

Varieties and Ecotypes

Anderson (1986a,c) recognized some 22 subspecies of rubber rabbitbrush. Often, two or more subspecies will occur sympatrically. Each subspecies is essentially inbred and morphologically clean (Anderson 1986c; McArthur and Meyer 1987; McArthur and others 1978a). However, reproductive isolation occasionally breaks down, especially at the limits of subspecies geographical ranges, and intermediate morphological forms are found (Anderson 1986c; Hanks and others 1975; McArthur and others 1978a). Because of the mostly inbreeding, but potential for outbreeding, system of rubber rabbitbrush, many local reproductively isolated populations of rubber rabbitbrush occur. We agree with Hall and Clements (1923) that "improvement in any desired direction may be brought about by selection, or by hybridization or by both of these methods." To date, no artificial improvement has been made, but individual populations with desirable characteristics such as high rubber content, palatability, or growth form have been identified. We discuss below the more common subspecies of rubber rabbitbrush.

White stem rubber rabbitbrush—*C. nauseosus* ssp. *albicaulis* (mountain), and *hololeucus* (basin)—are shrubs from 2 to 6.5 ft (0.6 to 2.0 m) high with erect, leafy branches and leaves covered with a permanent, dense, white to grayish tomentum (fig. 41). The leaves are 2.5 to 4 cm long, 0.5 to 1.5 mm wide or sometimes to 3 mm wide in a few forms. The strongly keeled, acute involucral bracts are white, more or less tomentose, 8 to 10 mm long, and arranged into five distinct vertical ranks. The yellow corollas are 8 to 11 m long and terminate in lobes 1 to 2 mm long. The achenes are densely pubescent. The subspecies differ in the length of their corolla lobes (ssp. *albicaulis* 1 to 2 mm long, ssp. *hololeucus* 0.5 to 1 mm long) and style appendage lengths for which ssp. *albicaulis* has style appendages longer than stigmatic portions, but ssp. *hololeucus* does not (Anderson 1986a). These subspecies tend to overlap morphologically in their area of sympatry (northern Utah, northeastern and western Nevada, southwestern Idaho, and southeastern California; Anderson 1986a,c). In these areas of sympatry, subspecies *albicaulis* occurs at higher elevations (over 6,000 ft; 1,800 m) whereas ssp. *hololeucus* is confined to lower elevations. White rubber rabbitbrush subspecies are common and widespread and are found in open places in plains, foothills, and mountains from British Columbia, Alberta, and Montana southward to northwestern Colorado, Utah, Nevada, and southern California (Anderson 1986c). Subspecies *hololeucus* grows in the Great Basin area whereas ssp. *albicaulis* occurs on mountains and foothills, east, north, and west fringes of the Great Basin and beyond (Anderson 1986a,c; Hall and Clements 1923). Subspecies

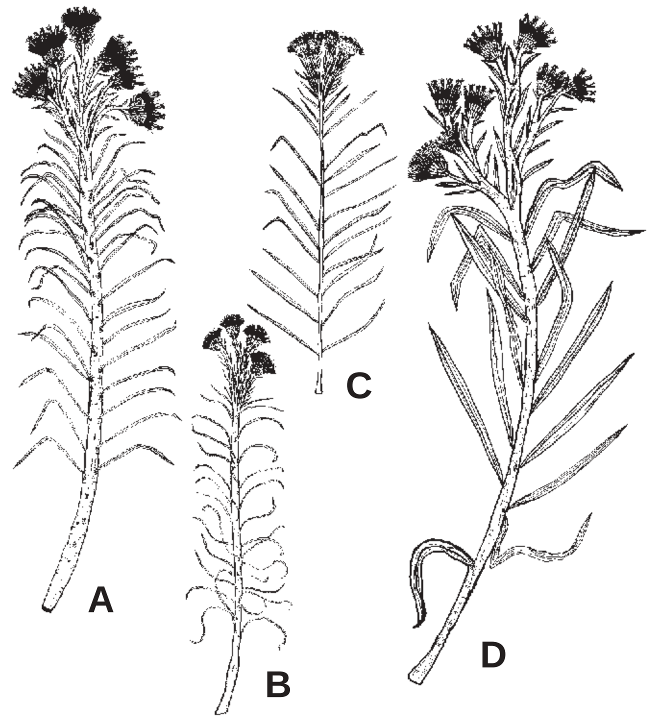


Figure 41—Four subspecies of rubber rabbitbrush: (A) *C. nauseosus* ssp. *albicaulis*; (B) *C. nauseosus consimilis;* (C) *C. nauseosus* ssp. *graveolens*; (D) *C. nauseosus* ssp. *salicifolius* (McArthur and others 1979a).

hololeucus is often intermixed with ssp. *graveolens* on foothill ranges and with subspecies *consimilis* in valleys and plains. The striking white forms of both subspecies have potential use as ornamentals (McArthur and others 1979a; Weber and others 1985). Another common white subspecies of the foothills and plains of Colorado, Wyoming, Montana, and the western Dakoatas is ssp. *nauseosus*. This subspecies is short statured, about 2 ft (61.0 cm) tall, and quite palatable to game and livestock.

Threadleaf rubber rabbitbrush (*C. n.* ssp. *consimilis*) may reach 10 ft (3.0 m) in height when mature. It has leafy, erect branches covered with a green to yellow-green tomentum. The narrow threadlike (linear-filiform) leaves are less than 1 mm wide and 2.5 to 5 cm long (fig. 41). They are usually covered with a green to yellow-green tomentum and are somewhat resinous. The involucral bracts are acute, glabrous, and keeled and are arranged in fairly distinct vertical rows. The bracts are 6.5 to 8.5 mm long. The corollas are 7 to 9.5 mm long, with glabrous lobes 1 to 2.5 mm long. The achenes are densely pubescent, suggesting that this subspecies may be a connecting link between rubber rabbitbrush and low rabbitbrush. Subspecies *consimilis* is most common in alkaline valleys and plains of the Great Basin where it is often associated with various saltbushes and black greasewood. In less alkaline areas, *consimilis* intermixes with ssp. *hololeucus* and *graveolens*. Threadleaf rubber rabbitbrush also occurs in alkaline soil outside the Great Basin from western Wyoming, Colorado, and New Mexico to northeastern Oregon and eastern California. A large ecotype, up to 12 ft (3.7 m) tall with treelike trunks, occurring principally in the western parts of its range, was formerly recognized as a separate subspecies (*viridulus*) (fig. 36). Perhaps ssp. *viridulus* should be maintained as it is higher in rubber content and in resins than ssp. *consimilis* (Ostler and others 1986). Another subspecies, *pinifolius*, has also been reduced to be synonymous with *consimilis* (Anderson 1986a). Plants formerly referred to as *pinifolius* grow in southern Colorado and New Mexico. Threadleaf rubber rabbitbrush is one of the least palatable of the *C. nauseosus* subspecies. It may, therefore, have value in revegetating disturbed sites such as roadcuts where attraction of browsing animals is not desired. This subspecies helps control erosion on open alkaline soils by providing ground cover and soil stabilization (McArthur and others 1979a).

Green rubber rabbitbrush (*C. n.* ssp. *graveolens*) ranges from 2 to 5 ft (0.6 to 1.5 m) high when mature. Its leafy, erect branches are yellow-green to green or sometimes gray-green and are covered with a compact tomentum (fig. 41). The linear leaves are 1 to 3 mm wide, 4 to 6 cm long, and only slightly pubescent. The involucral bracts are 6 to 8 mm long, glabrous at least on their backs, acute, keeled, and arranged in vertical rows. Achenes are densely pubescent. Green rubber rabbitbrush is widespread and sporadic from North Dakota to Idaho and southward to western Texas, New Mexico, and Arizona. It is most common on well-drained foothills but also extends up into the mountains and down into valleys and plains where it is often intermixed with ssp. *consimilis*. Green rubber rabbitbrush is generally less palatable than the white or gray subspecies, *hololeucus*, *albicaulis*, and *salicifolius*. Nevertheless, some forms of this subspecies have been found that are utilized to a moderate degree by livestock and mule deer.

Mountain rubber rabbitbrush (*C. n.* ssp. *salicifolius*) is a shrub from 1 to 6.5 ft (0.3 to 2.0 m) high. Its ascending to erect twigs are leafy and covered with a gray-green, fairly compact tomentum. The leaves are broadly linear, ranging from 4 to 8 cm long and 3 to 10 mm wide, which makes them the largest leaves of the species (fig. 41). The involucral bracts are 7 to 8 mm long, mostly obtuse, nearly glabrous, and arranged in rather obscure ranks. The yellow corollas are about 1 cm long and have a minutely pubescent throat. The achenes are densely pubescent. Hall and Clements (1923) reported that mountain rubber rabbitbrush is “apparently rare and confined to Utah.” However, McArthur and others (1979a) found it to be fairly widespread at higher elevations in Utah and perhaps extending to Nevada as part of the lower subalpine vegetation. It extends down to the foothills in parts of its range where it may be found intermixed with ssp. *albicaulis*, *hololeucus*, and *graveolens* (Plummer 1977). Mountain rubber rabbitbrush appears to be the most palatable subspecies for both livestock and big game of the five common subspecies, *salicifolius*, *albicaulis*, *hololeucus*, *graveolens*, and *consimilis* in Utah, and it is often browsed heavily in the fall (McArthur and others 1979a).

Other less common subspecies with locally large populations include *arenarius*, *junceus*, *leiospermus*, and *turbinatus*. Subspecies *arenarius* is a striking white shrub adapted to sand dunes in the Four Corners area. It has large heads up to 20 mm long. Subspecies *junceus* is a nearly leafless, yellow-green form adapted to sandy areas in the Colorado River drainage. Subspecies *leiospermus* is a low shrub usually less than a meter in height. It has affinities to ssp. *consimilis*. It occurs mostly on arid, rocky sites in the southern half of the Intermountain area. A distinguishing feature of ssp. *leiospermus* is its glabrous or nearly glabrous achenes. Subspecies *turbinatus* is a yellow form adapted to sandy sites, mostly in western Utah. It has large floral heads. A few additional subspecies occur principally outside of the Intermountain area. These include *bigelovii* (mostly south and west of the Four Corners area), *nauseosus* (mostly on the western edge of the northern Great Plains), and *mohavensis* (southern California) (Anderson 1986a,c; McArthur and Meyer 1987; McArthur and others 1979a).

Chrysothamnus parryi ____________

Parry Rabbitbrush

Parry rabbitbrush (*Chrysothamnus parryi*) is a shrubby species somewhat intermediate in height, stem and leaf tomentum, and growth habit between rubber rabbitbrush and low rabbitbrush. Parry rabbitbrush is a low, dense shrub similar in habit to certain forms of low rabbitbrush (fig. 42). It is usually from 8 to 24 inches (20.3 to 61.0 cm) in height with numerous spreading to erect flexible branches. Like rubber rabbitbrush, the branches of Parry rabbitbrush are covered with a feltlike white to green tomentum. The tomentum is neither as dense nor resinous as in rubber rabbitbrush. Paulsen and Miller (1968) and McArthur and others (1979a) observed that Parry rabbitbrush spread from underground roots. The glabrous to tomentose, somewhat viscid leaves are narrowly linear to elliptic and range in size from 0.5 to 8 mm wide and 1 to 8 cm long. Flowerheads usually are arranged in terminal leafy racemes that sometimes form panicles. The involucral bracts are 9 to 14 mm

Figure 42—Parry rabbitbrush (*C. parryi* ssp. *howardi*) growing at Current Creek, Duchesne County, UT.

high and terminate in acuminate to very attenuate herbaceous tips. The yellow, tubular to funnelform corollas are 8 to 11 mm long. Achenes are 5 to 6 mm long and are covered with long, shaggy, appressed hairs. Blooming occurs from July to September; seed matures in October and November.

Ecological Relationships and Distribution

Parry rabbitbrush occurs in dry, open places in mountains and foothills of Western North America from Wyoming and western Nebraska west to California and south to New Mexico and Arizona. Like other species of rabbitbrush, this species tends to increase on overgrazed and disturbed areas. Populations of Parry rabbitbrush are usually smaller and more scattered than those of the other common species (rubber and low rabbitbrushes) of rabbitbrush.

Varieties and Ecotypes

Parry rabbitbrush is a diverse widespread group, with 12 subspecies (Anderson 1986a; McArthur and Meyer 1987).

Chrysothamnus parryi ssp. *asper* is a low shrub 6 inches (15.2 cm) or more high with slightly spreading to erect branches. Its green leaves, roughened with short-stalked resin glands, are 2 to 5 cm long and 1 to 3 mm wide. The heads contain five to 10 disc flowers and are subtended by somewhat ranked involucral bracts with straight tips. This subspecies occurs on mountain sides bordering desert areas from 6,900 to 8,500 ft (2,100 to 2,600 m) in elevation in western Nevada and eastern California (Anderson 1986a; McArthur and others 1979a).

Chrysothamnus parryi ssp. *attenuatus* consists of low shrubs with mostly erect stems up to 2 ft (61.0 cm) high. It has green, slightly viscid, narrowly linear leaves, 2 to 4 mm long and about 1 mm wide. The leaves are erect but are not larger than the inflorescence. Heads contain five to seven disc flowers and are subtended by involucral bracts with slender, straight tips. The bracts are ranked into five vertical rows. Blooming occurs from August to October. Subspecies *attenuatus* is found in the sagebrush, pinyon-juniper, and yellow pine vegetation types in Utah and southwestern Colorado and northwestern New Mexico (Anderson 1986a; McArthur and others 1979a).

Chrysothamnus parryi ssp. *howardii* is a low shrub. Its spreading basal stems and erect branches are up to 2 ft (61.0 cm) high. The narrowly linear, tomentose leaves are 2 to 4 cm long, about 1 mm wide, and the upper ones usually extend beyond the uppermost heads of the inflorescence. Flowerheads contain five to seven pale yellow disc flowers. The heads are subtended by vertically ranked involucral bracts usually with spreading tips. Blooming occurs from July to September. The subspecies occurs on dry hills and mesas associated with sagebrush, pinyon-juniper, and ponderosa pine vegetational types in Utah, southern Wyoming, Colorado, New Mexico, and Nebraska (Anderson 1986a; McArthur and others 1979a).

Chrysothamnus parryi ssp. *monocephalus* is a low shrub from 4 to 24 inches (10.2 to 61.0 cm) high with rigid, spreading branches. Its viscid, somewhat tomentose leaves are linear-oblanceolate or spatulate, 1 to 3 cm long and 1.5 cm or less wide. The upper leaves usually extend beyond the inflorescence. The flowering heads occur singly or in pairs on the end of short, leafy branches. The heads contain five to six disc flowers and are subtended by obscurely ranked involucral bracts with straight, attenuate tips. This subspecies occurs in the high mountains of western Nevada and eastern California at elevations between 2,600 and 11,000 ft (790 and 3,400 m) (McArthur and others 1979a).

Nevada rabbitbrush (*Chrysothamnus parryi* ssp. *nevadensis*) consists of low shrubs with ascending to erect branches up to 2 ft (61.0 cm) high. The linear to linear-oblanceolate leaves are 1.5 to 4 cm long, 0.5 to 3 mm wide, and sometimes green to resinous, but usually gray-tomentose. The uppermost leaves rarely extend beyond the inflorescence. The flowering heads contain four to six yellow disc flowers and are subtended by ranked involucral bracts with slender recurved tips. *Chrysothamnus parryi* ssp. *nevadensis* occurs between 4,300 and 8,900 ft (1,300 and 2,700 m) in elevation on dry mountain sides from eastern California to eastern Nevada, southwestern Utah, and northern Arizona. It is most common along the eastern flank of the Sierra Nevada (Anderson 1986a; McArthur and others 1979a).

Chrysothamnus parryi ssp. *parryi* consists of low shrubs with erect branches 1 to 2.5 ft (30.5 to 76.2 cm) high. The uppermost leaves usually extend beyond the inflorescence. Flowering heads contain 10 to 20 disc flowers and are subtended by obscurely ranked involucral bracts with straight attenuate tips. It blooms during August and September. Subspecies *parryi* grows in dry plains, valleys, and hillsides in central Nevada, southern Utah, south-central Wyoming, western Colorado, and northern New Mexico (Anderson 1986a; McArthur and others 1979a).

A few other subspecies of *C. parryi*, such as *affinis*, *glandulosa*, *imulus*, and *vulcanicus*, occur outside of or only on the fringe of the Intermountain area and in small numbers (Anderson 1986a; Hall and Clements 1923). No efforts have been made to improve Parry rabbitbrush. The species contains abundant genetic variation. Its ssp. *howardii* is thought to be involved in the parentage of *C. nauseosus* ssp. *utahensis* (Anderson 1984).

Chrysothamnus vaseyi

Vasey Rabbitbrush

Vasey rabbitbrush is a low, rounded shrub with ascending to erect branches up to 1 ft (30.5 cm) high. The bark on the young branches is pale green to whitish and glabrous, becoming brown and fibrous with age. Leaves are linear to linear-oblanceolate, 1 to 2.5 cm long, 1 to 3 mm wide, and glabrous. Heads contain five to seven disc flowers each and are arranged into small, compact cymes. The obscurely ranked involucral bracts are 5 to 7 mm high, oblong, obtuse to rounded, and all but the innermost have a thickened greenish spot near the apex. The achenes are about 5 mm long, terete, longitudinally 10-striate, and glabrous. Blooming occurs from July to September; seed matures from October until mid-December (table 1).

Vasey rabbitbrush occurs scattered over plains, hillsides, and mountain valleys at altitudes of 5,600 to 8,500 ft (1,700 to 2,600 m) mostly in Utah and Colorado, but also in New Mexico and Wyoming (Anderson 1986a; Hall and Clements 1923).

This shrub is browsed by sheep but is small and so scattered that it provides little forage (McArthur and others 1979a).

Chrysothamnus viscidiflorus

Low Rabbitbrush

Low rabbitbrush varies in appearance and foliage characteristics. It is usually 1 to 3.5 ft (0.3 to 1.1 m) tall with many erect stems branching from a simple base (fig. 43). The brittle, erect twigs are glabrous or puberulent with pale green or white bark. Leaves are narrowly linear to oblong or lanceolate, 1 to 6 cm long and often twisted. Leaf vestiture is glabrous or pubescent and commonly viscidulous with usually scabrous margins. Degree of pubescence may vary tremendously in variants of this species. As Hall and Clements (1923) pointed out, sometimes the pubescence among the subspecies of low rabbitbrush "will occur as a fairly dense though minute puberlence in certain plants, while others almost exactly duplicating these in every other respect will be perfectly glabrous." Furthermore, L. C. Anderson (n.d.) has observed good correlation between plant stature and leaf size of ssp. *visicidiflorus* and *lanceolatus* with altitude and amount of precipitation. Flowerheads containing approximately five perfect, fertile disc flowers each are arranged in compact terminal cymes. Involucral bracts number about 15 per head and are arranged in poorly to well defined vertical ranks. The bracts of some subspecies have a greenish or brownish thickened spot near their apex (McArthur and others 1979a). Flowering occurs from August through October; seed matures from October to the end of December. Low rabbitbrush produces about 3.4 million seeds per lb (7.5 million/kg) of cleaned seed (see chapter 24). This species has strong basal sprouting tendencies, especially following top removal and injuries (Wasser 1982).

Ecological Relationships and Distribution

Low rabbitbrush is one of the most widely distributed shrubs on rangeland throughout Western North America (Anderson 1986a,b; McArthur and Meyer 1987). The species has great ecological amplitude. It occurs in dry, open areas from British Columbia and Montana, south to New Mexico, Arizona, and eastern

Figure 43—Low rabbitbrush growing at the Snow Field Station, Sanpete County, UT. This specimen is a mountain low rabbitbrush (*C. viscidiflorus* ssp. *lanceolatus*).

California at elevations between 2,600 and 11,000 ft (790 and 3,400 m). Low rabbitbrush is usually associated with sagebrush, snakeweed, and other species of rabbitbrush. Anderson (1986b) has shown that polyploid races in those subspecies where polyploidy occurs (ssp. *lanceolatus*, *puberulus*, *viscidiflorus*) are adapted to lower and drier sites than their diploid counterparts (Anderson 1986b).

Plant Culture

Low rabbitbrush can be transplanted in the fall and spring. When transplanting in the fall consideration needs to be given to frost heaving potential. Fall seeding is preferred; seed can be drilled or broadcast, and seed should not be covered more than $^1/_8$ inch (3.2 mm). Seeds can be harvested by hand and by vacuum harvesting techniques.

Uses and Management

This shrub may provide an important supply of browse to both game and livestock, particularly during late fall and winter after more desirable forage has been consumed. Throughout the Great Basin, low rabbitbrush, especially the flowering shoots, provide good sheep feed. In California small amounts of low rabbitbrush were found in deer stomachs examined between October and January (Sampson and Jespersen 1963). Much variation exists in palatability among the different subspecies. Some may be heavily utilized, whereas others are consumed little if at all (McArthur and others 1974). Variety *stenophyllus* of ssp. *viscidiflorus* on rocky foothills is often heavily used, and sometimes destructively so, with animals preferring mature or partially mature plants to green immature ones. On a Utah winter range, this subspecies averaged to 11.31 percent by weight of the diet of sheep (Cook and Harris 1950; Cook and others 1954). On another Utah winter range, mule deer diets consisted of over 80 percent low rabbitbrush in December (Austin and Urness 1983). Substantial use of ssp. *lanceolatus* in widely scattered areas of Utah and Nevada has been observed (McArthur and others 1979a). Antelope, elk, and bighorn sheep, as well as deer and livestock, show varying preferences for low rabbitbrush, depending on season, locality, and subspecies (Kufeld 1973; Kufeld and others 1973). The species, like rubber rabbitbrush, increases rapidly and vigorously on otherwise disturbed sites. Some subspecies such as stickyleaf low rabbitbrush (ssp. *viscidiflorus*) and mountain low rabbitbrush (ssp. *lanceolatus*) adapt well to higher elevations, while other subspecies such as hairy low rabbitbrush (ssp. *puberlus*) do best in lower desert and foothill habitats. Low rabbitbrush is valuable for revegetating depleted rangelands and other disturbed sites such as strip mines and roadsides (Plummer 1977).

Varieties and Ecotypes

This species includes five subspecies and several ecotypes within subspecies (Anderson 1980, 1986b; McArthur and Meyer 1987). Most important among these in the Great Basin are two glabrous subspecies, *viscidiflorus* and *axillaris*, and two pubescent subspecies, *lanceolatus* and *puberulus*. Anderson (1980) reduced ssp. *stenophyllus* to varietal status under ssp. *viscidiflorus*. Hall and Clements (1923) believe numerous intergrades have been held together in one rather close species through interbreeding where their ranges meet or overlap. Abrams and Ferris (1960) describe *C. viscidiflorus* as a highly polymorphic species composed of several freely intergrading subspecies of overlapping distribution. Intermediates are invariably found in the field. We believe forms of low rabbitbrush may be improved for grazing and other uses through selection and breeding. Because each subspecies is self-fertilized and predominately self-pollinated, each maintains its identify despite occasional outcrossing (McArthur and others 1978a).

Mountain low rabbitbrush (*Chrysothamnus viscidiflorus* ssp. *lanceolatus*) is a small shrub from 8 to 20 inches (20.3 to 50.8 cm) tall (fig. 43, 44). Its branches are straw colored or gray and are finely pubescent. Flowerheads are borne in small compact cypes with densely pubescent branches. Involucral bracts are 5.9 to 6.5 mm long, lanceolate to oblong, obtuse, and

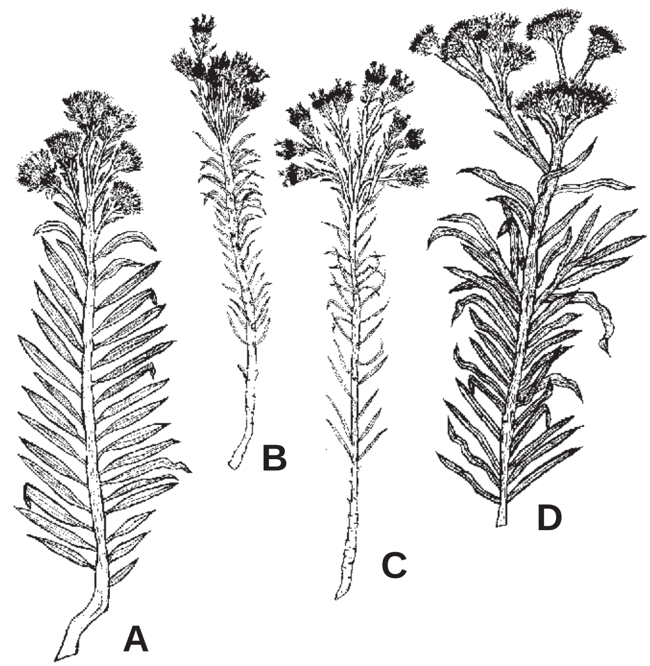


Figure 44—Three subspecies and a variety of low rabbitbrush: (A) *C. viscidiflorus* ssp. *lanceolatus*; (B) *C. viscidiflorus* ssp. *publerus*; (C) *C. viscidiflorus* ssp. *viscidiflorus* var. *stenophyllus*; (D) *C. viscidiflorus* ssp. *viscidiflorus*.

glabrous to pubescent. Achenes are densely strigose. On the basis of his systematic investigations in the genus *Chrysothamnus*, Anderson (1980) recommended placing the former ssp. *elegans* in synonymy with *C. viscidiflorus* ssp. *lanceolatus*. Chromatographic work by McArthur and others (1978a) supports this consolidation. Mountain low rabbitbrush is widespread and fairly common in dry foothill and mountainous habitats from 5,000 to 10,500 ft (1,500 to 3,200 m) ranging from British Columbia, east to Montana, and south to New Mexico, Utah, and Nevada. This subspecies may be found growing with such shrubs as big sagebrush, snakeweed, various subspecies of rubber rabbitbrush, Greene's rabbitbrush (*C. greenei*) and Parry rabbitbrush (*C. parryi*) (McArthur and others 1979a).

Hairy low rabbitbrush (*Chrysothamnus viscidiflorus* ssp. *puberlus*) is a small shrub up to 20 inches (50.8 cm) high with yellowish to green, finely pubescent branches (fig. 44). Its linear-filiform to linear leaves are sparsely to densely pubescent with scabrid-ciliate margins and are usually twisted or revolute. The leaves are up to 2 mm wide and up to 3 cm long. Flowerheads are borne in small compact cymes with densely pubescent branches. Involucral bracts are about 5 to 6 mm long, lanceolate to oblong, acute to obtuse, and are usually marked with a thickened greenish spot near their tips. Hairy low rabbitbrush occurs on dry plains, valleys, and foothills, especially on poorer soils and disturbed areas. Its range is essentially the Great Basin area from southern Idaho and Oregon south through Utah and Nevada to eastern California and northern Arizona (Anderson 1986a). This subspecies is most abundant in the big sagebrush communities of western Utah, Nevada, and south-central Idaho. However, it has been found growing in one locality or another with most of the other subspecies of low rabbitbrush, shadscale, winterfat, halogeton, and occasionally with pinyon and juniper (McArthur and others 1979a).

Stickyleaf low rabbitbrush (*Chrysothamnus viscidiflorus* ssp. *viscidiflorus*) is the largest subspecies of low rabbitbrush. Mature shrubs are usually more than 20 inches (50.8 cm) tall, whereas the other subspecies are normally under 20 inches (50.8 cm). Its branches, leaves, and inflorescences are glabrous but viscid (sticky). The broadly linear to narrowly lanceolate, bright green leaves are 1 to 5 mm wide, 2 to 5 cm long, and flat to twisted (fig. 44). Leaf margins are sometimes scabrid. Crushed foliage usually emits a pungent odor. Branches of the stems are glabrous. Involucral bracts are obtuse, oblong, not keeled, and 5 to 7 mm long. Stickyleaf low rabbitbrush is widely distributed on dry plains and hills from Washington, Idaho, Montana south to Colorado, Utah, Nevada, northern Arizona, and eastern California. It occurs primarily in sagebrush and pinyon-juniper communities at elevations between 5,000 and 8,500 ft (1,500 and 2,600 m). This subspecies often becomes dominant in cleared or overgrazed areas. At lower elevations stickyleaf low rabbitbrush may be associated with such halophytes as shadscale, winterfat, and halogeton. Other subspecies of low rabbitbrush are also often associated with it.

Anderson (1971) recommends placing the former ssp. *pumilis* in synonymy with *C. viscidiflorus* ssp. *viscidiflorus* because its specimens are "only environmentally modified variants of *C. v.* ssp. *viscidiflorus*." Chromatographic work (McArthur and others 1978a) supports Anderson's reduction of *pumilus* to synonymy. Because of its distribution from moist to arid sites, the species is well suited to a wide range of disturbed sites over the Western States (McArthur and others 1979a). Recently Anderson (1980) reduced ssp. *stenophyllus* to varietal status under ssp. *viscidiflorus*. This variety is known as narrowleaf low rabbitbrush (fig. 44). It is a low, glabrous shrub up to 12 inches (30.5 cm) high with white bark. Leaves are linear-filiform, often twisted, viscidulous, 1 mm or less wide, 1 to 3 cm long, and glabrous except for the usually scabrid and revolute margins. The branches of the small, compact cymes are glabrous. Involucral bracts are 4 to 6 cm long, not keeled, and lance-oblong.

Narrowleaf low rabbitbrush is rather common on many desert ranges, particularly in the northern Great Basin and adjacent areas (Anderson 1980, 1986c). On these ranges this variety is usually found in the sagebrush type on poorer soils and disturbed sites, but is also found growing with halophytes such as shadscale, fourwing saltbush, greasewood, and halogeton.

Anderson (1980, 1986a) recognized two other subspecies of low rabbitbrush. These are ssp. *axillaris* and *planifolius*. The former subspecies is morphologically quite similar to var. *stenophyllus*, but occurs mostly in the southern Great Basin and on the Colorado Plateau and appears by its somewhat attenuate bracts to be introgressed by Greene's rabbitbrush. It is quite abundant in certain locales. Subspecies *planifolius* is a local form with small heads and flat leaves endemic to Coconino County, AZ (Anderson 1986a).

Other Rabbitbrushes

Alkali rabbitbrush (*C. albidus*) and Greene's rabbitbrush (*C. greenei*) are two other relatively important species. Alakli rabbitbrush is a much branched, leafy shrub. It has erect, brittle, glabrous, very resinous, whitebarked branches up to 3 ft (91.4 cm) high. The glabrous, filiform leaves are 1.5 to 4 cm long, 0.5 to 2 mm wide, and the margins become revolute. Their surface is covered with small pits and abundant resinous exudate. Heads with four to six white disc flowers each are arranged in small compact cymes. Each head is subtended by approximately 15 glabrous, resinous, involucral bracts. These are 7 to 9 mm long and terminate in attenuate to acuminate, usually curved tips. The pappus is abundant and longer than the corollas. Mature achenes are about 4 mm long and densely covered with long soft hairs. Blooming occurs from August to November. This species is a definite halophyte. It occurs most commonly along the western side of the Great Salt Lake desert but is also found across Nevada to eastern central California in alkaline soils. Alkali rabbitbrush may invade strongly alkaline areas as a pioneer plant. In less alkaline flats it may be associated with threadleaf rubber rabbitbrush, basin wildrye, and greasewood. This species has value as ground cover on alkaline soils (McArthur and others 1979a).

Greene's rabbitbrush is a small highly branched shrub only 4 to 14 inches (10.2 to 35.6 cm) high. Its glabrous brittle twigs are green at first but soon become white and shiny. Bark on the lower branches often peels off in sheets (Hall and Clements 1923). The nearly glabrous or slightly scabrous-ciliate leaves are narrow, linear, 1.2 cm or less wide, 1 to 3.5 cm long, and are more or less viscidulous. Flowerheads normally contain five disc flowers in rounded or flat topped cymes. The involucral bracts are 5 to 7 mm long, arranged in five poorly defined vertical ranks, and terminate in narrowly acuminate, greenish tips. The tubular to funnelform corollas may be whitish or yellow and 4 to 4.5 mm long. Achenes are about 3 mm long and are covered with dense, long, shaggy hairs. Greene's rabbitbrush has been divided into two subspecies, ssp. *greenei* and ssp. *filifolius* by some authors (Hall and Clements 1923; Harrington 1964; Kearney and Peebles 1960). These authors separate ssp. *filifolius* from *greenei* by its normally larger stature and shorter narrower leaves. McArthur and others (1978a) believe no subspecies should be recognized because the purported subspecies are (1) chromatographically similar and (2) often occur in mixed populations. The chromatographic data from McArthur and others (1978a) further suggest that *C. greenei* could be considered a subspecies of *C. viscidiflorus* rather than a separate species. *Chrysothamnus greenei* closely resembles *C. viscidiflorus*, particularly ssp. *axillaris* and ssp. *viscidiflorus* var. *stenophyllus*. All have a low bushy habit, whitebarked stems, and short narrow leaves. Furthermore, ssp. *axillaris* has involucral bracts with attenuate tips (Anderson 1964) that closely resemble those of *C. greenei*. We concur with Hall and Clements (1923) who felt the similarity between *C. greenei* and *C. viscidiflorus* indicated a close genetic relationship. Greene's rabbitbrush occurs on plains, valley, and foothills in Colorado, New Mexico, Nevada, and Utah. Overgrazing allows it to greatly increase, sometimes forming a subclimax community (Hall and Clements 1923). This species provides cover and emergency browse in areas where it is abundant.

There are several other rabbitbrush species (Anderson 1986a). These are all less common than the species discussed or are outside of the geographical area of concern for this treatment. These are *C. gramineus* and *C. eremobius* both related to the genus *Petradoria* and of limited distribution in uplands of southern Nevada (and for *C. gramineus*, adjacent California). *Chrysothamnus molestus* is a rare, distinctive species from Coconino County, AZ. Both *C. pulchellus* and *C. spatulatus* are distinctive species that occur southeast of the main distribution of the genus *Chrysothamnus*. *Chrysothamnus humilus* is similar in some respects to low rabbitbrush, but is distributed on the northwest fringe of the species distributional range. Both *C. paniculatus* and *C. teretifolius* are viscid hot desert southwest shrubs. The former is more common in gravelly washes whereas the latter occurs mostly on rocky slopes.

Other Composite Shrubs

Haplopappus species (goldenweed), *Tetradymia* species (horsebrush), *Gutierrezia* species (matchbrush or snakeweed), *Lepidospartum latisquamatum* (scalebroom)

Both goldenweed and snakeweed belong to the same tribe (Astereae) of Compositae that rabbitbrush does (McArthur and others 1978a). Horsebrush and scalebroom belong to the tribe Senecionieae. *Haplopappus* is a large genus that is mostly herbaceous. Its constituent species are widely distributed but usually scattered over Western rangelands (Hall 1928; USDA Forest Service 1937). The most notable shrubs are goldenweed rabbitbrush (*Haplopappus bloomeri*) and its near relatives (Anderson 1983). Goldenweeds are generally of little forage value, but they are of value in erosion control (USDA Forest Service 1937). Other shrubby goldenweeds include *H. macronema*, *H. suffruticosus*, *H. resinosus*, *H. greenei*, and *H. carthamoides* (Hitchcock and others 1955).

The genus *Tetradymia* consists of rather low, stiffly branched shrubs (fig. 45). The stems are uniformly canescent or have glabrous to woolly streaks running down the stem internodes from the primary leaves. The tomentum may be permanent or deciduous on both the stem and leaves. Spines may be present (fig. 46). *Tetradymia* bears primary and secondary leaves. Primary leaves develop alternately along

Figure 45—Gray horsebrush growing at Wasatch Station, Summit County, UT.

elongated shoots and are usually long-lived. Secondary leaves develop in fascicles in the axils of the primary leaves. They are generally short-lived and often dry up and fall away within a few weeks (Strother 1974). Horsebrush flowers are borne in heads located singly or in pairs in the upper primary leaf or spine axils or are clustered in short, dense racemes or corymbs at the tips of branches. Each head contains from four to nine yellow disc flowers. Ray flowers are lacking. Four to six equal involucral bracts with overlapping sides subtend each head. The pappus consists of numerous bristles or scales or may be lacking. The ovary of each flower develops into a glabrous to densely longhaired achene.

This genus blooms from April to August depending on elevation, climatic conditions, and species. Numerous small moths, bees, flies, and beetles visit the

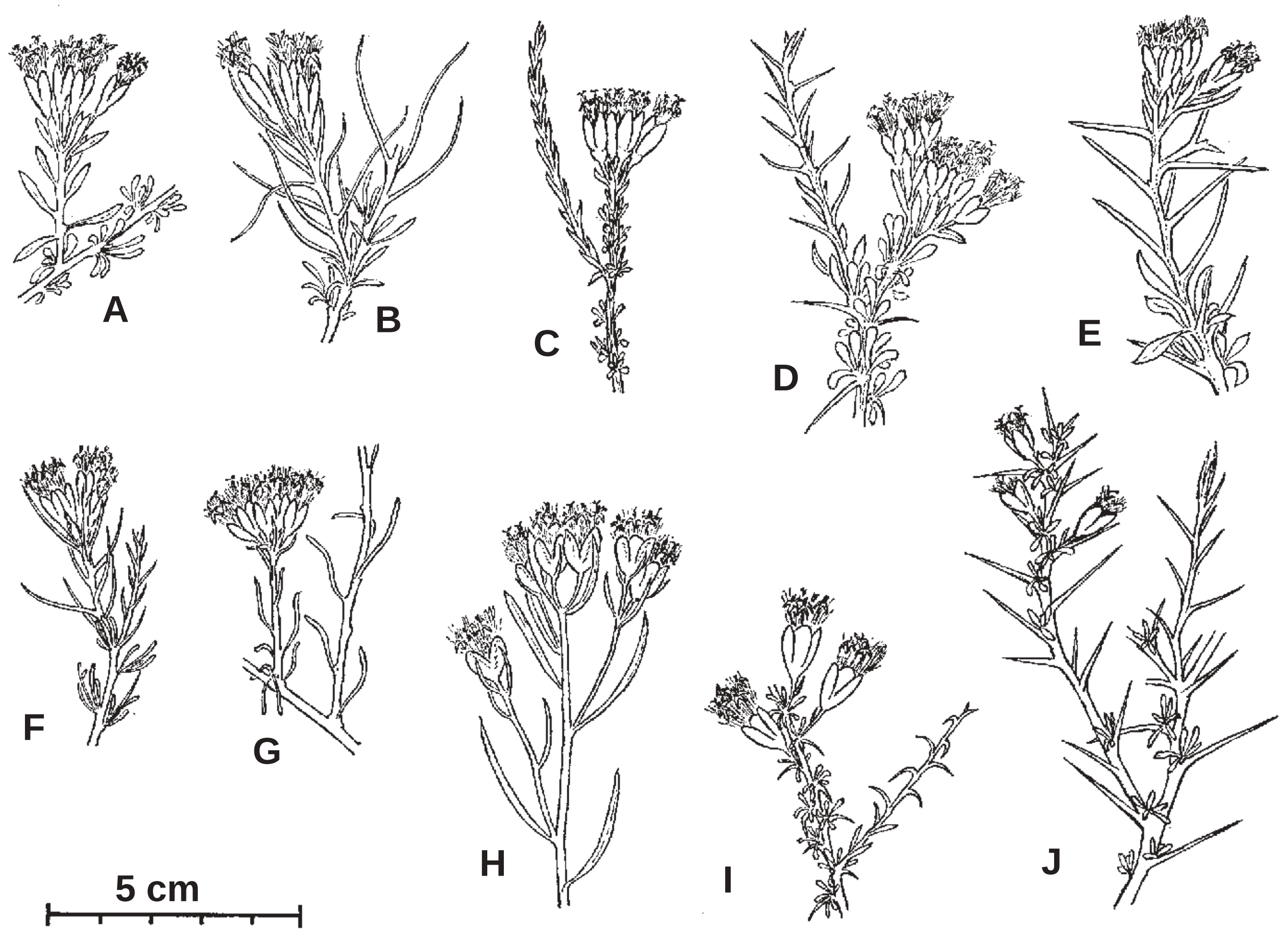


Figure 46—Horsebrush species (Strother 1974): (A) *Tetradymia canescens*, (B) *T. filifolia*, (C) *T. glabrata*, (D) *T. nuttallii*, (E) *T. stenolepis*, (F) *T. argyraea*, (G) *T. tetrameres*, (H) *T. comosa*, (I) *T. spinosa*, (J) *T. axillaris* var. *longispina*.

flowers. Although numerous potential pollinators are available and the flowers are highly fertile, seedlings are not commonly seen in nature. This is probably due to the harsh environment in which horsebrush is usually found (Strother 1974). However, young plants and sprouts may be found growing in burned-over areas (McArthur and others 1979a). Horsebrush provides some critically needed ground cover in the dry, sparsely vegetated desert ranges where it grows. Although several species are poisonous to sheep and have caused losses of thousands of animals in Utah and Nevada, horsebrush is browsed particularly heavily during winter and early spring on desert ranges and overgrazed areas where little else may be available this time of year. In fact, Zimmerman (1980) has built a successful winter range cattle operation in central Nevada on horsebrush and other desert shrub species that are often considered useless. Severe losses have occurred when hungry animals have been trailed from winter to summer ranges through stands of horsebrush without allowing the animals a chance to graze other plants (Kingsbury 1964). Considerable variation in toxicity within and between species of *Tetradymia* has been noted by Johnson (1974a,b), who believed ingesting black sagebrush and horsebrush under certain poorly understood conditions is responsible for toxicity. Four horsebrush species (*T. canescens*, *T. glabrata*, *T. nuttallii*, and *T. spinosa*) are quite common in the Intermountain area. The first two species are spineless, and the latter two are spiny (McArthur and others 1979a). *Tetradymia axillaris*, another spiny species, occurs on the edge of the Intermountain area in scattered populations from southwestern Utah to southern California. Two other species are found southwest of the Intermountain area: *T. argyraea* (southeastern California) and *T. comosa* (southern California and Baja California) (McArthur and others 1979a; Strother 1974).

The broom snakeweeds (*Gutierrezia* formerly *Xanthocephalum*) consist of mainly perennial herbs and low suffrutescent shrubs (subshrubs) with woody roots, crowns, and stem bases (fig. 47). A few species are annuals (Lane 1985). However, of these only, *G. sphaerocephala* occurs in the Intermountain area (in New Mexico). These perennials are ordinarily short-lived as well. Snakeweed leaves are entire, linear to narrowly oblanceolate, and usually sticky from resin exuded to the surfaces of both leaves and young stems. Numerous small heads form in loose or crowded terminal clusters. Resinous, imbricated involucral bracts within thin membranous margins and green tips subtend each head. A few yellow ray and disc flowers are both present (fig. 48). The ray flowers are usually pistillate and fertile, while the disc flowers are usually perfect and fertile or sometimes staminate. Pappi of several small scales or awns are generally pubescent. Blooming occurs from May to October. The numerous common names of this genus are perhaps indicative of its wide distribution. The genus consists of about 25 species scattered throughout western North and South America (Hitchcock and others 1955; Lane 1985). Only two of these species, *G. sarothrae* and *G. microcephala*, are of importance in the Intermountain area although there are two less common endemics, *G. petradoria* and *G. pomariensis* (Welsh and others 1987). Some additional North American species include *G. bracteata*, *G. californica*, and *G. serotina* (Lane 1985; McArthur and others 1979a; Solbrig 1971; . Snakeweed commonly invades depleted ranges and is considered an indicator of

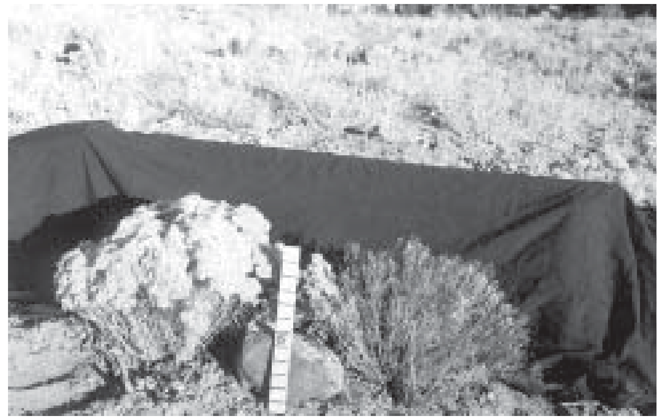


Figure 47—Broom snakeweed, right, growing next to hairy low rabbitbrush, left, near Ephraim, Sanpete County, UT.

Figure 48—Broom snakeweed, right, with its showy ray flowers, growing next to Parry rabbitbrush, left, in Salina Canyon, Sevier County, UT.

overgrazed rangelands. It does occur, usually in a low, but fluctuating density, in ranges in good to excellent condition. Species in this genus are generally unpalatable and seldom grazed. When eaten in quantity, this plant is more or less poisonous to sheep and goats (Benson and Darrow 1945; Kearney and Peebles 1960).

Scalebroom (*Lepidospartum latisquamatum*) is confined to sandy washes and gravelly plains in the Mojave Desert extending to the southwestern portion of the Intermountain area (Kay and others 1977e). This plant superficially resembles rubber rabbitbrush but is a member of the tribe Senecioneae and hence has diagnostic morphological as well as chemical differences from rabbitbrush (McArthur and others 1978a). Scalebroom has potential use as a revegetation plant in areas where it is adapted (Graves and others 1975; Kay and others 1977e). These authors demonstrated that seed should be planted less than 1 cm deep. Furthermore, seed viability is lost rapidly (in less than 2 years) if not stored in sealed containers.

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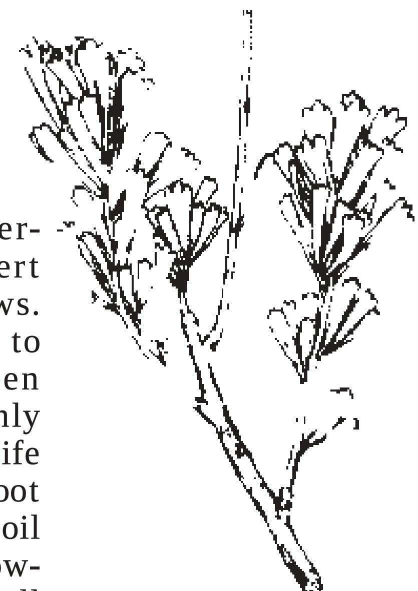
Chapter 22

Rosaceous Shrubs



Important shrubs of the Rose Family (Rosaceae) in the Intermountain region are distributed from blackbrush and salt desert shrub communities through high elevation forests and meadows. Growth habits of this group vary from trailing brambles to upright shrubs and small trees. Some species are evergreen while others are deciduous. Many of these species are highly valued for the cover, fruits, and forage they provide for wildlife and livestock. Rosaceous species that develop spreading root systems, root suckers, rhizomes, or stem layers provide soil stabilization. Several species are capable of regenerating following fire. Those that produce fragrant flowers or colorful fall foliage are prized for their ornamental value.

Because of their browse value, antelope bitterbrush and several other rosaceous shrubs were among the first species to be used in wildlife habitat improvement efforts. Members of the bitterbrush-cliffrose complex as well as serviceberries, chokecherries, and the mountain mahoganies lend themselves to artificial seeding; their seed are fairly large and relatively easy to collect, clean, store, and plant. Additional species of this family are seeing increased use in response to the growing emphasis on use of native species for wildland revegetation and low maintenance landscaping, community restoration issues, mitigation for endangered species, and a general shift to employ revegetation when deemed necessary to conserve or restore ecosystem diversity and functionality.

Chapter Contents by Species

Use of rosaceous species often presents challenges to those involved in revegetation efforts. Size and quality of seed crops vary considerably from year to year. Complex germination requirements, low initial growth rates, sensitivity to competition, and rodent and bird preference for seed and seedlings of some species hinder their establishment and reduce survival. Appropriate planting practices and management of young seedlings or plants are required to minimize these problems. Control of browsing by livestock and wildlife during the first 2 to 3 years is often essential to improve establishment and early growth.

Bareroot or containerized planting stock is commonly used to shorten the period of seedling vulnerability. Seedlings of native or introduced species of *Prunus* and *Rosa* are traditionally grown by many nurseries for conservation plantings. Antelope bitterbrush, Saskatoon serviceberry, and curlleaf mountain mahogany or true mountain mahogany seedlings are commonly grown for wildlife habitat improvement. Seedlings of specific ecotypes and most other species must generally be obtained through contract production.

Characteristics of the site of origin of seed or planting stock should be matched to those of the planting site as closely as possible; ecotypes of individual species vary considerably in range of adaptability. Although few rosaceous shrub cultivars have been selected and released for commercial production of seed and planting stock by the USDA Soil Conservation Service (Hassell 1988), a number of others are under study. Site requirements and characteristics of released cultivars have been extensively studied and documented. Publications are available describing the attributes and site requirements of commonly collected antelope bitterbrush populations (Tiedemann and Johnson 1983). Verification of seed origin of wildland collections may be accomplished by monitoring contract seed collections from designated native sites or plantings. Seed certifying agencies have developed a "source identified" classification for wildland seed certification that provides verification of site of origin as well as compliance with minimum seed quality standards (Young 1995).

Seeding recommendations for major vegetative types and conditions are discussed in chapter 17. Rosaceous shrubs adapted to these vegetative types and conditions are included in the seeding recommendations. Seed characteristics are found in chapter 24.

The following sections include a brief species description and discussions of ecological relationships, distribution, culture requirements, use, improved varieties, and management for each of these Rosaceae species.

Amelanchier alnifolia

Saskatoon Serviceberry

Saskatoon serviceberry is a deciduous shrub or small tree 1 to 20 ft (0.3 to 6 m) or more in height (fig. 1). The root system varies from a strong taproot to a branching lateral root system. New shoots develop from rhizomes extending up to 5 ft (1.5 m) from the parent plant (Hemmer 1975). Branches are reddish brown and pubescent when young, but later became glabrous. Leaf shape is extremely variable. They are approximately 1 inch (2.5 cm) long and oval to suborbicular with serrate or dentate margins to the middle or below. Perfect flowers with five showy white petals appear in large terminal clusters. Mature pomes are purple to black and 0.4 to 0.6 inch (1.0 to 1.5 cm) in diameter. Each pome contains 10 locules, each with one seed; one third to one half are commonly abortive (Blauer and others 1975; Brinkman 1974a; Harrington 1964). Seed are dark purplish-brown with a leathery seed coat (Belcher 1985). Flowers bloom from May through June and fruits ripen in July and August (Dittberner and Olson 1983).

Ecological Relationships and Distribution

Three species of serviceberry are distributed through the western United States. Saskatoon serviceberry, dwarf Saskatoon serviceberry, and Utah serviceberry. Although different geographic races have not been identified, they are expected to occur within these widely distributed species (Brinkman 1974a). In addition, several hybrids have been reported (Cruise 1964).

Saskatoon serviceberry is distributed from Alaska and the Yukon east to Hudson's Bay and south to California, New Mexico, and Nebraska (Harrington 1964; Welsh and others 1987). Plants occur from near sea level to over 9,000 ft (2,770 m) in the Rocky Mountains in areas with an annual precipitation of 12 to 25 inches (30 to 64 cm) or more (Jones 1946). Saskatoon serviceberry grows on sites ranging from dry, rocky, exposed slopes to riparian areas with deep moist soils. At the lower edge of its range, plants are often intermixed with mountain big sagebrush/grass and to a lesser extent with Wyoming big sagebrush/grass communities (Tisdale and Hironaka 1981). Saskatoon serviceberry also occurs in mountain brush, upper pinyon-juniper, and ponderosa pine communities (Blauer and others 1975). It sometimes grows in nearly pure stands, dominating other shrubs, but supporting a productive understory.

Plant Culture

A few small nurseries or conservation plantings of Saskatoon serviceberry are managed to furnish seed for planting stock production. Most seed currently used in artificial revegetation is harvested from wildland stands. Large quantities of seed can be harvested at reasonable costs during good production years. Some stands produce consistently good seed crops, but harvestable yields usually occur at intervals ranging from 1 to 5 years, depending on the site. Plants usually produce numerous flowers each year, but

Figure 1—Saskatoon serviceberry occurs as single plants, thickets, and nearly pure stands on sites ranging from riparian areas to dry, rocky slopes.

spring frosts, rust infestations, and insect damage often diminish seed production (Blauer and others 1975). Seed is disseminated by gravity and by birds and other animals that pass the seed through their digestive tracts (Hemmer 1975).

Pomes are fleshy when mature and dry slowly on the shrub. They are normally collected by hand picking or by beating the shrub to dislodge them. Seed can easily be separated from the fresh pomes. However, once the fruits dry, the pericarp remains closely attached to the seed. Dry pomes are macerated in a blender or Dybvig to separate the seed from the dried pulp. Dried material is then extracted from the seed by screening. For seed purchases recommended purity is 95 percent and germination 85 percent. There are about 45,395 seed per lb (100,078 per kg) at 100 percent purity (see chapter 24). Seeds have varying degrees of embryo dormancy that can sometimes be overcome by wet prechilling (Brinkman 1974a). Seed prechilled at 34 to 41 °F (1 to 5 °C) for 3 to 20 months germinated from 84 to 100 percent; the time requirement varied considerably among seedlots (Hargrave 1937; Heit 1968b; McKeever 1938). The seed coats of some serviceberry species also prevent germination (Young and Young 1986). Weber and others (1982) found acid scarification for 30 minutes and imbibition in a mixture of thiourea and benzyladenine released this form of dormancy. These authors found no differences in germination among different sized seed. Some selections from central Montana appear less dormant than many other populations.

Saskatoon serviceberry should be seeded separately from rapidly growing herbs. Plantings should be made in strips or scalps at least 25 to 30 inches (63 to 76 cm) wide. Seed may be drilled or broadcast seeded in a firm, prepared seedbed and should be covered with 0.25 to 0.50 inch (0.64 to 1.25 cm) of soil. Broadcast seeding without soil coverage is not recommended. Rodents quickly gather seed, even those placed in soil. Consequently, seeding in late fall or early winter after rodent activity has diminished is advised (Brinkman 1974a; Plummer and others 1968)

Seedling growth is dramatically affected by available soil water. Survival may be low if seedlings are subjected to drought during the first few months of growth. Stressed plants are often stunted, and although they may persist through one or more growing seasons, they usually do not recover. In contrast, healthy seedlings that survive the first growing season are usually very tenacious.

Saskatoon serviceberry can be grown and field planted as bareroot or container stock. Bareroot seedlings reach adequate size for outplanting in one season, developing a heavy taproot (Shaw 1984). Container seedlings are propagated from seed, germinants, or small transplants and require a 3 to 4 month cropping period (Landis and Simonich 1984). The shrub is not easily propagated from cuttings (Doran 1957). Komissarov (1938) found rooting occurred in 25 percent of all softwood cuttings taken in midsummer following treatment with 50 mg/L indole-3-acetic acid (IAA) for 24 hours. Untreated cuttings did not root. Field survival of planting stock depends on use of healthy dormant or properly hardened stock and reduction of competition on the planting site.

Uses and Management

Saskatoon serviceberry is an important browse plant for game and livestock due to its fair to high palatability (Blauer and others 1975). It is capable of persisting with a diverse and productive understory that is important for summer grazing. Saskatoon serviceberry is used by livestock, particularly sheep, in midsummer after full leaf development and after more palatable species have been browsed (Blauer and others 1975).

Big game animals make considerable use of the shrub (Kufeld 1973; Kufeld and others 1973). Tueller (1979) found serviceberry was utilized by deer during the entire year, but it was most important during the midsummer and fall months. New shoots are particularly palatable, but deer consuming large quantities of new serviceberry growth in spring can be poisoned by it. Problems also occur if Saskatoon serviceberry comprises more than 35 percent of the fall or winter diet of stressed deer (Quinton 1985). Birds utilize the bark, fruits, and leaves. The fruit is a key grizzly bear food (Mace and Bissell 1986; Zager 1980). Seed are used by rodents and small birds (Blauer and others 1975). Saskatoon serviceberry is particularly valuable as a minor species in sagebrush communities on open hillsides and ridges. Use should not be allowed to reduce plant productivity at these locations.

Saskatoon serviceberry is a useful shrub for landscape plantings in recreation areas, roadways, and other low maintenance areas. It persists in areas that receive heavy traffic and can withstand wind and severe storms. It can also be used as a background screen or for focal plantings.

Saskatoon serviceberry should not be planted off site. Sources from mountain brush communities are not well suited to lower elevations. The species has not performed well on road or mine disturbances. Developing seedlings do not survive if heavily grazed or subjected to drought stress. However, established plants, those 5 or more years of age, can withstand rather heavy use, particularly winter browsing. In fact, mature plants may be stimulated by some grazing. Plant vigor can be maintained with 60 percent fall or winter use or 40 to 50 percent spring use (Young and Payne 1948).

Saskatoon serviceberry seedlings develop slower than antelope bitterbrush seedlings. Young seedlings are seriously affected by grazing, and, unfortunately, game animals tend to seek these plants. If not heavily grazed, 4- to 5-year-old plants often begin to grow relatively rapidly. Such plants usually require 8 to 12 years to reach mature size, but some plantings of adapted ecotypes established on dry sagebrush sites have taken as much as 20 years to mature. Production of good seedcrops may not occur until shrubs reach full size. Moderate grazing of established plants may keep bushes hedged, but this usually does not cause mortality.

Mature plants tend to persist for long periods. Hemmer (1975) reported ages of 50 to 85 years for serviceberry growing in climax brush fields. Saskatoon serviceberry can remain suppressed in closed conifers stands for long time periods. Reducing canopy cover stimulates resprouting (Wright and others 1979). Regeneration from seed is normally rare (Noste and Bushey 1987).

Saskatoon serviceberry is most vigorous in seral communities. Productivity may increase following burning or mechanical control in such situations. However, where density is low or succession far advanced, such efforts may be counterproductive (Hemmer 1975; Howard 1997). Plants recover well following fires and survive even severe burns if the soil is moist at the time of burning (Fischer and Clayton 1983). Tops may be killed, but plants can resprout from rhizomes (Frischknecht and Plummer 1955). Those rhizome buds located immediately below the burned tissue sprout most readily (Bradley 1984).

Varieties and Ecotypes

Selection work has focused on comparing seed germination characteristics and site requirements of selected ecotypes. To date, studies have not resulted in identification of ecotypes unusually well suited to restoration and revegetation work, although some populations seem to produce consistently higher seed fill. For this reason, use of local material on sites previously occupied by Saskatoon serviceberry is recommended.

Amelanchier utahensis

Utah Serviceberry

Utah serviceberry is similar in growth habit to Saskatoon serviceberry. Plants vary from large upright shrubs to small trees 4 to 15 ft (1.2 to 4.6 m) tall (fig. 2). Twigs are unarmed. The alternate deciduous leaves are simple, about 0.8 to 2.0 inches (2 to 5 cm) long, and are borne on a short petiole (Harrington 1964). Leaves are suborbicular, oval, ovate or obovate with coarsely serrate-dentate margins to the middle or below. Flowers are clustered on racemes borne on short leafy branchlets. They are perfect and regular with five white petals. The stamens are numerous and inserted on the rim of the calyx tube. The ovary is inferior with three or four styles. Each locule contains two ovules. Fruits are purple to black pomes 0.2 to 0.4 inch (6 to 10 mm) in diameter (Harrington 1964; Welsh and others 1987).

Utah serviceberry differs from Saskatoon serviceberry in having a somewhat smaller stature, smaller leaves that are pubescent at least on the lower surface, three to four styles compared to four or five, and a hard, dry fruit. Davis (1952) considered Utah serviceberry a subspecies of Saskatoon serviceberry, but Jones (1946), Blauer and others (1975), and Welsh and others (1987) considered differences in fruiting and growth habits sufficient to warrant species status.

Ecological Relationships and Distribution

Utah serviceberry occurs at scattered sites from eastern Oregon to Montana and south to Texas, California, Baja California and Sonora (Blauer and others 1975; Welsh and others 1987). It is generally found on drier sites than Saskatoon serviceberry. It occurs on foothill sites at elevations from 2,000 to 7,000 ft (600 to 2,600 m) where it grows on dry, rocky outcrops and on shallow soils. It is associated with a wide number of plant communities including aspen, ponderosa pine, pinyon-juniper, mountain brush, and big sagebrush. Although it may occur in dense stands, plants are usually scattered and intermixed with other woody species.

Figure 2—Utah serviceberry is a highly variable species that usually occurs on drier sites than Saskatoon serviceberry.

Plant Culture

Fruits of Utah serviceberry ripen in late summer, but may remain on the bush for up to 2 years. Utah serviceberry plants generally produce fewer fruits than Saskatoon serviceberries; this may be due to its occurrence on drier sites. However, some stands in southern Utah's Iron County often yield extremely heavy crops. Seed are dispersed by birds and small mammals (Brinkman 1974a).

The pomes are somewhat more difficult to dislodge than those of Saskatoon serviceberry but can be collected in fairly large quantities during years of good production. To obtain seed, the dry pomes are usually placed in a blender or a Dybvig with water and macerated to separate the seed from the dry pulp. Seeds are smaller and often have lower fill than those of Saskatoon serviceberry, but germination characteristics are quite similar. For seed pruchases, recommended purity is 85 percent and germination 95 percent. There are about 25,800 seeds per lb (56,900 per kg) at 100 percent purity (see chapter 24).

Utah serviceberry is best established by drill seeding. Seed should be planted at a depth of 0.5 inch (1.3 cm) in a weed-free seedbed. Hand seeding disturbed sites or seeding with interseeders or similar implements that can selectively place seed in the soil are also effective. Seeding at rates of 2 to 4 lb per acre (2.2 to 4.4 kg per ha) is required to produce acceptable stands. Seedlings establish slowly and are sensitive to herbaceous competition. Bareroot or container seedlings are reasonably easy to produce, but they are also highly sensitive to competition.

Uses and Management

Utah serviceberry is adapted to low foothill sites, and may be used to improve diversity in sagebrush communities. Selections of Utah serviceberry have been seeded in relatively arid situations such as pinyon-juniper and big sagebrush communities where serviceberry is not native, in expectation that it may successfully establish and improve wildlife cover. Successful plantings in such areas have persisted for approximately 30 years to date, but natural recruitment has not occurred. Saskatoon serviceberry has failed to persist in such situations. Utah serviceberry is resistant to rust (*Gymnosporangium* spp.) diseases that often attack Saskatoon serviceberry (Krebill 1972; Plummer and others 1968) and is occasionally selected for planting where the rust is prevalent.

Slow establishment and poor survival have somewhat limited the use of both serviceberry species, but Utah serviceberry establishes and grows faster than Saskatoon serviceberry (Plummer and others 1968). Seedlings fail to establish when seeded in poorly prepared, weedy seedbeds. Young seedlings require protection from grazing until plants have fully established, but mature shrubs withstand considerable browsing. Some early plantings have been productive for 40 years, although little spread has been noted (Monsen n.d.). Neither serviceberry species establishes or grows well on highly disturbed sites such as roadways or mine spoils.

Utah serviceberry provides good forage for cattle and good to excellent browse for sheep and goats in early spring. Deer browse it year long, but use is particularly heavy in winter. Birds and small mammals use the berries in winter and spring (Blauer and others 1975). Plants survive fires and regenerate by sprouting (Tisdale and Hironaka 1981; Wright and others 1979).

Varieties and Ecotypes

There are no releases. Local ecotypes are recommended for on-site planting.

Cercocarpus betuloides ___________

Birchleaf Mountain Mahogany

Birchleaf mountain mahogany is an open, erect shrub or small tree varying in height from 6 to 23 ft (2 to 7 m). Although evergreen, it is similar in other respects to true mountain mahogany (Welsh and others 1987) (fig. 3). It occupies dry slopes and washes below 6,000 ft (1,846 m) from central California to southwestern Oregon (Munz and Keck 1959).

Figure 3—Birchleaf mountain mahogany stem with new leaves and flowers, just after petal fall.

Collections of birchleaf mountain mahogany from central California have been planted within the Intermountain region on game and livestock ranges because of their evergreen growth habit, seedling vigor, and drought tolerance. Healthy birchleaf mountain mahogany seedlings that survive the first growing season are usually very tenacious. However, young plants are often stunted when stressed and although they may persist for 1 or more years, they usually do not recover. The seedlings and young plants grow slightly faster than most selections of true mountain mahogany for about the first 5 or 6 years. After this time, growth rates and growth habits of the two species are quite similar.

Cercocarpus intricatus

Littleleaf Mountain Mahogany

Littleleaf mountain mahogany is an intricately branched shrub usually less than 8 ft (2.4 m) tall (fig. 4), with strongly revolute linear leaves (Blauer and others 1975). It occurs primarily in Utah, Nevada, and southern Arizona, occupying harsh rocky sites, particularly areas with high summer temperatures and infrequent rain storms. There are low-growing forms of littleleaf mountain mahogany in Oregon and Washington (Hitchcock and others 1961). Stutz (1974) suggests that littleleaf mountain mahogany is a segregant of curlleaf mountain mahogany that tends to be associated with more xeric sites. Seed germination and cultural requirements for littleleaf mountain mahogany and other mountain mahogany species are quite similar.

Littleleaf mountain mahogany is productive and evergreen with a low shrubby growth habit. It hybridizes with both curlleaf and true mountain mahogany (Blauer and others 1975; Stutz 1974).

Figure 4—Littleleaf mountain mahogany is evergreen, low-growing, and generally very palatable.

Cercocarpus ledifolius

Curlleaf Mountain Mahogany

Curlleaf mountain mahogany is an erect shrub or small tree sometimes attaining heights of 22 to 26 ft (7 to 8 m) (fig. 5) (Harrington 1964; Munz and Keck 1959). It has a rather deep, well developed root system (Noste and Bushey 1987) and one to several main trunks up to 7 inches (18 cm) in diameter with deeply furrowed reddish-brown bark. The shiny leaves are thick and evergreen, 0.4 to 1.2 inches (1 to 3 cm) long and 0.2 to 0.4 inch (0.5 to 1 cm) wide. Leaves are resinous and aromatic, entire, lanceolate, usually glabrous above and white tomentose below. Leaf margins are highly revolute, hence the name curlleaf. Flowers are solitary or in twos or threes with white to greenish-yellow sepals and no petals. The fruit is an achene 0.3 to 0.4 inch (0.8 to 1.0 cm) long with an attached plumose style elongating to 1.6 to 2.8 inches (4 to 7 cm) at maturity. The flowering period extends from May to June; fruits ripen from May to August (Blauer and others 1975; Harrington 1964; Munz and Keck 1959).

Figure 5—Curlleaf mountain mahogany, note highlining by deer.

Ecological Relationships and Distribution

Curlleaf mountain mahogany is distributed east of the Cascades and Sierra Nevadas from Washington to Baja California and east to Montana, Colorado, and Arizona. Curlleaf mountain mahogany occurs at elevations from 2,000 to 9,000 ft (615 to 2,770 m) (Harrington 1964; USDA Forest Service 1937).

Curlleaf mountain mahogany is usually found on warm, dry, rocky ridges on southern or western slopes but may occur on all exposures (Brayton and Mooney 1966; Martin 1950; Miller 1964; Tidestrom 1925). At lower elevations in the Great Basin, it often grows on limestone, decomposed granite, or other coarse-textured soils on steep north slopes and among cliffs and ledges (Dayton 1931). Plants may be nodulated by the nitrogen-fixing endophyte *Frankia* (Lepper and Fleschmen 1977).

Curlleaf mountain mahogany characteristically grows in isolated patches that are nearly pure stands. These sometimes cover considerable acreages and often form a band between conifer forests and sagebrush or other shrub communities. Curlleaf mountain mahogany is not reported as a dominant or associated species of principal forest habitat types in Montana (Pfister and others 1977), northern Idaho, or Washington (Daubenmire and Daubenmire 1968). However, the plant is a codominant with Douglas-fir in some drier forested areas in Idaho (Steele and others 1981). Dealy and others (1981) described five communities dominated by curlleaf mountain mahogany in southeastern Oregon. These include curlleaf mountain mahogany/mountain big sagebrush/bunchgrass, curlleaf mountain mahogany/mountain snowberry/grass, curlleaf mountain mahogany/Idaho fescue, curlleaf mountain mahogany/bearded bluebunch wheatgrass, and curlleaf mountain mahogany/pinegrass. Johnson and Simon (1987) described a curlleaf mountain mahogany plant community type for the Wallowa-Snake Province of northeastern Oregon. Curlleaf mountain mahogany is the dominant understory in some limber pine, white fir, and juniper series (Dealy and others 1981; Hironaka and others 1983; Steele and others 1981; Youngblood and Mauk 1985). It also grows in association with other woody species such as pinyon, oak, serviceberry, bitterbrush, or gooseberry (USDA Forest Service 1937). Curlleaf mountain mahogany occasionally occurs with ponderosa pine where both species overlap, but these sites generally do not form large or distinct communities. Extremely tall curlleaf mountain mahogany plants occur with Douglas-fir and Rocky Mountain maple in canyon bottoms and narrow draws or drainages in central and southern Utah. These small communities provide important habitat for big game and livestock.

In most situations where curlleaf mountain mahogany dominates, its crown cover ranges from 35 to 60 percent. Dealy and others (1981) counted 300 to 800 stems per acre (120 to 325 per ha) with an average of 500 per acre (200 per ha) in eastern Oregon. Somewhat higher numbers were reported from Montana, the average figure being 1,375 stems per acre (550 per ha) (Duncan 1975). In Idaho, Scheldt (1969) reported a mean of 207 shrubs per acre (84 per ha).

Three principal species of mountain mahogany (*Cercocarpus ledifolius*, *C. intricatus*, and *C. montanus*) occur in the Intermountain region (Harrington 1964; Welsh 1982). Holmgren (1987) divided *C. ledifolius* into two taxa: *C. ledifolius* var. *ledifolius* and var. *intermontanus* (Intermountain curlleaf mountain mahogany). Intermountain curlleaf mountain mahogany is distinguished from variety *ledifolius* by its broader leaves that are less densely pubescent ventrally, its usually longer petioles and hypanthium tubes, and more treelike habit. Stutz (1990) concurred with Holmgren's revision, concluding that the taxa growing in the Intermountain West apparently arrived from different origins. The evolutionary processes that produced the existing species, particularly littleleaf mountain mahogany are still proceeding. All three hybridize in areas where they overlap (Blauer and others 1975; Plummer and others 1957; Pyrah 1964; Stutz 1974). The resulting hybrid populations are frequently important components of local vegetation.

Intermountain curlleaf mountain mahogany occurs in southeastern Washington, eastern Oregon, northern, eastern, and southern California, central and southern Idaho, western Wyoming, Utah, and adjacent parts of Colorado and Arizona (Holmgren 1987). It often exists in pure stands surrounded by open sagebrush or mixed with Gambel oak, bigtooth maple, pinyon-juniper, ponderosa pine, Douglas-fir, or white pine at elevations of 4,300 to 9,800 ft (1,300 to 3,000 m). Variety *ledifolius* occurs in eastern Oregon, central and southern Idaho, southwestern Montana, north-central Wyoming, and northern Utah (Holmgren 1987). It grows on talus slides, rock outcrops and rocky slopes at elevations from 1,300 to 6,900 ft (400 to 2,100 m).

Plant Culture

Stands of curlleaf mountain mahogany produce good seed crops about in 2 of every 5 years. Few years occur when little or no seed develops. However, to be profitable for hand harvesting, a heavy seed crop with good viability must be produced; seed must ripen fairly uniformly; and most seed must remain on the bush for a period of time to permit a collection period.

Elevational range and aspect affect the period of flowering and seed development. Seed are sometimes dispersed rapidly by stormy weather conditions. Consequently, ripening seed should be checked periodically if possible, and harvested immediately when mature. Ripe seed are normally wind dispersed and can be carried some distance from the parent plant (Deitschman and others 1974a). Once the achenes fall to the ground, rodents begin gathering them; a high percent of all viable seed may be removed within 1 or 2 days. Field mice remove embryos from the achenes. Consequently, fallen achenes should be carefully examined before they are collected. Twisting of the plume in response to changes in water content plants the seed by drilling it into the ground (Dealy 1978).

Seed are harvested by beating the shrub to dislodge the achenes and catching them in lightweight tarps or netting placed down wind. Plumes can be removed with a Dybvig or barley debearder. The material is then screened with a fanning mill to separate the seed from the remaining debris. If harvested lots contain numerous small twigs, they must be separated over a gravity table to improve purity. Seeds are not removed from the achenes. The ripened seed are hard and brittle and can be fractured or broken by improper cleaning procedures, thus hammermilling should be avoided. Purity of at least 90 percent and germination of at least 80 percent are recommended for seed purchases. There are about 51,865 seeds per lb (114,342 per kg) at 100 percent purity (see chapter 24). Curlleaf mountain mahogany seeds remain viable for extended periods in storage. Stevens and others (1981a) found little loss of viability after 7 years of warehouse storage. Nearly 85 percent of seeds stored for 15 years germinated.

Freshly harvested seed is dormant and requires wet prechilling (Dealy 1975; Deitschman and others 1974a). Dealy (1975) found seed prechilled at 39 °F (4 °C) for 170 or 270 days germinated to 98 and 100 percent, respectively. He concluded that the membrane surrounding the embryo may block gas diffusion and be a principal factor in controlling dormancy. Young and others (1978) found that soaking seed at 41 °F (5 °C) for 21 days in an aerated solution of potassium nitrate and gibberellin improved germination over a range of temperatures. Drying the seed narrowed the temperature range permitting germination, but increased germinability was retained at these temperatures.

Curlleaf mountain mahogany fruit size varies among ecotypes and collection sites. To date, seed size has not been closely correlated with site conditions. Differences may be due, in part, to genetic traits; sources producing large fruits tend to perpetuate this trait when planted on different sites.

The oblong achenes of curlleaf mountain mahogany are large enough that they are easily handled and planted alone or in mixtures with other shrub seed using conventional drills. They may also be hand seeded in selected spots. Curlleaf mountain mahogany establishes best from fall seeding because of its wet prechilling requirement and ability to germinate at low temperatures (Dealy 1975; Plummer and others 1968). In addition, late fall or early winter seeding, when rodents are less active, reduces seed predation. Concentrating seedings in areas with low rodent populations can greatly enhance seeding success.

Curlleaf mountain mahogany seedlings are not competitive with exotic annuals, particularly cheatgrass. Attempts to plant curlleaf mountain mahogany at lower elevations of mountain brush and big sagebrush communities infested with these weeds have generally not been successful. Proper seedbed preparation and control of competing herbs are essential for shrub establishment. Phillips (1970) reported high seed germination occurred on mineral soils cleared of litter and plant competition.

Seedlings emerge early in spring following ground thaw when soil water is likely to be favorable. However, seedlings are sensitive to late frosts. Dealy (1975) found new seedlings exhibit rapid root growth in relation to top growth, providing some resistance to drought and codeveloping competition. However, Scheldt and Tisdale (1970) did find heavy seedling mortality occurred during the first summer of establishment, often resulting from drought and predation by rodents and rabbits.

Curlleaf mountain mahogany can be propagated and field planted as bareroot or container stock (Butterfield and Tueller 1980; Landis and Simonich 1984; Shaw 1984). Seedlings develop rapidly in bareroot nurseries. They must be lifted when dormant. Evergreen plants are particularly sensitive to lifting and handling once growth has begun. Damage to the taproot should be avoided during lifting. Container stock is easier to handle and often provides better establishment (Ferguson 1983; Landis and Simonich 1984). Propagation of curlleaf mountain mahogany from stem cuttings is difficult (Everett and others 1978).

Uses and Management

Because of its evergreen habit and occurrence between forest and shrub communities, curlleaf mountain mahogany provides important cover and forage for a wide variety of wildlife species. Curlleaf mountain mahogany produces highly palatable winter browse and thermal and hiding cover for elk, deer and other big game (Dealy 1971, 1975; Kufeld and others 1973; Mueggler and Stewart 1980; Smith 1952). Tueller (1979) reported curlleaf mountain mahogany was one of six shrub species that comprised the largest single fraction of deer diets on winter ranges in Nevada. It is also ranked as a principal winter browse for big game in Utah (Richens 1967), Oregon, and Washington (Mitchell 1951). Curlleaf mountain mahogany provides food, hiding cover, and nesting sites for many birds (Dealy and others 1981).

Blauer and others (1975), Duncan (1975) and Mueggler and Stewart (1980) reported livestock make light use of mature curlleaf mountain mahogany shrubs. However, seedlings and young stands can be heavily browsed. Many healthy stands support a diverse herbaceous understory that provides good summer forage for sheep and cattle (Dealy and others 1981), but they are often inaccessible to livestock in winter. Curlleaf mountain mahogany has good nutritive value (5.9 percent digestible protein) and digestibility (64.8 percent) in winter (Bissell and Strong 1955; Smith 1952; Welch 1981). It is one of only a few shrubs to exceed the protein requirements of wintering mule deer; its leaves are evergreen and retain high protein levels throughout the winter (Welch and McArthur 1979b). Winter phosphorus level (0.18 percent) exceeds the lower range of phosphorus required for wintering mule deer (Trout and Thiessen 1973; Tueller 1979).

Curlleaf mountain mahogany is a useful species for revegetating roadway and mine disturbances (Hungerford 1984; Stark 1966) and it is an excellent ornamental. It requires little maintenance, the leaves are attractive and evergreen, and it withstands considerable traffic and browsing. Compared to other wildland shrubs, it responds well to supplemental watering. Curlleaf mountain mahogany wood is extremely dense as a result of its low growth rate. It has been used for charcoal, fenceposts, and wood carving (Blauer and others 1975). Stands are occasionally logged for firewood.

Curlleaf mountain mahogany exhibits three characteristics that should be recognized and understood if the species is to be used in revegetation projects. First, seedlings can perform well on exposed sites if protected from competition. Second, young plants can persist and furnish considerable high quality forage even when moderately to heavily grazed. Under such conditions plants will not reach mature stature and could be weakened or killed if subjected to other forms of stress. Third, although seedlings are not compatible with herbaceous competition, established plants do very well in conjunction with some highly productive herbs. Curlleaf mountain mahogany could be more widely planted with some herbaceous species to improve total and seasonal forage production if the shrubs were planted in separate strips or spots from the herbaceous species.

Many stands of curlleaf mountain mahogany exist with little herbaceous understory. Shrub/grass plantings established with intermediate wheatgrass and other introduced herbs can be very productive. However, the ability of the shrub to regenerate naturally under such conditions is reduced, particularly on deep, productive soils. On shallow, rocky soils, where weedy grasses and herbs have not gained dominance, native forbs can usually be seeded along with the shrubs.

Curlleaf mountain mahogany requires a longer period to attain mature stature than most other shrubs. Plantings and stand rejuvenation treatments should be extensive to reduce the impact of browsing during establishment or recovery (Gruell and others 1985). Plantings established in south central Idaho and protected from livestock and deer use grew relatively slowly for about 6 years, but then grew dramatically during the next 4 to 6 years. This growth pattern has been noted in other protected study locations (Monsen n.d.). Because the species is highly palatable (Mueggler and Stewart 1980; Smith 1952), the naturally slow-growing plants are continually browsed and, if not protected, remain in a stunted condition, assuming a rounded, hedged form (Blauer and others 1975; Garrison 1953). Plantings established in central Utah in 1950, for example, have survived continuous heavy browsing, and the shrubs have remained quite small. Once released from grazing, hedged plants can recover quickly. Ferguson (1983) recommended browsing be limited to 50 to 60 percent of current annual growth to maintain productivity and a vigorous, shrubby growth habit.

Many extensive stands of curlleaf mountain mahogany have been highlined. Most plants are mature to decadent. New growth is out of reach of browsing animals. Growth from lower branches diminishes as a result of hedging and shading. Little or no reproduction occurs in these closed stands (Phillips 1970). Various treatments have been investigated to regenerate them. Stands with live branches within reach of browsing animals have been treated by top pruning in Utah and Montana. Pruning in spring or early fall prompted regrowth and increased forage availability (Austin and Urness 1980; Garrison 1953; Ormiston 1978; Thompson 1970), but such treatments are expensive. Chaining or bulldozing kills most older or highlined, single stemmed plants (Christensen and others 1966; Dealy 1971), but can be used to open areas within closed stands for natural regeneration or planting.

Plants growing on shallow soils and exposed sites, usually midwinter ranges for game, are difficult to manage. Curlleaf mountain mahogany growing in monotypic stands or in mixed stands with other shrubs such as antelope bitterbrush, skunkbush sumac, and green ephedra often receives heavy browsing year after year. Most of these species are capable of withstanding considerable use, but may be weakened and killed over time. Natural recovery is slow and often prevented by continued use. Artificial revegetation is also very difficult on these sites.

Curlleaf mountain mahogany plants are not highly fire tolerant. The plants and onsite seed banks can be killed by high intensity burns (Noste and Bushey 1987; Wright and others 1979). The thick lower bark protects plants from low-intensity fires and although the species is a weak sprouter, some surviving plants can resprout from stem buds. In addition, new seedlings may emerge from unburned seed (Bushey and Noste 1987; Gruell and others 1985). Some stands are now restricted to rocky slopes due to high wildfire frequency. In other areas, intense fire suppression and understory reduction with grazing have permitted curlleaf mountain mahogany to invade sites with deeper soils (Dealy 1975; Gruell and others 1985).

Low intensity fires can be used to stimulate communities with low vigor or maintain curlleaf mountain mahogany where it occurs as a seral species with conifers (Gruell and others 1985). Burning can also improve age class structure of curlleaf mountain mahogany stands. Natural recovery can occur following prescribed fires, but it is often significantly enhanced by mechanical site preparation that reduces herbaceous competition and creates a weed free seedbed (Phillips 1970). Stands may also be rejuvenated by thinning them to 40 to 60 clumps per acre (99 to 148 per ha) and mechanically clearing seedbed areas within the stand. Protection of stands less than 50 years of age from fire is recommended if curlleaf mountain mahogany is the climax species. Reduction of browse use is essential for all stand improvement projects.

The mountain mahoganies are relatively free from infestation by insects and disease (Ferguson 1983). However, serious outbreaks have destroyed sizeable stands in southwestern Idaho. Furniss and Barr (1967) reported the looper destroyed 46 percent of a 5,900 acre (14,580 ha) stand of curlleaf mountain mahogany over 3 years. Tent caterpillars have been responsible for severe defoliation in the Great Basin (Furniss and Barr 1967).

Varieties and Ecotypes

Numerous accessions of curlleaf mountain mahogany have been collected and evaluated for forage value, seedling establishment, and vegetative growth characteristics. Attempts have been made to select and develop ecotypes with improved seedling vigor and high growth rates, but to date no major improvements have been achieved. In general, selections appear universally adapted to all areas where the species occurs. However, it is possible that differences exist, but have not yet been fully recognized.

Differentiation of the ancestral mountain mahogany may have resulted in the appearance of some important traits. Stutz (1974) proposed that the highly plastic true mountain mahogany, a plant better adapted to mesic conditions, may have evolved from curlleaf mountain mahogany. In contrast, the smaller, narrower leaves of littleleaf mountain mahogany may have evolved as a response of curlleaf mountain mahogany to more xeric circumstances. Because the three species are closely related, each with chromosome number 2n = 18 (McArthur and Sandersen 1985), artificial hybridization is possible and could be employed to incorporate specific traits into selected populations.

Natural hybrids between Intermountain mountain mahogany and true mountain mahogany and later generation backcrosses are quite common where both parents are found growing together (Blauer and others 1975; Plummer and others 1957). Hybrids are somewhat fire tolerant, a characteristic of true mountain mahogany. They often have a wider area of adaptation than curlleaf mountain mahogany. Hybrids are easy to recognize; they are tall and treelike with evergreen leaves and always occur in stands of true mountain mahogany where true mountain mahogany is the female parent (Stutz 1990). These hybrids rarely reproduce. Few hybrids of *C. ledifolius* var. *ledifolius* and true mountain mahogany have been reported. This is perhaps due to the fact that these taxa occur together only infrequently and hybrids are less easily recognized. They are highly fertile. Hybrids between littleleaf mountain mahogany and true mountain mahogany are rare (Pyrah 1964), perhaps due to reproductive barriers (Stutz 1990). They are usually sterile. Hybrids between littleleaf mountain mahogany and Intermountain mountain mahogany are common in some areas where the species overlap (Blauer and others 1975; Plummer and others 1957; Stutz 1990).

Cercocarpus ledifolius var. *ledifolius* is a small shrub or tree occurring in the northern part of the Intermountain region, and is most common in Wyoming and Montana (Cary 1917; Miller 1964). It also occurs in Oregon, Idaho, California, Nevada, Utah, Colorado, and Arizona. It is taller in stature than littleleaf mountain mahogany with larger leaves and flowers. Hybridization with curlleaf mountain mahogany is common.

Some *C. ledifolius* var. *ledifolius* populations express unique features of value in range and wildlife habitat improvement. Ecotypes occurring in eastern Wyoming and western Montana include low decumbent and semi-erect forms (Miller 1964). They are evergreen, propagate by stem layering, and produce profusely branching root systems (Miller 1964). Some plants are also capable of resprouting, a feature uncommon in curlleaf mountain mahogany. The decumbent ecotypes exist primarily on shallow soils developed from a fractured limestone substrate.

Members of these ecotypes vary in stature and growth form. Most develop multiple stems and are semi-erect with leaves of varying sizes. The decumbent growth form and the hybrids provide an extremely valuable base for future plantings. If adapted to typical curlleaf mountain mahogany sites, the hybrids could be used to decrease the size of the tree-like curlleaf mountain mahogany growth forms. In addition, the stem layering and root sprouting features could enhance the fire tolerance and soil stabilization values of this important shrub.

Cercocarpus montanus ___________

True Mountain Mahogany

True mountain mahogany also known as blackbrush, deerbrush, alder, sweetbriar, and tallow brush, is an erect shrub or small tree 2 to 13 ft (0.6 to 4 m) in height. Stems of main branches have smooth, grayish-brown bark (fig. 6). Young twigs are often villous. The short petiolate leaves are oval to broadly ovate, serrate above the middle, 0.4 to 2.0 inches (1 to 5 cm) long, and 0.4 to 1 inch (1 to 2.5 cm) wide. Leaves are deciduous to semi-evergreen, dark green and glabrous above with prominent veins and a fine whitish tomentum beneath. Flowers are perfect and regular, borne in small clusters in the axils of short spurs. There are five sepals extending from a trumpetlike hypanthium, no petals, 25 to 40 stamens in two to three whorls, and a single pistil. The fruit is an elongate achene with a plumose style, 2.4 to 3.9 inches (6 to 10 cm) long at maturity. Flowering occurs from mid-May to late June. Fruits mature from July into September depending on elevation. They are wind dispersed (Harrington 1964; Hitchcock and others 1961; Welsh and others 1987).

Chromosome number of true mountain mahogany is n = 9 (McArthur and Sanderson 1985). Natural hybridization between species of mountain mahogany in Utah has been observed in areas of overlapping ranges. Curlleaf mountain mahogany x littleleaf mountain mahogany hybrids are most abundant because of their overlapping flowering periods. True mountain mahogany x curlleaf mountain mahogany hybrids are less common, and true mountain mahogany x littleleaf mountain mahogany hybrids are rare (Pyrah 1964).

Figure 6—True mountain mahogany post-flowering, but prior to development of the elongate plumose styles.

Ecological Relationships and Distribution

The range of true mountain mahogany extends from Montana to South Dakota and south to New Mexico, Arizona, and Colorado (Harrington 1964; Martin 1950) in areas receiving 10 to 23 inches (25 to 58 cm) of annual precipitation. It occupies bluffs, mountain slopes, and foothills from 3,500 to 10,000 ft (1,070 to 3,050 m) in elevation. It commonly grows on rocky or well-drained soils on all exposures. It is also common on moist fertile sites, canyon bottoms, and north and east slopes. It usually grows in association with other shrubs and trees including ponderosa pine, Gambel oak, Utah juniper, pinyon, and other woody species of mountain brush communities (Blauer and others 1975). It frequently grows with mountain big sagebrush. Pure stands do exist, but are limited in extent.

In Utah the species is widespread, occupying diverse situations, but most commonly occurring on shallow soils and slickrock sites (Greenwood and Brotherson 1978). In Colorado, Medin (1960) found soil depth to be the most important factor influencing true mountain mahogany production on both shale and sandstone-derived soils. Clay content of the A horizon was very important in sandstone-derived soils; greater clay content was beneficial. Factors influencing water availability to the plant were key in influencing production. Brotherson and others (1984) also found factors affecting water availability had a significant impact on the development of true mountain mahogany communities. In Utah, Anderson (1974) reported a combination of site factors including soil texture, percent litter, soil pH, and exposed rock influenced the distribution of the shrub. However, no specific combinations of factors could be used to predict its occurrence. Stands on north-facing slopes of central Utah study sites were transitional in succession to other mountain brush types (Christensen 1964). Succession progressed much more slowly on more xeric southerly sites, and perhaps would never progress beyond the true mountain mahogany stage (Brotherson and others 1984).

Plant Culture

Reproductive phenology of true mountain mahogany is related to aspect and elevation (Blauer and others 1975). Stands of true mountain mahogany growing on fertile sites usually produce an abundant seed crop. Seeds are more easily harvested than those of curlleaf mountain mahogany; plants are smaller in stature.

Seed is usually hand collected from wildland stands; no commercial nurseries are being maintained. Plumes are removed with a Dybvig or barley debearder, followed by screening. Piatt (1973) reported that the larger seed of true mountain mahogany germinate better than small seed, but relative size may not be a reliable index of differences in source germinability. Seed may be stored for up to 7 years in an open warehouse without a major decrease in viability (Stevens and others 1981a). Purity of 90 percent and germination of 80 percent are recommended for seed purchases. There are approximately 59,030 seeds per lb (130,138 per kg) at 100 percent purity (see chapter 24).

Ecotypes of this species appear much more sensitive to site conditions than do collections of curlleaf mountain mahogany. Utilization of ecotypes acquired near the proposed planting site or from similar sites is recommended.

Seed must be fall sown at a depth of approximately 0.5 inch (1.25 cm). Surface plantings are not successful and should be avoided. Growth of emerging seedlings is seriously depressed if they are subjected to competition from herbs. Consequently, the shrub should be seeded in strips or plots separate from grasses. Seeding this species with a Hansen seed dribbler attached to a caterpillar tractor has been very successful on pinyon-juniper chainings. This method also serves to prevent development of such a dense shrub overstory that herbaceous species are eliminated. Interseeding the shrub into established stands of perennial grasses can be successful if strips or patches of understory vegetation are first removed.

True mountain mahogany is frequently scattered among the upper big sagebrush communities. In those situations it has sometimes been eliminated or seriously reduced by browsing. Natural recovery is slow, and artificial seedings are difficult to establish if the sites are infested with weedy annuals. If populations of exotic annuals are low, natural and artificial seedings are quite successful.

Germination requirements are similar to those of curlleaf mountain mahogany; seeds require after-ripening and wet prechilling (Deitschman and others 1974a). Seedlings emerge shortly after the ground thaws. Many of the small seedlings are lost to drought and early spring frost (Plummer and others 1968). Mortality also results from severe browsing by rodents, rabbits, and big game. Consequently, seedings should be protected from browsing for 3 years or more.

Seedlings are easily grown as either container or bareroot stock. Planting stock must be dormant or properly hardened to ensure success. Bareroot seedlings should not be root pruned during lifting or outplanting. Transplants should be planted in strips or scalps cleared of competing vegetation. Field survival of container or nursery grown transplants of all mahogany species is only fair to good. However, true mountain mahogany usually transplants better than curlleaf mountain mahogany.

Uses and Management

Medin and Anderson (1979) and Tueller (1979) reported true mountain mahogany is one of the principal browse species used by wintering deer within its range. The widespread occurrence, nutritive value, and high palatability of this species ensure its rank as a valuable shrub for big game habitat (Plummer and others 1968; Young and Bailey 1975). The plant also receives considerable spring and summer use by big game and livestock and provides cover for numerous wildlife species. Compared to curlleaf mountain mahogany it is a superior browse for livestock, particularly sheep (Ferguson 1983). True mountain mahogany is fairly tolerant of browsing. A Colorado clipping study indicated plants can withstand 60 to 80 percent browsing (Shepherd 1971). However, Brotherson and others (1984) found that about one-half of the true mountain mahogany in central Utah stands was highlined and out of reach of browsing animals. Some stands have been severely reduced by heavy browsing (Ream 1964).

Nutrient value of true mountain mahogany in winter is not as high as that of curlleaf mountain mahogany. Digestibility of true mountain mahogany has been reported as 48.4 percent. Digestible protein is 3.4 percent (Smith 1957; Urness and others 1977; Welch 1981); adequate winter digestible protein content is 5.2 percent for wintering deer.

True mountain mahogany also has value as an ornamental. Plants are used for landscaping along the West coast. In inland areas they are very hardy, requiring low maintenance. Its semi-evergreen habit, shiny plumose fruits, and growth habit are unique and attractive. It grows rapidly with limited irrigation.

Burning is a good technique for rejuvenating stands and increasing plant vigor. True mountain mahogany can resprout vigorously from surviving root crowns following burning. Recovery may be rapid even following rather intense burns (Blauer and others 1975; Wright and others 1979). Survival after burning may be high at all seasons, but response is greater following dormant season burns in Colorado (Young 1983). Current annual growth measured in late winter was 475 to 650 percent greater on burns than on controls. Production was greater on low intensity than on high intensity burns. Seed dispersed long distances by winds from unburned sites also contributes to recovery of burned or otherwise disturbed sites.

True mountain mahogany has been established from direct seedings on mine disturbances in Utah and Idaho (Ferguson and Frischknecht 1985). Seedlings survive on infertile soils; on spoil wastes they appear to benefit by the addition of even small amounts of topsoil. Plants may be nodulated by the nitrogen-fixing endophyte *Frankia* (Hoeppel and Wollum 1971). Transplants grow slowly and are sensitive to competition.

Varieties and Ecotypes; Other Species

Attempts have been made to enhance seed germination, seedling vigor, and growth rate of true mountain mahogany by selection of ecotypes. A selection referred to as "Montane" was released by the U.S. Department of Agriculture, Natural Resource Conservation Service, Los Lunas Plant Materials Center (Thornburg 1982). This cultivar, collected on the Santa Fe National Forest near Coyote, NM, has nondormant seed and excellent seedling vigor. Its adaptation to sites outside its area of collection has not been fully documented.

Coleogyne ramosissima

Blackbrush

Blackbrush, the only member of its genus, is a long-lived densely branched shrub usually about 3 ft (0.9 m) in height, but sometimes reaching 6 ft (1.8 m) or more (fig. 7). The root system is shallow and spreading with most roots less then 16 inches (40 cm) deep. Roots are associated with the nitrogen fixing actinomycete *Frankia* (Bowns and West 1976; Dittberner and Olsen 1983). The tangled ash-gray branches give the shrub a dark appearance, particularly when wet; hence the name blackbrush (Benson and Darrow 1945). Main stems proliferate by stem splitting. The short branches die back from the apex after a few years of growth leaving a spiny tip. Lateral branches then develop producing a rounded shrub (Bowns and West 1976). The small persistent leaves are clustered along the branches. They are simple, leathery, about 0.2 to 0.6 inch (5 to 15 mm) long, and 0.04 to 0.12 inch (1 to 1.5 mm) wide. The flowers are terminal on new branchlets. They have four yellow to brownish sepals and are usually apetalous. Numerous stamens are inserted at the base of the disk that encircles the ovary. The fruit is a glabrous, brown achene 0.2 to 0.3 inch (5 and 8 mm) in length (Harrington 1964; Munz and Keck 1959; Welsh and others 1987). Plants normally flower as early as March at lower elevations (McMinn 1951) and as late as June at higher elevations (Munz and Keck 1959). Seeds mature in midsummer. Blackbrush has n = 8 chromosomes, which is unusual for the subfamily Rosoideae (McArthur and Sanderson 1985). The 4-merous apetalous flowers and opposite leaves are also unusual for the Rosaceae.

Figure 7—Blackbrush community in southwestern Utah.

New growth and flowering are dependent on the quantity and distribution of precipitation. In the absence of adequate fall or winter/spring rain, vegetative and reproductive growth are curtailed (Ackerman and others 1980). Blackbrush enters a period of summer inactivity in response to low soil moisture. Flowering occurs from April to August depending on location. Fruits ripen from April to June and are dispersed shortly thereafter (Ackerman and others 1980).

Ecological Relationships and Disribution

Considered a relict endemic species of arid and semiarid areas of western North America (Stebbins 1972), blackbrush's present distribution is thought to represent a restriction of a once more extensive range (Stebbins and Major 1965). Blackbrush is distributed from southern California, east through southern Nevada, northern Arizona, southeastern Utah and southwestern Colorado in areas with annual precipitation in the 6 to 12 inch (150 to 300 mm) range (Harrington 1964; Munz and Keck 1959; Turner 1982; USDA Soil Conservation Service and USDI Bureau of Land Management 1981; Welsh and others 1987). Blackbrush occurs as a dominant species over extensive areas and is particularly common in the southwestern Great Basin Desert along the Colorado River drainage system (Turner 1982). Blackbrush is a major shrub along the Transition Zone between the Great Basin and Mojave Deserts (Tidestrom 1925). Monotypic stands within this Zone intergrade into mixed communities of Mojave Desert, Colorado Plateau, and Great Basin vegetation.

Monotypic stands of blackbrush are characterized by low understory species diversity and greater total cover than most desert shrub communities. Plants are long-lived and slow growing; their communities are highly stable. Blackbrush often replaces itself following disturbances, but reestablishment of shrub cover occurs very slowly due to extremely erratic seedling establishment and low growth rates (Webb and others 1987). In southern Nevada, Beatley (1974) characterized blackbrush as requiring Great Basin precipitation and Mojave Desert temperatures and existing primarily between creosotebush and pinyon-juniper or sagebrush communities (Wells and Jorgensen 1964). In Arizona, blackbrush occurs in areas having a mean annual soil temperature of 59 °F (15 °C) (USDA Soil Conservation Service and USDI Bureau of Land Management 1981).

In general, blackbrush stands occur on upland sites, broad terraces, and gently rolling hills (USDA Forest Service and USDI Bureau of Land Management 1981). Soils are usually shallow, calcareous, and coarse textured, ranging from gravelly to cobbly loam or gravelly clay loam (Foster 1968; Kearney and Peebles 1960; Shreve 1942). The shrub is less prevalent and occurs with an understory dominated by grasses in drainage bottoms, where soils are moderately deep to deep with fine sandy loam surface textures and calcareous underlying layers of very gravelly sandy loam or gravelly clay loam (USDA Soil Conservation Service and USDI Bureau of Land Management 1981). Other blackbrush sites with good fertility and soil water also support a herbaceous understory (Bowns 1973). Blackbrush normally occurs on soils low in salt content (McCleary 1968). Seedlings are sensitive to salinity, which may limit its distribution and spread (Wallace and Romney 1972).

Blackbrush is often a component of many transitional shrub communities that provide important forage and habitat for game and livestock. These include spiny hopsage, Nevada ephedra, rabbitbrush, big sagebrush, desert bitterbrush, cliffrose, and pinyon-juniper communities. It is considered a potential candidate for use in revegetation; it occupies or once occupied extensive areas that have suffered severe abuse by destructive grazing practices.

Plant Culture

Blackbrush seed production is highly erratic. Most stands produce a harvestable seed crop in perhaps 1 of every 6 to 10 years. Ripe seed readily detach from the plant and are dispersed by gravity. Seed collection is slow and tedious; consequently, commercial supplies are rarely available. Fruits are cleaned using a fanning mill or gravity separator. Purity of 95 percent and germination of 70 percent are recommended for seed purchases. There are approximately 27,015 seeds per lb (59,557 per kg) at 100 percent purity (see chapter 24).

Seeds require a short wet prechilling period to relieve dormancy. Bowns and West (1976) reported prechilling at 39 °F (4 °C) for 23 days and incubation at 57/40 °F (14/4 °C) provided 80 percent germination in 6 days and 90 percent in 13 days. Natural seedlings are uncommon. Their appearance may be associated with dry autumns and winter or spring precipitation totaling 2 to 5 inches (50 to 130 mm) (Beatley 1974).

Plants can be established by artificial seeding, but sufficient plantings have not been attempted to adequately determine appropriate seeding rates or seedbed requirements. Local seed sources should be used; populations are not adapted to areas other than their sites of origin. Seed can be planted with most conventional seeders. A planting depth of about 0.5 inch (1.3 cm) is recommended. Rodents may aid in natural seed dispersal and planting, but rodent predation of planted seed has been observed (Bowns and West 1976). Fall planting is recommended to provide adequate wet prechilling and reduce rodent problems (Bowns and West 1976). Stark (1966) reported good success from seedings in Nevada, but wildland seedings in Utah have not been as successful. Seedlings developing from plantings in central Utah, north of the species natural range, have failed to persist for more than 2 to 3 years due to cold winter temperatures. Seedlings developed slowly and some were suppressed by herbaceous competition. In general, most attempts to plant blackbrush offsite have not been successful.

Only fair survival has resulted from planting projects using either container or bareroot stock. Container stock grows moderately well in a buffered peat-vermiculite medium, but seedlings are sensitive to overwatering. Four to 6 inch (10 to 15 cm) tall seedlings can be produced in 6 to 10 months under greenhouse conditions. Survival has not exceeded 30 percent from plantings conducted in southeastern Utah. Shading the small transplants improved survival (Kitchell n.d.).

Uses and Management

Dayton (1931) and Allen (1939) reported blackbrush provides fair winter forage for cattle, sheep, goats, deer, desert bighorn, and other game animals. Blackbrush communities are commonly used as winter range for sheep. However, blackbrush is often regarded as a poor forage species with low palatability (Bates 1984; Sampson and Jesperson 1963). Although used by big game and livestock (Gullion 1964), it is usually not a major component of their diet. It may become an important forage during severe winters (Kufeld and others 1973; Sampson and Jesperson 1963). Blackbrush is deficient in phosphorus for sheep and cattle and low in protein during fall and winter (Bowns and West 1976). In addition, the low growing, intricately branching habit of the shrub reduces its attractiveness to livestock (Provenza and others 1983). Light to moderate grazing may reduce woody materials and spininess and increase production of palatable new growth (Provenza 1977; Provenza and others 1983). Mule deer make moderate use of this shrub in winter and spring (Leach 1956). Its seeds are used by birds and rodents (Mozingo 1987; USDA Forest Service 1937) and it provides cover for many small animals.

Blackbrush is adapted to harsh sites, but its slow growth and limited area of adaptation have restricted its use in revegetation projects on non-native sites. All blackbrush sites do not respond similarly to restoration and management practices. Bates (1984) and West (1969) concluded that blackbrush occupies two different situations, each responding differently to fire and other improvement techniques. In the first situation, blackbrush occurs in monotypic stands as a climax species supporting few native understory species. Shrubs are widely spaced and cover provided by grasses and forbs may be extremely low. Cryptogamic crusts covering interspaces reduce soil erosion; those with a blue-green algae phycobiont provide an important source of soil nitrogen (West and Skujins 1977). These sites are frequently considered for range improvement projects. Burning has not been a successful means of releasing the existing understory due to the unpredictable recovery of native herbs, invasion of annual weeds, and loss of cryptogamic crust that recovers very slowly (Jensen and others 1960). In the absence of annual weeds, these sites often revert back to blackbrush without any intermediate stage (West and Skujins 1977). Attempts to plant substitute shrubby species have not been successful.

Monotypic stands of blackbrush are often associated with shallow soils and soil water conditions that do not favor seeding success. Annual weeds, principally red brome, compete with the shrub seedlings. Attempts to replant blackbrush back onto these sites following wildfires or other disturbances often meet with failure.

The second common revegetation situation occurs on sites where blackbrush invades other plant communities or is naturally present in low density. Invasion normally occurs on sites with deeper soils and better water availability than is found on monotypic blackbrush sites. Blackbrush increases on these sites when heavy grazing suppresses other plants. Under these conditions, burning or chaining can be used to reduce blackbrush density and allow release of existing natives or aid in the establishment of seeded species. Success is dependent on edaphic and climatic conditions. Sites with deeper soils generally respond more favorably (Bates 1984; Halliday 1957).

The successional patterns of recovery following fires are somewhat unpredictable in blackbrush communities. The shrub is reported by some to be a nonsprouter (Bowns 1973; Bowns and West 1976). Most plants are killed if the understory is dense enough to carry a fire. Low intensity burns may not kill mature plants. Bates (1984) reported considerable resprouting following fires in California. Blackbrush seed may remain viable in the soil for several years; new seedlings may emerge from seed banks many years after mature plants are destroyed by fires or other disturbances (Bates 1984). Blackbrush seedlings establish very slowly following fires (Anderson 2001; Wright and Bailey 1982); red brome and other annuals develop quickly and dominate burned sites, often precluding blackbrush recovery (Rickard and Beatley 1965). However, Bates (1984) observed blackbrush reestablishment from seed on sites occupied by annual and perennial grasses following wildfires. Thus, the species may exert some competitiveness with herbaceous species in some locations.

Jensen and others (1960) found burns in Nevada effectively killed blackbrush plants. Unless native perennial grasses and broadleaf herbs recovered rapidly following burns on these sites, annual weeds quickly dominated and prevented blackbrush recovery. Some shrubs, including turpentine bush, desert bitterbrush, and desert peachbrush, are capable of recovering following fires, and if present prior to burning, may soon dominate burns where blackbrush was once common (Bowns 1973).

In California, annuals quickly invaded blackbrush burns, but were replaced by perennial herbs within 10 to 15 years (Bates 1984). A mixed shrub community then appeared in about 30 years, eventually reverting back to solid stands of blackbrush if the stands were poorly managed. Not all sites responded so favorably. Once annual weeds established, the reentry of more desirable herbs and shrubs was often limited. Burning or chaining increased the density of other shrubs present after treatment.

Blackbrush communities provide desirable ground cover and soil protection and should not be removed or converted to other species unless the treatments are assured of some success. Anchor chaining has been effective in reducing blackbrush density where it exists in pure stands or intermixed with pinyon-juniper. Brush beating has also been used to decrease shrub density, remove older wood, and stimulate new growth (Bowns and West 1976). Neither chaining nor brush beating kills all shrubs. Double chaining for example, initially killed about 25 percent of the plants on two large blackbrush chaining projects in southern Utah (Monsen n.d.). Crested, intermediate, and pubescent wheatgrass were seeded at both sites, producing good understory stands. Blackbrush resprouted and regained its earlier productivity in about 10 years. Its productivity was not suppressed by the presence of the seeded grasses. Indian ricegrass has also responded favorably following chaining of certain blackbrush sites. Blackbrush is particularly compatible with Indian ricegrass, and when protected from livestock grazing these sites often support a mixed grass-shrub community (Jeffries and Klopatek 1987).

Varieties and Ecotypes

Native stands in the Colorado River drainage in southeastern Utah provide the seed for most blackbrush revegetation projects. However, collections acquired from this area have not demonstrated adaptation to other locations. If artificial plantings are contemplated, seed should be acquired from native stands growing near the planting sites. Different ecotypes demonstrate specific attributes that appear to be genetic traits. Certain ecotypes demonstrate adaptability to arid desert conditions; others express compatibility with herbaceous understory plants, and some appear better able to recover from burning.

Cotoneaster acutifolia ____________

Peking Cotoneaster

Peking cotoneaster is an unarmed, low-spreading shrub, often reaching 12 ft (3.7 m) in diameter (fig. 8). Plant height is usually less than 5 ft (1.5 m). The shrub is described as deciduous (Welsh and others 1987), but numerous leaves often remain on the plant until late winter. Branches are numerous, reddish brown, and arcuate to horizontal. Flowers are small, perfect, regular, and solitary or in cymes terminating lateral branches. Flowers are white or pink. The fruit is a black, two-celled pome about 0.4 inch (1 cm) long (Johnson and Anderson 1980; Welsh and others 1987).

Figure 8—Peking cotoneaster, an introduction from China, has received considerable use in midwestern windbreaks and shelterbelts where it provides winter cover and food for birds and big game.

Ecological Relationships and Distribution

Peking cotoneaster was originally introduced from northern China in 1883 as an ornamental shrub (Hoag 1958; Leslie 1954; Slabaugh 1974). It has been planted for conservation and shelterbelt purposes throughout the United States, particularly in the northern Great Plains and upper Midwest. It is also used in the southern Canadian prairie provinces (Johnson and Anderson 1980; Slabaugh 1974). Like other *Cotoneaster* species, Peking cotoneaster is commercially cultured and sold for ornamental plantings. A number of varieties have been developed and are widely used. Plants have demonstrated a wide range of adaptation when planted in shelterbelts and conservation plantings in the West and Midwest.

Plant Culture

Peking cotoneaster normally flowers in early May; fruits ripen in September or October (Slabaugh 1974). Plummer and others (1968) reported that fruits do not ripen until mid November in Utah. Fruits remain on the shrub until mid to late winter. Abundant crops are often produced on cultivated hedges and shelterbelt plantings. Fruits become rather dry as they ripen. Mature fruits are easily dislodged from the shrub and are hand collected in late fall or early winter after some leaves have fallen. Seed are removed by macerating the fruits and flushing the pulp with water. The remaining seeds and pulp are then dried and screened. Empty seeds are removed by flotation (Slabaugh 1974). Conditioned seedlots normally are very pure with little debris. The average number of cleaned seeds per lb varies from 21,984 to 32,310 (48,465 to 71,231 per kg) (Plummer and others 1968; Slabaugh 1974). Purity of 98 percent and germination of 80 percent are recommended for seed purchases.

Germination of Peking cotoneaster is restricted by the presence of a hard, impermeable seedcoat and embryo dormancy (Slabaugh 1974). Scarification with sulfuric acid and wet prechilling pretreatments are recommended to hasten germination (Fordham 1962). However, fall nursery or wildland plantings usually provide sufficient wet prechilling. An alternating temperature regime of 50 °F (10 °C) for 15 hours and 77 °F (25 °C) for 9 hours, with light supplied during the warm cycle, usually provides optimal germination conditions for pretreated seed (Slabaugh 1974).

Peking cotoneaster is commonly grown as nursery stock for outplanting and is usually lifted after the second growing season. Cuttings are easily propagated; the plants layer readily. Wildings or rooted stem layers can be harvested early in the spring for field plantings. Doran (1957) reported softwood cuttings of cotoneaster taken in early summer root well.

Wildland seedings have been only marginally successful. Seed germination is erratic. Seedlings grow slowly and are easily suppressed by herbs. Planting success is improved if the seedbed is kept weed free. Established plants are more resilient and persist well. This shrub rarely suffers heavy damage from insects, disease, or use by small mammals. Little damage has been noted during heavy grasshopper infestations.

Uses and Management

Peking cotoneaster has been most widely used for windbreaks, shelterbelts, conservation, and ornamental plantings (Hoag 1958; Johnson and Anderson 1980; Leslie 1954; Slabaugh 1974; Wyman 1949). The shrub is used in multi-row windbreaks and cover plantings to protect soils and reduce wind erosion. It furnishes a low, dense groundcover that provides year-long protection. The plants are also commonly used in roadway, recreation, or conservation plantings where ground cover, low maintenance, and aesthetics are important. Plants are attractive and provide glossy green foliage with persistent red or black berry-like pomes. The shrub withstands snow deposition and is used to trap snow and protect roadways and buildings.

Peking cotoneaster is commonly used to control erosion in residential areas, recreation sites, and wildlands. It is particularly useful in these areas as plants establish well from transplanting and quickly improve ground cover. Transplants can be planted at various spacings depending on the availability of seedlings. Planted shrubs will spread to occupy the planting site, but do not seed into adjacent areas.

Peking cotoneaster is adaptable to many ranges where native species have been lost and are difficult to reestablish. It has been used to provide winter food for various birds and big game (Johnson and Anderson 1980; Miller and others 1948). The plant exhibits high palatability to game and livestock and is moderately tolerant of grazing (Plummer and others 1968). It is readily grazed in midsummer by mule deer (Kufeld and others 1973; Leach 1956). Winter browsing has been heavy in Utah. Spring and fall use is light. Game animals are attracted to the shrub and can damage landscape plantings. Peking cotoneaster should not be used in roadway or other plantings where wildlife concentrations create hazards.

Peking cotoneaster may be used to improve areas where game animals concentrate and more productive forage and cover is essential. This shrub can be planted to enhance depleted native communities and attract and reduce animal use of native species. It can also be planted to reduce erosion on disturbed sites and to protect watershed and soil values.

Varieties and Ecotypes

There are no releases.

Cowania stansburiana ____________

Stansbury Cliffrose or Cliffrose

Stansbury cliffrose has often been identified as a variety of *C. mexicana* var. *stansburiana* [Torr.] Jeps. However, we have elected to accept it as a separate species as proposed by McArthur and others (1983b). Plants are long-lived, erect, evergreen, aromatic shrubs or small trees 3 to 18 ft (1 to 5.4 m) tall with stiff, often somewhat brittle stems and gray shreddy bark (Cline 1960; Welsh and others 1987). New growth is flexible with glandular bark. Stansbury cliffrose has an extensive root system with long, spreading, and descending roots (Sutton and Johnson 1974). Roots may form symbiotic nitrogen-fixing associations with *Frankia* (Nelson and Schuttler 1984). Plants are resinous and strong smelling. The light to dark green leaves are clustered along the branches and are 0.5 to 1 inch (1.2 to 2.5 cm) in length with revolute margins and five to seven teeth at the apex. Leaf surfaces are glandular dotted and resinous above with a white tomentum beneath (Blauer and others 1975; Munz and Keck 1959). About 90 percent of the showy, fragrant, cream to yellow flowers appear during the first flush of flowering and are formed on lateral spurs of the previous year's wood. Later flowers appear sporadically throughout the summer near the tip of the current year's leaders (Shaw and Monsen 1983b). Later flowers are particularly abundant following summer rains. Flowers are about 0.8 inches (2 cm) in diameter and are normally perfect with two series of stamens enclosing 5 to 12 hairy pistils. Fruits are plumose achenes (fig. 9) dispersed by gravity and wind (Blauer and others 1975).

Figure 9—Stansbury cliffrose branch with mature achenes, note the plumose styles.

Ecological Relationships and Distribution

Stansbury cliffrose is distributed from southern California east to Colorado and south to Sonora and Chihuahua (USDA Forest Service 1937; Welsh and others 1987). It does not occur north of about the 42 °N parallel (McArthur and others 1983b). It is found primarily on dry, rocky, well-drained silty to gravelly soils of foothills and mesas growing in blackbrush, chaparral, oak, desert shrub, mixed grass-desert shrub, mountain brush, and pinyon-juniper woodlands up to the edge of ponderosa pine forests at elevations from 3,000 to 9,000 ft (900 to 2,700 m) (Blauer and others 1975; McArthur and others 1983b; Welsh and others 1987).

Cowania and *Purshia* are closely related genera but differ in many physical characteristics (table 1) and geographical distribution (McArthur and others 1983b; Stutz and Thomas 1964; Thomas 1957). Because of these differences, we prefer to retain the genus name *Cowania* even though Welsh and others (1987) recently transferred its species to *Purshia*.

Disjunct flowering periods normally prevent hybridization between antelope bitterbrush and Stansbury cliffrose. Antelope bitterbrush usually flowers earlier than Stansbury cliffrose (McArthur and others 1983b; Shaw and Monsen 1983b), but aspect or site conditions may result in overlapping periods of anthesis and pollination. Stutz and Thomas (1964) and Thomas (1957) reported that hybridization is so common that no populations of antelope bitterbrush in Utah have been examined that are free from the influence of Stansbury cliffrose. Introgression of antelope bitterbrush into Stansbury cliffrose is less common, but does occur. McArthur and others (1983b) concluded that two adaptive products have evolved through natural hybridization. Desert bitterbrush, the southern adaptive derivative, is one product. The second is less distinct. It occurs in areas north of Utah on sites not occupied by Stansbury cliffrose and consists of antelope bitterbrush populations that express Stansbury cliffrose characteristics, particularly low palatability. Stutz (1972) suggested selection pressure resulting from heavy browsing has favored the less palatable plants.

Both *Purshia* and *Cowania* were present in the Madro-Tertiary geoflora, which evolved from the Arcto-Tertiary and Neo-Tropical geofloras in response to increasingly drier conditions in the Southwest (Axelrod 1958, McArthur and others 1983b). McArthur and others (1983b) postulated that the weak isolation barriers now existing between the two genera indicate that the present zone of contact of the two species developed after a long separation. Much of the area where they now coexist was occupied by Pleistocene lakes and glaciers as recently as 12,000 years ago.

Table 1—Morphological characteristics separating *Cowania* and *Purshia* (after Stutz and Thomas 1964).

Character	*Purshia*	*Cowania*
Twig pubescence	heavy	glabrous
Dorsal leaf pubescence	heavy	glabrous
Hypanthium glands	none	3+/mm^2
Stalked glands	absent	present
Pistils	1 or 2	4+
Style length	<1.5 cm	1.6 - 3.4 cm
Style pubescence	puberulent	plumose
L/W ratio of achenes	<3.1	>3.3
Stamen insertion	hypanthium margin	hypanthium throat
Leaf margin revolution	slight	pronounced
Hypanthium pubescence	pubescent	glabrous
Stamen series	one	two
Lobes/leaf	three	five+
Leaf glandulosity	none	3+/mm^2
Leaf retention	deciduous	evergreen

Plant Culture

Although Stansbury cliffrose grows in semiarid regions it usually produces at least some seed each year. Abundant or commercially harvestable seed crops develop in about 2 out of every 3 to 4 years. Although flowering usually occurs after the last spring frost, unusually late frosts can diminish seed yields.

The period of floral development, anthesis, and fruit development lasts from 68 to 78 days in southern Idaho (Shaw and Monsen 1983b). Anthesis and pollination occur over a 10-day period. Fruits then mature about 37 days later. The plants are insect-pollinated and self-incompatible, consequently seed production is significantly impacted by high winds, rainy periods, unusually hot temperatures, and other factors that influence insect pollination.

Fruit (achene) ripening is less uniform for Stansbury cliffrose than for antelope bitterbrush, but the bulk of the fruit can generally be harvested on one date. Fruits are hand collected by striking the limbs with a paddle or stick to knock them into collection hoppers or trays. The brittle styles are removed with a Dybvig or barley debearder and separated by fanning. Seeds are not removed from the achene to avoid damaging the embryo (Young and Evans 1983). Generally about one-third of the harvested material by weight consists of viable seed (achenes) (Alexander and others 1974). There are about 64,600 seeds per lb (64,500 per kg) (Alexander and others 1974; Plummer and others 1968). Purity of 95 percent and germination of 85 percent are recommended for seed purchases (see chapter 24).

Seed can reportedly be warehouse stored for 5 to 7 years (Alexander and others 1974; Plummer and others 1968; Springfield 1973), or even as long as 15 years (Stevens and others 1981a). Germination tests conducted on seed lots harvested from the same area in different years exhibit similar germination patterns. However, some differences do occur. Poorer and slower germination results from unfavorable growing conditions during the year of seed production; more rapid and complete germination characterize seed produced during years of abundant production (Jorgensen n.d.). Shaw and Monsen (1983b) reported the loss of achenes prior to the time of maturation was 13 percent in 1979 and 52 percent in 1980. Although insects were a major factor, losses could not be attributed to insect damage alone.

Stansbury cliffrose seed requires a wet prechilling treatment to release dormancy. The optimal treatment duration varies with population and year of harvest. Consequently, seed should be planted in fall or winter; spring seeding should be avoided. Meyer and Kitchen (n.d.) found that the rate and total germination percentage increased from 30 percent after 2 weeks of wet prechilling at 33 °F (1 °C) to 100 percent in 7 days after 6 weeks of wet prechilling. Seed maintained at 33 °F (1 °C), began germinating during prechilling within 8 weeks and completed germination in 11 weeks. Plummer and others (1970b) reported 89 percent germination after 90 days at alternating temperatures of 32/85 °F (0/31 °C) and 99 percent germination after 90 days of alternating temperatures of 32/38 °F (0/3 °C). Young and Evans (1981b) recommended prechilling at 32, 36, or 39 °F (0, 2, 4 °C) for approximately 6 weeks. Seeds do not require light for germination (Sabo and others 1979).

Stansbury cliffrose is generally fall seeded in a mixture with other shrub seed. Seed can be planted with most conventional drills or seeders. Cleaned seed must be incorporated into the soil to a depth of about 0.25 to 0.50 inch (6 to 12 mm) (Alexander and others 1974; Plummer and others 1968). Surface broadcasting is generally unsuccessful if the seed is not subsequently covered. Seedling emergence is similar to that of antelope bitterbrush, occurring early in spring. Small seedlings are sometimes subjected to late frosts. During the establishment period, seedlings are quite sensitive to competition and water stress. However, once established, Stansbury cliffrose seedlings tolerate drought, heat, and soil salinity better than antelope bitterbrush or Apache plume (Plummer and others 1968). Seedlings are not capable of competing with cheatgrass, red brome, or dense stands of some perennial grasses.

Stansbury cliffrose is easily grown as bareroot (Shaw 1984) or container stock (Landis and Simonich 1984); it develops rapidly if properly cultured. One-year-old bareroot seedlings generally attain satisfactory size for field transplanting. Container plants are usually propagated from seed, but stem cuttings can be rooted (Shaw and Monsen 1983b). Because Stansbury cliffrose is an evergreen shrub, plants are sensitive to lifting and transplanting if not properly hardened or dormant. Survival of actively growing plants is generally low.

Grasshoppers utilize Stansbury cliffrose (Edgerton and others 1983) but have not been observed to seriously damage or eliminate new plantings. Weedy competition on the planting site should be controlled by burning, mechanical, or other means of seedbed preparation prior to transplanting (Giunta and others 1978; Shaw and Monsen 1983b).

Uses and Management

Stansbury cliffrose is regarded as a desirable winter forage for big game as well as cattle and sheep (Blauer and others 1975; Plummer and others 1968; Robertson 1974; Tueller 1979; USDA Forest Service 1937). Kufeld and others (1973) reported that mule deer make heavy use of it in fall, winter, and spring but only moderate use in summer. Some Stansbury cliffrose stands are grazed by big game and livestock during all seasons. However, the species is not as universally palatable as antelope bitterbrush (McArthur and others 1983b; Stutz and Thomas 1964). Plants often receive negligible use in spring and summer in areas where other forage is available (USDA Forest Service 1937). Certain ecotypes, including some southern Arizona populations, evidently have low palatability in all seasons. Two dimensional chromatograms of their phenolic compounds can be distinguished from those of more palatable populations (Blauer and others 1975).

Like other evergreen species, Stansbury cliffrose maintains its protein levels and energy values in winter (Dittberner and Olsen 1983; Smith and Hubbard 1954; Welch and others 1983a). In a common garden study in southern Idaho, Stansbury cliffrose leaders were found to contain a significantly higher percentage of crude protein in winter (8.4 to 8.6 percent, dry weight basis) than those of antelope bitterbrush or Apache plume, but slightly less than those of desert bitterbrush (Welch and others 1983a). The *in vitro* digestible dry matter of Stansbury cliffrose exceeded that of all species tested (37.6 percent).

Stansbury cliffrose can withstand heavy grazing and does occur in areas where winter use is quite intense. Flowering and production of new growth may be stimulated by 65 percent use; browsing in excess of 80 percent of new growth decreases vigor (Wasser 1982). Stands frequently sustain game animals during years of heavy snow accumulation and should be managed to ensure forage availability during the critical midwinter period.

Stansbury cliffrose has been seeded on a variety of sites to improve diversity and winter wildlife habitat value of vegetation (Edgerton and others 1983). Good stands can be established in the mountain brush zone and in most pinyon-juniper communities (Davis 1983; Giunta and others 1978; Monsen and Christensen 1975). Stansbury cliffrose is frequently intermixed with Wyoming big sagebrush, blackbrush, and salt desert shrubs and can be successfully reseeded on such sites. Although Stansbury cliffrose frequently grows on soils derived from limestone, it is not limited to such sites. Establishment and survival are less certain when the species is planted in shrub communities where it does not occur naturally. However, plantings have established and survived successfully for nearly 40 years in antelope bitterbrush communities in south central Idaho and for over 10 years in northeastern Oregon and eastern Washington (Blauer and others 1975; Edgerton and others 1983; Monsen and Shaw 1983c). Stansbury cliffrose is not fire tolerant and should not be planted in areas subject to repeated burning.

On native sites Stansbury cliffrose may function as a pioneer species following disturbances (Wright and others 1979). It has been considered a candidate plant for mined areas, roadways, and other disturbed sites. It provides only moderate erosion control due to its upright habit and low growth rate (Dittberner and Olsen 1983; Smith and others 1978). Its frequency of nodulation by the nitrogen-fixing endophyte is generally low and varies with collection date and location (Nelson 1983). Plants have been successfully established on mine sites near Alton, UT, and on the phosphate mines of southeastern Idaho (Ferguson and Frischknecht 1985; Monsen, data on file, Shrub Science Lab., Provo, UT). Replacement of topsoil is required to attain satisfactory stands. Results of roadway seedings and transplanting trials in Utah and Idaho have been erratic, even when plantings are conducted in areas where Stansbury cliffrose naturally occurs.

Stansbury cliffrose is an attractive, drought-tolerant ornamental. The leaves are evergreen, the flowers and fruits are showy, and flowering occurs over a prolonged period. Mature shrubs can become rather ragged in profile, but respond well to pruning.

Stansbury cliffrose seedlings grow slowly and may require 3 to 4 years to reach a height of 6 to 12 inches (15 to 30 cm) (Monsen and Christiansen 1975). Growth thereafter is much more rapid. In a big game exclosure near Boise, ID, Stansbury cliffrose planting stock grew more slowly than several sources of antelope bitterbrush for the first 4 to 5 years, but exceeded their growth rates thereafter. Both species produced seed 5 to 6 years after planting (Shaw and Monsen 1983b).

Seedlings of Stansbury cliffrose must be protected from excessive competition and heavy grazing until plants are 3 to 5 years of age. In addition, Stansbury cliffrose stands have been and are being lost due to the invasion of weedy annuals that restrict natural or seeded shrub establishment and expansion and ultimately contribute to the loss of the shrub overstory (Cline 1960; Price 1982). Sites should be managed or treated to create a weed-free seedbed and maintain a suitable native understory after planting.

Stansbury cliffrose frequently does not recover from burning, chaining, or other methods of mechanical treatment. Multiple stemmed shrubs are more tolerant than older single-stemmed shrubs (Plummer and others 1968). Extreme variability in response to fire has been reported (Ferguson 1983; Howard 1995; Wright and others 1979), perhaps reflecting differences among ecotypes. Attempts to improve existing stands using these treatments have not been successful unless the sites are also seeded.

Varieties and Ecotypes

The extensive natural hybridization of Stansbury cliffrose with antelope and desert bitterbrush, and to a lesser extent Apache plume, provides an immense array of material for improving palatability; increasing drought, heat, and fire tolerance; broadening areas of adaptation; enhancing evergreen growth characteristics and forage traits; and manipulating growth habits of these taxa (McArthur and others 1983b; Monsen and Davis 1985; Stutz 1972). Improvement of seedling vigor, establishment, and initial growth rates would enhance the use of Stansbury cliffrose and its hybrids.

Stansbury cliffrose selections from central Utah have been among the most successful and productive populations seeded on pinyon-juniper sites in Utah (Monsen and Davis 1985). Hybrids with antelope bitterbrush collected from Utah County, UT, also offer excellent forage traits, including evergreen growth, high productivity, dramatic regrowth, good palatability, and an upright growth form. Davis (1983a) listed five different central Utah accessions of Stansbury cliffrose that have performed best in artificial seedings in Utah nearly 30 years after planting. Studies were based on continuous evaluations from 60 sites and include such factors as growth, persistence, and vigor.

Stansbury cliffrose introgressions with desert bitterbrush acquired from Benton, CA, demonstrate a wide range of adaptation and survival under harsh circumstances. Selections from hybrids with desert bitterbrush show promise for improved fire tolerance and adaptation to arid situations.

Crataegus douglasii ______________

Douglas or River Hawthorn

Douglas or river hawthorn is a compact, deciduous, deep rooted shrub or small tree growing 3.3 to 13 (26) ft (1 to 4 [8] m) tall (fig. 10). The bark is smooth and reddish brown, becoming reddish bronze in winter. Stems are armed with stout, usually straight thorns 0.4 to 0.8 inch (1 to 2 cm) long. The petiolate leaves are 1.2 to 2.4 inches (3 to 6 cm) long, usually less than half as wide, and lanceolate to elliptic ovate. Leaf edges are serrate to doubly serrate. Leaves turn bright red in fall. Flowers are perfect, regular, and epigynous, developing in corymbose cymes that terminate short lateral spurs. The clusters of fragrant white blossoms sometimes appear to cover the crown of the plant. Fruits are lustrous black, glabrous pomes about 0.25 inch (0.6 cm) in diameter that resemble small apples. They are fleshy, dry, and mealy, and contain light yellow pulp with one to five seeds. Flowering occurs in May and June; fruits ripen from July to September (Brinkman 1974e; Hitchcock and others 1961; Welsh and others 1987). Fruits are dispersed by gravity and animals.

Ecological Relationships and Distribution

There are approximately 300 species of *Crataegus* distributed throughout the Northern Hemisphere. In North America the genus is most abundant east of the Rocky Mountains. However, approximately 8 to 10 species occur in the Rocky Mountain area (Preston 1968). Hawthorn taxonomy is extremely complex; the genus consists of numerous species exhibiting great variation. Hybridization is common, particularly in the central and eastern United States. Characteristic of the subfamily Pomoideae, their chromosome number is n = 17 (McArthur and Sanderson 1985).

Figure 10—Douglas hawthorn is an excellent wildlife species that often occurs in or near riparian areas.

Douglas hawthorn, the most common species in our area, is distributed from Alaska east to Alberta and the Dakotas and south to California and northern Wyoming. It also occurs in Michigan and Ontario (Hitchcock and others 1961). In sagebrush and ponderosa pine communities it is largely confined to riparian zones where it may form dense thickets. It is well adapted to deep, moist, organic soils, but may be found on soils ranging from silty to rocky clay loams. Although it commonly grows on well-drained sites, Douglas hawthorn is capable of withstanding periods of soil saturation (Stark 1966). The species is an alternate host for cedar apple rust and may be damaged by leaf spot in drier locations (Krebill 1972; Stark 1966).

Plant Culture

Ripe fruits are hand collected. Freshly collected fruits must be kept cool and not allowed to mold prior to extraction. Seed can be separated from fleshy material with a Dybvig cleaner or blender and water followed by air drying and fanning. A variable percentage of the seed is usually unsound but cannot be removed by flotation. Some of these may be separated on a gravity table. There are about 15,050 seed per lb (33,179 per kg) at 100 percent purity (see chapter 24). Treatment with concentrated sulfuric acid has been used to release dormancy. The appropriate length of acid treatment varies from 0.5 to 3 hours depending on the seedlot (King 1947; McKeever 1938). Effectiveness of acid scarification has not been consistent; acid can penetrate the seed coats and damage the embryos of fresh seed. Embryo dormancy is released by a 3 to 5 month wet prechilling (King 1947; McKeever 1938; SEAM 1976). Because of the variability in dormancy among seedlots, combinations of standard pretreatments may be only partially effective in its release. Tetrazolium or excised embryo tests are often used as indicators of seed quality because current germination tests are time consuming and not highly reliable.

Results of direct seedings have been erratic. Spot plantings in desirable locations conserve seed and provide developing seedlings with the best opportunity for establishment.

Douglas hawthorn is most reliably established from planting stock. Container and bareroot seedlings are easily propagated, handled, and planted with good survival on adapted sites. In the bareroot nursery, seed should be planted to provide a seedling density of 25 per ft^2 (278 per m^2). Untreated seed should be planted in early fall, but wet prechilled seed must be spring planted (Hartmann and others 1990; Van Dersal 1938). Container seedlings of uniform size are most economically produced from germinants (Landis and Simonich 1984). Rooting of hardwood or softwood cuttings is not recommended (Marchant and Sherlock 1984). Root cuttings have been used to propagate cultivated ornamental *Crataegus* species (Wyman 1971). Seedlings may be planted in mixtures with other shrubs, but should be protected from competition with perennial grasses and weedy species.

Uses and Management

Douglas hawthorn is a valuable shrub deserving more frequent inclusion in revegetation projects. It has been successfully used in conservation and wildlife projects to furnish soil protection and food and cover for wildlife. It is well suited to mixed plantings with other shrub species. The dense thickets provide hiding and thermal cover food for birds, small mammals, bear, big game, and livestock. They add valuable structural diversity on grassland sites. Winter mule deer use was evaluated as moderate to heavy in Washington (Brown and Martinsen 1959). Douglas hawthorn receives moderate summer use by mule deer (Kufeld and others 1973). Use by white-tailed deer and livestock is variable (Van Dersal 1938). Douglas hawthorn is rated as a valuable honey plant and fruits are heavily used by birds.

Fruits of Douglas hawthorn are high in sugar, but low in fats and protein. They were eaten fresh or dried and used in pemmican by Native Americans. They are sometimes used for jams and jellies (Craighead and others 1963). Where adapted, Douglas hawthorn is an excellent candidate for landscape plantings in parks and recreation areas.

Natural reproduction from seed is often prevented by heavy use and trampling in riparian areas where game and livestock tend to congregate. Seedlings develop slowly and should be protected from browsing and competition with weeds and grasses during the first two seasons. Young seedlings may be girdled by rodents. Established plants are not easily damaged by excessive browsing.

Varieties and Ecotypes

Although Douglas hawthorn exhibits many good attributes, selection trials have been limited. Appropriate growth forms of Douglas hawthorn may be selected for shelterbelt and windbreak plantings. The deep rooted, thicket-forming plants are useful for stabilizing mine spoil banks, riparian sites, and other disturbances. They are resistant to beaver damage (Marchant and Sherlock 1984). A number of hawthorn species and varieties are native to riparian zones in the Intermountain region and may be selected for the revegetation of adapted sites (Hitchcock and others 1961). Columbia hawthorn is a small tree or shrub with red fruit and thorns 1.5 to 3 inches (4 to 7 cm) long. It is distributed from British Columbia and Alberta south to Oregon, Idaho, and Montana. It grows well in heavy clay soils over basalt. Yellow hawthorn is found from central Utah east to Pennsylvania and southeastern Canada.

Fallugia paradoxa

Apache Plume

Apache plume, the only species of its genus, is a much-branched shrub 2 to 7 ft (0.6 to 2.2 m) tall (fig. 11). Branches are white to straw colored with flaking or scaly bark (Harrington 1964). Leaves are described as often evergreen in the southern portion of its range (Blauer and others 1975; Deitschman and others 1974b; USDA Forest Service 1937) and persistent or deciduous in cooler areas (Munz and Keck 1959; Welsh and others 1987). Leaves are borne in fascicles along the branches and are 1.2 to 1.8 inches (3 to 5 cm) long. They are cuneate with revolute margins and pinnately divided into three to seven linear lobes (Welsh and others 1987). Leaves are lepidote on both surfaces, light green above and rusty below (Harrington 1964; Munz and Keck 1959; Welsh and others 1987). The large showy, perigynous flowers, 1.2 to 1.8 inches (3 to 4 cm) broad, develop singly or in few-flowered cymes. A typical flower has five broad sepals alternating with five bracts and five large white petals. Numerous stamens are inserted in three series on the margin of the hypanthium. There are 20 to 30 pistils. The hairy achenes are 0.25 inch (6 mm) long with plumose persistent styles that elongate to 1 to 2 inches (2 to 5 cm) at maturity (Deitschman and others 1974b; Young and Young 1986). The distinct plumose styles resemble an Indian war bonnet, hence the name "Apache plume."

Figure 11—Apache plume is a resprouting relative of bitterbrush that often grows in dry washes.

Flowers are bisexual or rarely staminate (McMinn 1951). Blauer and others (1975) found monoecious as well as dioecious populations. At a study site near Richfield, UT, Blauer and others (1975) encountered shrubs with mostly perfect flowers. However, some plants had well-developed stamens but rudimentary and nonfunctional pistils. Other plants bore flowers with well-developed pistils, but rudimentary and nonfunctional stamens. Plants grown from seed collected at this location exhibited similar differences when grown at a study location near Boise, ID (Shaw and Monsen 1983b). McArthur (n.d.) considers many populations to be functionally dioecious.

Ecological Relationships and Distribution

Apache plume is found on a wide variety of sites from southeastern California to southwestern Colorado and south into Mexico and western Texas, largely outside the Great Basin (Deitschman and others 1974b). It is more abundant in the southern portion of its range. Apache plume grows in a variety of plant communities from the lower desert brush types up through the pinyon-juniper woodlands to open ponderosa pine communities at elevations from 4,000 to 8,500 ft (1,200 to 2,550 m) (Dietschman and others 1974b; Monsen and Davis 1985). It is commonly found in washes and ephemeral waterways, but also occurs on rocky or gravelly slopes and alluvial fans. Plants tend to be widely spaced, even when in pure stands.

Apache plume superficially resembles Stansbury cliffrose; both have lobed leaves and clusters of long plumed fruits. Unlike Stansbury cliffrose, Apache plume produces functionally dioecious plants (Blauer and others 1975; McArthur and others 1983b), and it does not form symbiotic nitrogen fixing root nodules with the actinomycete *Frankia* spp. (Klemmendson 1979; Nelson 1983; Righetti and others 1983). The species occur in broadly overlapping areas (Benson 1957; Blauer and others 1975), and a few suspected natural hybrids have been reported (Blauer and others 1975). Some seeds have been produced by artificial crosses, but no progeny have been produced (Blauer and others 1975). Chromosome number for Apache plume is n = 7 compared to n = 9 for Stansbury cliffrose.

Plant Culture

Flower buds are formed on elongated peduncles produced from vegetative growth of the current season. Buds may appear on terminal or lateral leaders or from new root sprouts (Rehder 1940). Flowering begins as early as April but may extend into August (Rydberg 1954; Van Dersal 1938). Plants flower from April to June in California (McMinn 1951), and as late as October in Arizona (Kearney and Peebles 1960). Plants established in southwestern Idaho flowered erratically from May until early October (Shaw and Monsen 1983b). Time from the appearance of floral buds to fruit ripening was 67 days in 1979 and 86 days in 1980.

Pollination is insect dependent; the flowers attract a variety of colorful bees, ants, hornets, and beetles (Blauer and others 1975). Good seed (achene) crops occur at 1 to 3 year intervals (Deitschman and others 1974b). Because flowers of Apache plume appear in late spring, seed crops are usually not damaged by spring frosts. Determining the appropriate date to harvest seed is difficult; seeds ripen unevenly over a period of several months. Most flowers develop early in the season, producing up to 90 percent of the annual seed crop. As seeds ripen they are detached and dispersed by the wind. Consequently, the period for collecting the maximum amount of seed may be rather short, perhaps only 1 to 2 weeks in duration. Later blooming is associated with summer rains.

Achenes turn from green to reddish as they ripen and plumes sometimes change from reddish to white. They are harvested by dislodging the fruits from the bush. The entire fruit, including the achene and plume is collected. Fruits comprise only 15 to 20 percent of the collected material by weight. Unless the plumes are removed with a barley debearder, the collected material remains in a thick entangled mass that cannot be seeded. There are approximately 546,000 seeds (achenes) per lb (1,203,712 per kg) at 100 percent purity. For seed purchases, acceptable purity is 80 percent and germination is 75 percent (see chapter 24).

Apache plume has been somewhat difficult to establish from direct seeding. A better understanding of the species' seed germination requirements and seedbed ecology would facilitate its use. Seeds are nondormant and germinate quite readily. Plummer and others (1969) reported 60 and 70 percent germination after 60 days at temperatures of 32 and 38 °F (0 to 3 °C). Deitschman and others (1974b) found seeds sown in nursery beds germinated within 4 to 10 days.

Although the plumed seeds are wind dispersed and adapted to shallow or surface seeding, broadcast seeding without seed coverage has not been a satisfactory means of planting. Apache plume is generally included in shrub seed mixtures that are planted separately from grasses. The seeds are easily sown with conventional drills if the styles are removed. Seed should be planted 0.25 to 0.5 inch (6 to 12 mm) deep in a firm seedbed. Fall seeding or seeding prior to the season of most dependable soil water is recommended. Rodents often gather and bury or eat seeds that have fallen from shrubs as well as sown seed. Seeding in late fall or winter when rodents are less active reduces these losses.

Seedlings emerge and grow rapidly under favorable conditions. They are reasonably drought tolerant, especially those that persist through the first summer.

The small plants are not able to persist amid herbaceous competition.

Bareroot and container reared seedlings are easily started and grow rapidly with irrigation, often flowering during the first growing season. When grown under field or nursery conditions in northern climates, the seedlings are mostly deciduous. Once the leaves have fallen, the plants are dormant and can be lifted and transplanted. The brittle stems must be handled carefully to prevent damage. In addition, the root system usually consists of a main root with few side branches. Any damage to the roots can be detrimental to field survival. Greenhouse-maintained plants tend to remain evergreen. These must be adequately hardened or overwintered in a shade house and planted as dormant stock or field survival will be reduced.

Uses and Management

Apache plume occurs throughout the dry, hot portions of the pinyon-juniper, big sagebrush, and southern desert shrublands. It is a useful species for these difficult-to-plant areas and can be planted on southern aspects and shallow soils. To date, Apache plume has most frequently been planted on drier portions of pinyon-juniper communities in central and southern Utah. Seed of the more northerly-occurring ecotypes is harvested for these projects. Once established Apache plume also does well on sites within its range occupied by green ephedra, Stansbury cliffrose, and black sagebrush. It can be planted on benchland sites where spiny hopsage, shadscale, blackbrush, low rabbitbrush, desert bitterbrush, littleleaf mountain mahogany, and singleleaf ash may occur. It is also adapted to fourwing saltbush, winterfat, and roundleaf buffaloberry sites. The species has been established from seed or planting stock on big sagebrush and antelope bitterbrush/bunchgrass ranges in central and northern Utah, southwestern Idaho (Shaw and Monsen 1983b), and northeastern Oregon (Edgerton and others 1983), all outside its native range.

Apache plume does not form thick stands. When seeded with other shrubs it quickly thins out to occupy only specific microsites. This characteristic has also been observed when it is planted on mine wastes and road disturbances. Apache plume has been slow to spread from seed, particularly when planted outside its natural range. Few seedlings are noted, even following years of heavy seed production. On coarse soils, vegetative spread occurs through root proliferation and root sprouting. Sprouts are more numerous during years with good precipitation or following physical damage to the plant. Individual sprouts may attain heights of 1 to 2 ft (30 to 70 cm) in one season (Monsen n.d.).

Although Apache plume's palatability to cattle and sheep is generally considered low, it is rated as good on some ranges. It does not receive heavy summer browsing by livestock on most sites. However, because of its fine twigs and evergreen leaves, it is a fairly valuable winter forage, particularly in the southeastern portion of its range (Ferguson 1983; Monsen and Davis 1985; USDA Forest Service 1937). The bushy habit provides good cover for birds and mammals (Blauer and others 1975).

Ferguson and Frischknecht (1985) considered Apache plume a secondary species for use on mine disturbances in northeastern Utah. It is not nodulated by the nitrogen-fixing endophyte *Frankia* (Nelson 1983; Nelson and Schuttler 1984). Because of its ability to spread vegetatively, Apache plume can be used to provide ground cover and soil protection in dry regions where infrequent storms can cause considerable erosion (Thornburg 1982). It is capable of recovering by vigorous crown sprouting. On native sites it spreads naturally onto disturbed areas.

Apache plume provides diversity for landscape plantings, particularly for dry, low maintenance situations. The white branches and the flowers and plumes are showy and quite unusual. Under cultivation the plant can be over irrigated and will not withstand even partial shade. Increased sprouting and a thicker, bushy habit can be obtained for landscape or erosion control plantings by trimming or grazing the planting. Apache plume has been cultivated as far north as Massachusetts (Deitschman and others 1974b).

The Tewa Indians of New Mexico used bundles of the smaller branches of Apache plume as brooms and the larger straight branches as arrow shafts (USDA Forest Service 1937).

Varieties and Ecotypes

Ecotypic differences have been observed among Apache plume collections currently under test. Shrubs of different populations vary in size and growth habit. Some populations appear better adapted to more northerly climates than others. Breeding system expression, palatability, and rootsprouting following fire also vary. There are at present no released varieties of the species.

Holodiscus discolor ______________

Creambush Oceanspray

Creambush oceanspray, also known as arrowwood, hardhack, rockspirea, and mountain spray, is a highly variable, but usually erect multiple-stemmed, deciduous shrub (fig. 12). Mature plants range from 2.5 to 10 (20) ft (1 to 3 [6] m) in height, with large tree-like forms growing in coastal areas. Young twigs are fine hairy; bark of the older stems is gray to deep grayish red. Leaf buds are covered by two to three purplish-brown bud scales. The alternate leaves are 1 to 4 inches (2.5 to 10 cm) long and ovate to ovate lanceolate with lobed to doubly toothed edges. Upper surfaces are

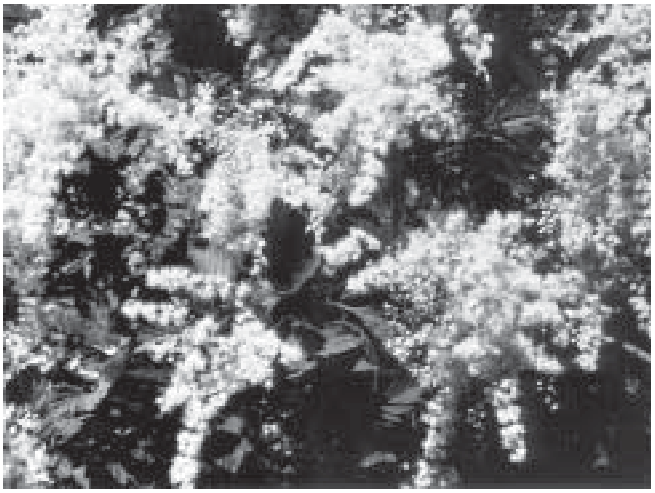


Figure 12—Creambush oceanspray in full bloom.

hirsute, while lower surfaces are pilose lanate to lanate and sometimes glandular. The common name creambush oceanspray is derived from the appearance of the diffuse, showy panicles of tiny, perfect, perigynous, white to pink flowers. Panicles are 4 to 7 (12) inches (10 to 17 [30] cm) long and overtop the shrub. Flowers are about 0.2 inch (5 mm) in diameter, regular, and 5-merous; petals exceed the sepals. Dried flower parts and panicle branches turn brown and persist well into the winter. Fruits are light yellow hirsute achenes approximately 0.1 inch (2 mm) long.

In communities where it exists, creambush oceanspray is one of the first shrub species to leaf out in spring (Orme and Leege 1980). Floral buds develop in late spring and flowering occurs from late June to late August, depending on location. Fruits mature in late summer and may persist into fall. Seeds are wind dispersed (Hitchcock and others 1961; Orme and Leege 1980; Stickney 1974a; USDA Forest Service 1937).

Ecological Relationships and Distribution

The genus *Holodiscus* existed in the Madro-Tertiary geoflora of western North America. It is now disjunct across the tropics, and occurs in western North America and Columbia. Creambush oceanspray is distributed from British Columbia east to western Montana and south along the coast to southern California. It grows in northeastern Oregon, Idaho, and northeastern Nevada (Hitchcock and others 1961; Munz and Keck 1959; Stark 1966; USDA Forest Service 1937). Creambush oceanspray grows on a wide variety of sites at elevations ranging from sea level to 7,000 ft (2,100 m). It is adapted to rich, deep soils of coastal forests, riparian areas, and canyon bottoms. It may also be found growing on dry, shallow soils or rocky talus slopes and along streams in drier areas (Patterson and others 1985). Creambush oceanspray is associated with drier conifer types of the interior and is a climax species in a number of forested communities (Cholewa and Johnson 1983; Cooper and others 1987; Halverson and others 1986; Steele and others 1981). An understory shrub layer of mallowleaf ninebark and creambush oceanspray is common in ponderosa pine and Douglas-fir forests in eastern Washington, northeastern Oregon, northern Idaho, and western Montana (Daubenmire and Daubenmire 1968; Steele and others 1981).

Creambush oceanspray occurs as a climax in open stands of conifers; it survives fires and other disturbances by resprouting from buds on the root crowns to become a member of early seral brushlands (Mueggler 1966; Stickney 1986). Mixed seral brushfields provide valuable forage and cover for deer, elk, and other wildlife. Regeneration from seed following burns is often limited and seedlings develop slowly (Ferguson 1983; Wright and others 1979; Young 1983). However, regeneration from seed may be important following extremely hot fires (Stickney 1974a). Owens (1982) found weight and length of current annual leader growth increased directly with degree of canopy mortality. However, regrowth was slightly lower for complete canopy mortality than for the 51 to 99 percent mortality class. Prescribed burning at 10 to 15 year intervals has been recommended to rejuvenate brush fields that have grown beyond the reach of browsing animals (Orme and Leege 1980).

Plant Culture

Collection of creambush oceanspray achenes is tedious; supplies are rare and costly. Fruits are “combed” from the branches by hand in late fall and conditioned by air drying and screening out larger material with a fanning mill. Achenes of oceanspray are among the smallest of shrub fruits. Only a small percentage of the seeds are normally sound; these are identified by examining wet seed through a dissecting microscope for the presence of an embryo (King 1947). Seeds require wet prechilling at 34 to 36 °F (1 to 2 °C) for about 120 days to break dormancy (Marchant and Sherlock 1984; Young and Young 1986).

Seeding may be accomplished by broadcasting fresh achenes over a rough seedbed in fall and allowing them to be covered by natural soil sloughing. Achenes may be mixed with seeds of other shrub species, but they should not be sown with grasses or forbs. Spots to be planted should be carefully selected to make best use of the seed. Seeding results have been erratic.

Creambush oceanspray is readily propagated from bareroot or container stock. Achenes should be fall sown in the nursery or artificially prechilled and spring sown. Cleaned achenes can be planted at reasonably uniform spacings. They can be surface sown and covered by dragging a lightweight chain over the seedbed. Seedlings develop rather slowly and may be lifted as 1-0 or 2-0 stock depending on size specifications and growing conditions. Container seedlings are propagated by planting germinants or about 10 wet prechilled seeds in each container. Plants can be grown from cuttings, but techniques have not been refined (Everett and others 1978a). Marchant and Sherlock (1984) achieved 19 percent rooting success with softwood cuttings harvested in late June and propagated under a greenhouse mist system and 12 percent rooting success with hardwood cuttings overwintered in a cold frame.

Uses and Management

Creambush oceanspray is generally not considered a palatable shrub, particularly when alternative browse species are available (Daubenmire and Daubenmire 1968; USDA Forest Service 1937). It is taken by deer and elk; peak use occurs in fall and winter (Stickney 1974a). Use varies geographically depending on ecotype and associated species. Creambush oceanspray receives year round use by elk and deer in eastern Washington, where it forms an important component of the available browse (USDA Forest Service 1937). Garrison (1953) recommended that browsing be limited to 50 to 60 percent of current annual growth on these sites. In the northern Rocky Mountains, use by big game is limited, but the species can be important on some winter ranges (Leege 1969; Stickney 1974a). Use increases tremendously the first winter following fires, but decreases the second winter (Leege 1969). Palatability of creambush oceanspray is rated fair for cattle and poor to fair for sheep (USDA Forest Service 1937). The species tends to increase on heavily grazed sites (Hall 1973; USDA Forest Service 1937). The quantity of the plant consumed in summer and fall in these areas may be considerable due to its abundance and accessibility.

Creambush oceanspray is a useful erosion control plant. The species is adapted to steep, dry, rocky areas with shallow, sandy to clay loam soils (Stark 1966). Seedlings quickly develop a spreading, highly branched fibrous root system. Their low palatability and their ability to resprout following top damage contribute to their value in stabilizing critical sites such as roadcuts and fills (Hungerford 1984; Stark 1966). In some areas, creambush oceanspray is grown as a horticultural species for its dark green foliage, extremely long flowering period, and orange to dull red fall coloration (Sutton and Johnson 1974). It is one of the first shrubs to leaf out in the spring. The small, dry fruits were eaten by Native Americans.

Seedlings establish readily from seed or transplant stock, but grow at only a moderate rate. Consequently, they require protection from grass and forb competition for one or two growing seasons. Excessive browsing is rarely a threat to developing seedlings, but they may be girdled by rodents or trampled by big game or livestock.

Varieties and Ecotypes

To date, selection work with *Holodiscus* species has been limited. The erosion control and ornamental potential of both creambush oceanspray and rockspirea deserve further investigation.

Holodiscus dumosus ______________

Rockspirea

Rockspirea, bush oceanspray, or rock spray spiraea is somewhat similar in appearance to creambush oceanspray, but has a lower and more compact growth habit (fig. 13). The rounded plants branch from the base and range from 3 to 12 ft (1 to 4 m) in height with crown diameters of 5 to 10 ft (1.5 to 3 m) (Hitchcock and others 1961; Sutton and Johnson 1974; Welsh and others 1987). Inflorescences and leaves are smaller. Leaves are decurrent along the petioles; blades are shallowly or coarsely toothed, sometimes with a few secondary mucronulate serrulations. Roots are densely fibrous and spreading. Flowering occurs unevenly all summer (Mozingo 1987). The species has n = 18 chromosomes (McArthur and Sanderson 1985).

Rockspirea is distributed from northeastern California across central and southern Oregon and Idaho to Wyoming and south to Chihuahua, Mexico (Hitchcock and others 1961) at elevations from 2,500 to 12,000 ft (762 to 3,660 m) (Dittberner and Olsen 1983; Harrington 1964; Hopkins and Kovalchek 1983). It occurs in a wide array of plant communities including

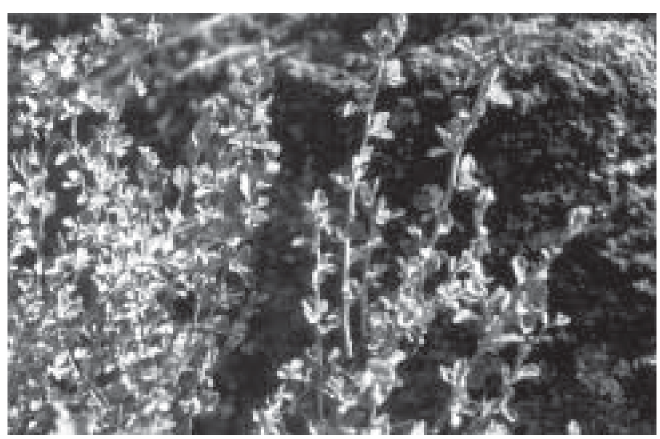


Figure 13—Rockspirea has smaller leaves and a more compact growth habit than creambush oceanspray; it often occurs on cliffs and rock outcrops.

big sagebrush, pinyon, curlleaf mountain mahogany, chaparral, aspen-lodgepole pine, spruce-fir, Douglas-fir, white fir, and ponderosa pine forests (Sutton and Johnson 1974; USDA Forest Service 1937). Within its range it commonly occurs on dry to moderately dry sandy or gravelly soils, rocky ridges, talus slopes, and basalt outcrops (Alexander and others 1974; Hitchcock and others 1961; Welsh and others 1987). It is frequently a codominant in climax communities, but has been reported to occur as a pioneer species following disturbances in a white fir/Rocky Mountain maple/ rockspirea habitat type, where it persisted as the site recovered (Alexander 1985).

Cultural and management practices recommended for creambush oceanspray may be generally applied to rockspirea. King (1947) determined that although there are about 5,400,000 achenes per lb (12,000,000 per kg), only about 7 percent were sound. These required wet prechilling at 41 °F (5 °C) for 18 weeks to release dormancy. Heat generated by wildfires may also stimulate germination.

The palatability and forage value of rockspirea generally receive low ratings (USDA Forest Service 1937). Kufeld and others (1973) reported its use by mule deer was moderate in fall and light during the remainder of the year. It is used by birds and rabbits to some extent (Sutton and Johnson 1974; Van Dersal 1938). Based on results of clipping studies in Oregon, Garrison (1953) recommended a maximum of 50 to 60 percent use for sustained production. Present primarily on summer ranges where other species receive preferential use, excessive grazing of rockspirea rarely occurs, and, at least on some western juniper/big sagebrush habitat types of eastern Oregon, the species tends to increase when other species receive excessive use (Ferguson 1983; Hopkins and Kovalchik 1983). Rockspirea thrives on dry slopes and unstable hillsides. It has high potential for use in revegetating disturbed sites (Johnston 1987; Stark 1966).

Seeding practices and propagation of nursery stock are as described for oceanspray. Plants are occasionally planted as ornamentals because of their long flowering period, attractive foliage, and compact growth habit (Stark 1966; Sutton and Johnson 1974). Use of the species to date has been seriously limited by a lack of commercially available seed.

Management of the species is also as described for creambush oceanspray. Little is known of the plant's regenerative ability following use, fire, or other physical damage (McMurray 1987a). Sprouting capabilities have not been well documented. Some regeneration might occur from wind-dispersed seed or from soil seed banks.

Varieties and Ecotypes

There are no releases.

Peraphyllum ramosissimum

Indian apple

Indian apple is a deciduous rounded shrub growing to 6 ft (2 m) in height from numerous, gray-barked basal stems (fig. 14). Fascicles of simple, nearly sessile oblanceolate leaves 0.6 to 0.8 inch (15 to 20 mm) long, and 0.2 to 0.4 inch (5 to 9 mm) wide are produced at the ends of short lateral spurs of the season. Leaves are glabrous above with a minute pubescence below. Perfect, 5-merous, epigynous flowers appear with the leaves, singly or in clusters of two to five. Leaves may be dropped in midsummer, possibly in response to water or temperature stress. Flowers are regular, perfect, and fragrant with spreading pink to rose petals. The style and the 15 or more stamens inserted on the edge of the hypanthium are exserted at anthesis. Fruit is a yellowish, bitter tasting, apple-like pome, 0.5 inch (12 mm) in diameter containing four seeds. In Utah, Indian apple flowers from April to July. Fruits ripen and are gravity or animal dispersed in July or August (Hitchcock and others 1961; Welsh and others 1987).

Ecological Relationships and Distribution

Peraphyllum is a monotypic genus of the subfamily Pomoideae distributed from southern and eastern Oregon along the east side of the Sierra Nevadas through central California and east to western Colorado and northwestern New Mexico at elevations ranging from 3,000 to 9,000 ft (900 to 2,700 m) (Dayton 1931; Ferguson 1983). It grows from the sagebrush/grass, pinyon-juniper, mountain brush, and oak/sagebrush zones to the lower fringes of ponderosa pine forests

Figure 14—Indian apple is an intricately branched shrub with potential for use in low maintenance landscaping.

(Hitchcock and others 1961; Welsh 1982). Chromosome number is n = 17 (McArthur and Sanderson 1985). Historically, Indian apple appeared in the Conifer Woodland Element of central Nevada's Upper Miocene floras in an area where the Arcto-and Madro-Tertiary floras overlapped (Axelrod 1950).

Plant Culture

Seed is harvested by hand picking or beating the fruits into containers. Fresh or dry fruits are macerated in a Dybvig or blender with water. Pulp that cannot be separated by flotation may be removed from the seed by fanning after the pulp is dried. Approximately 6.5 to 10.3 lb (2.9 to 4.6 kg) of cleaned seed may be obtained from 100 lb (45 kg) of fruit (Swingle 1939). There are approximately 23,000 seeds per lb (50,706 per kg) at 100 percent purity. Acceptable purity is 95 percent and germination is 50 percent for seed purchases (see chapter 24).

Seed requires a wet prechilling period of approximately 45 days at 38 °F (3 °C) to relieve dormancy (Belcher 1985; SEAM 1976; Smith 1974b). Germination of seedlots tested by the Coeur d'Alene Forest Service Nursery ranged from 60 to 80 percent (SEAM 1976). Seed testing techniques have been described by Belcher (1985). Seeds remain viable for up to 5 years if stored in a cool, dry, well ventilated container (Smith 1974).

The existence of distinct ecotypes, possibly restricted to specific soil types, makes selection of appropriate seed sources important. Seed should be fall planted on medium textured, well-drained soils in adapted areas (Stark 1966). Seeding may be accomplished by hand planting or drilling with other shrubs, but separately from grass and forb species. Little seed is available commercially; production of bareroot or container planting stock may maximize the number of seedlings obtained (Ferguson 1983).

Uses and Management

The forage value of Indian apple varies with accession and associated plant species. It is grazed by deer, particularly in fall. The fruits are used by birds and rodents. Indian apple can be incorporated into windbreak and conservation plantings on arid lands. The thick branching habit of the shrub offers cover for birds and other small animals in winter, even after the leaves have fallen. It also has potential for landscaping in arid areas, along roadways, and in recreation areas (Monsen and Davis 1985). It increases diversity on adapted sites. Indian apple is highly persistent once established, leading Blauer and others (1975) to suggest that it be used as a rootstock for related, but less tenacious species.

Initial survival of Indian apple plantings is often quite low. Seedlings grow slowly and may require protection for up to 3 years following planting. Indian apple may be entirely defoliated by grasshoppers when their populations are high. However, plants can recover even after successive defoliations.

Varieties and Ecotypes

Indian apple accessions have received little testing. When selecting ecotypes for revegetation, emphasis should be placed on plant size, fruit production, growth rate, and palatability.

Physocarpus malvaceous

Mallowleaf Ninebark

Mallowleaf ninebark is an open, multiple-stemmed shrub 3 to 8 ft (1 to 2.5 m) tall (fig. 15) that spreads vegetatively from long rhizomes (Hitchcock and others 1961; Welsh and other 1987). Roots are shallow and spreading. Bark is gray to red brown, shredding in thin layers. Leaves are alternate and currant- or mallow-like with three to five palmate lobes. Leaves are doubly crenate, nearly glabrous above, stellate pubescent to glabous below, and about 0.75 to 3.2 inches (2.0 to 8.0 cm) long. Clusters of stellate white flowers develop on the terminal corymbs. Flowers are regular and perigynous. Fruits are paired, densely stellate, flattened follicles with ascending beaks that dehisce along two sutures. Each follicle contains 1 to several tiny, hard, shiny, pyramiform seed each about 0.1 inch (2 mm) long (Gill and Pogge 1974a). Mallowleaf ninebark flowers in May or June and sets seed in August or September. Some fruits persist on the plant through the winter.

Figure 15—Mallowleaf ninebark grows rapidly; its dense root systems stabilize soil on unstable disturbances.

Like other shrubby members of the subfamily Spiraeoideae native to western North America, the chromosome number for mallowleaf ninebark is n = 9 (McArthur and Sanderson 1985). Species with n = 7 and n = 9 occur among Asian taxa of the genus (McArthur and others 1983b).

Ecological Relationships and Distribution

Mallowleaf ninebark occurs east of the Cascades from British Columbia and Alberta south through Nevada, Utah, and Wyoming. It grows in association with mountain big sagebrush, aspen, and many conifer communities at elevations from 5,200 to 10,800 ft (1,560 to 3,240 m) (Welsh 1982). It may be found on dry open slopes, talus slopes, northern exposures, in scattered to heavy timber, and on riparian sites (Davis 1952). Mallowleaf ninebark is adapted to deep, well-drained organic soils of medium texture and pH of 7.0 to 7.5 (Marchant and Sherlock 1984), but it will grow on drier, sandy or rocky soils (Daubenmire and Daubenmire 1968; Ferguson 1983). It is often abundant and highly productive.

Mallowleaf ninebark is frequently a member of seral shrub communities that develop following logging or wildfires in conifer forests (Olsen and Nagle 1965; Owens 1982). The species is highly adapted to fire; it resprouts from the root crown or horizontal rhizomes. The more completely buried rhizomes have the greatest resprouting capacity (Bradley 1984). Owens (1982) and Merrill (1982) found that number of plants and twig production increased on burned sites relative to unburned sites. In addition, recovery is enhanced by arrival of seed from undisturbed sites. The light seed is dispersed over long distances by wind and gravity (Young 1983).

Seral shrub communities provide forage and cover for deer, elk, and other wildlife, but rapidly grow out of reach of browsing animals. Overmature brushfields have been rejuvenated by prescribed burning, cutting, or topkilling tall shrubs with herbicides (Merrill 1982; Mueggler 1966; Orme and Leege 1980). Control of brush species to promote conifer regeneration has also been accomplished with herbicides (Miller 1981; Miller and Pope 1982a,b).

In addition to mallowleaf ninebark, several other ninebark species occur within the Intermountain region. Dwarf ninebark occurs in pinyon-juniper and related habitats of Idaho, Nevada, Colorado, and Utah. Mountain ninebark is found on moist soils of aspen and coniferous forests from Nevada east to Wyoming and south to Arizona and New Mexico. Pacific ninebark also grows on moist soils, but is restricted to California and the area west of the Cascades in Oregon and Washington. A disjunct population occurs in northern Idaho (Ferguson 1983; Hitchcock and others 1961).

Plant Culture

Mallowleaf Ninebark seed are hand collected by detaching the dried flower heads (Van Dersal 1938). Seed is separated from debris using a barley debearder and an air screen fanning machine. There are approximately 756,000 seed per lb (1,666,700 per kg). Acceptable purity for seed purchases is 98 percent and germination 40 percent (see chapter 24). Seed is expensive and rarely available. Little is known of the seed biology of this species. A high percentage of the tiny seeds are normally not sound. Sound seeds are dormant and require a 77-day prechilling at 40 to 43 °F (4 to 6 °C) (Gill and Pogge 1974a; Marchant and Sherlock 1984).

Direct seeding is accomplished by broadcasting seed onto a rough seedbed in fall and allowing natural soil sloughing to cover it. Best results are obtained when seed is planted separately from other species in selected spots. Seedlings can establish with some shade and limited herbaceous competition.

For bareroot nursery plantings, mallowleaf ninebark is fall seeded or artificially wet prechilled and spring seeded. Seed should be covered lightly and mulched. Swingle (1939) estimated that a pound of seed would yield about 30,000 usable seedlings. Seedlings are lifted as 1-0 to 2-0 stock depending on purchase specifications and growing conditions. Container stock may be propagated from germinants or cuttings. Hardwood stem cuttings are easily propagated and frequently used. Container and bareroot stock develop slowly, producing densely branched root systems. Both container and bareroot seedlings establish readily (Monsen n.d.).

Uses and Management

The value of mallowleaf ninebark as a forage plant varies with season, location, class of game or livestock being considered, and availability of other vegetation. It is generally considered to be more valuable on ranges where better forage plants are depleted or unavailable, and on drier sites (Noste and Bushey 1987). Stands are rarely lost as a result of browsing. The USDA Forest Service (1937) rated mallowleaf ninebark as fair for sheep, fairly good for goats, and poor for cattle; Van Dersal (1938) rated it as good browse for sheep, goats, and cattle. Kufeld and others (1973) reported it receives light spring use and moderate summer and fall use by mule deer. In cafeteria style feeding trials with tame mule deer, Smith (1953) found mallowleaf ninebark was one of the most highly preferred native forages in the Logan, UT, area from May 1 to June 20. Because of its deciduous habit, it is of little value on winter ranges. New growth is more heavily browsed by deer for up to 3 years following burning (Noste and Bushey 1987).

Mallowleaf ninebark has potential value as an erosion control plant. It grows rapidly, producing a network of rhizomes and a densely branched fibrous root system. It is a useful species for the restoration of high elevation acid minespoils in Nevada (Butterfield and Tueller 1980; Everett and others 1980). In spite of its rapid growth rate, mallowleaf ninebark receives little use in windbreak and farmstead plantings because of its bushy growth habit (Olsen and Nagle 1965). Mallowleaf ninebark has gained acceptance as an ornamental in some areas. It is a hardy, easily grown plant with attractive white flowers and dull to bright reddish brown leaf coloration (Gill and Pogge 1974a; Sutton and Johnson 1974). Plants that become too bushy can be pruned back.

Once established, seedlings of mallowleaf ninebark grow rapidly compared to those of many other members of the Rosaceae. They compete successfully with other shrub species, but require some protection from grass competition for one or two growing seasons. Seedlings are not browsed heavily if alternative forage is available, but they may suffer predation by rodents and trampling by big game and livestock.

Potentilla fruticosa ______________

Shrubby Cinquefoil

Shrubby cinquefoil, also known as bush cinquefoil, buckbrush, hardhack, ninebark, or yellow rose, is a rather short lived, densely branched, round-topped to low spreading shrub with spreading and fibrous roots. It produces white to bright yellow flowers throughout the summer, when adequate soil water is available (fig. 16) (USDA Forest Service 1937). The shreddy brown bark of the main stems peels off in long strips. Leaves are pale to gray-green, leathery, 0.4 to 1.2 inch (1 to 3 cm) long, and pinnately compound with five to seven narrow, often revolute, leaflets. Leaves turn yellow in fall, but may be retained over winter. Flowers are 5-merous, complete, and solitary or in three to seven-flowered cymes. Each flower is 0.75 to 1 inch (2 to 2.5 cm) in diameter with a saucer-shaped hypanthium and five petals. There are 10 to 30 stamens and numerous pistils. Fruits are golden tan, teardrop-shaped achenes crowded on a hairy receptacle. Individual achenes are 0.04 to 0.08 inch (1 to 2 mm) long with very thin seed coats covered with white hairs. Fruits mature and are dispersed continuously by wind and gravity throughout the flowering season (Hitchcock and others 1961). However, in Alberta, Canada, flowering apparently occurs in two flushes, one in May and the other in August (Scotter 1975). Fruits mature in mid to late summer and fall.

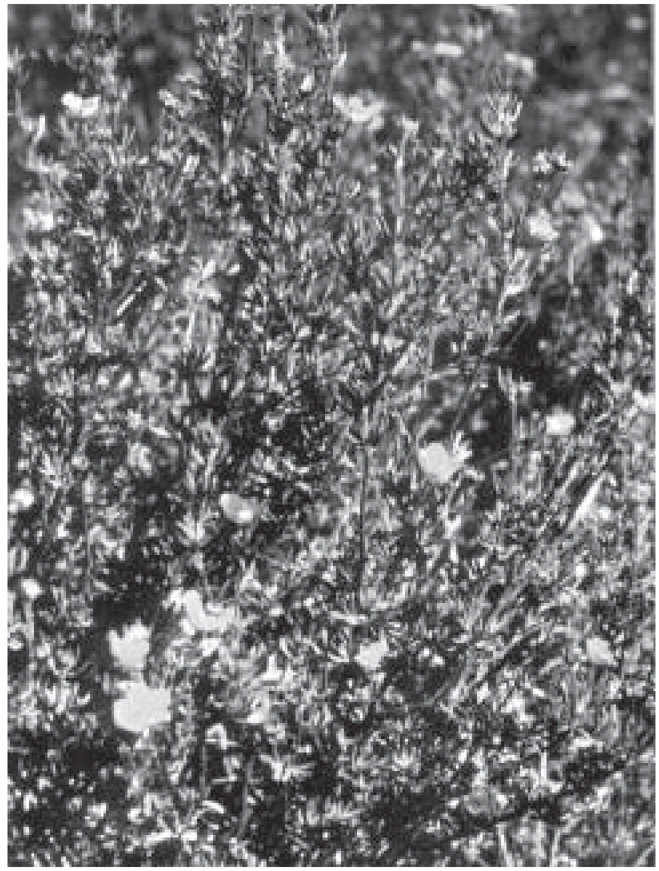


Figure 16—Shrubby cinquefoil is a common riparian species in wet meadows at mid to upper elevations.

Ecological Relationships and Distribution

There are about 250 species of *Potentilla* occurring in temperate to subarctic regions of the Northern Hemisphere (Young and Young 1986). Shrubby cinquefoil is widely distributed in the Northern Hemisphere, ranging east from Alaska’s north slope to Greenland and Labrador and south to California, New Mexico, Minnesota, and New Jersey. It also grows in Europe and Asia (Hitchcock and Cronquist 1973; USDA Forest Service 1937). In common with several mesic shrubby North American members of the subfamily Rosoideae, the diploid chromosome number of shrubby cinquefoil is 2n = 14 (McArthur and Sanderson 1985); that of European plants is 2n = 28 (Elkington and Woodell 1963). Hitchcock and others (1961) reported hybridization occurs within this genus, but hybridization of shrubby cinquefoil with other species has not been observed (Elkington and Woodell 1963).

Shrubby cinquefoil is associated with cool climates and wet areas; it grows from plains and lower foothills to above timberline over an elevation range of 6,100 to 12,000 ft (1,850 to 3,600 m) (Belcher 1985). In the western United States shrubby cinquefoil is a common summer range plant in wet subalpine meadows. It also grows near springs and marshes and along streambanks and floodplains in chaparral, sagebrush, aspen/lodgepole pine, ponderosa pine, Douglas-fir/white fir, and spruce/fir forests (Sutton and Johnson 1974; Welsh 1982; Welsh and others 1987). It is most abundant on areas with deep, wet, medium-textured soils and can withstand some salinity (Davis 1952; Stark 1966).

The response of shrubby cinquefoil to burning depends on the season, site conditions, and fire intensity, and may vary among populations. Plants may be relatively unaffected to heavily impacted by burning (Fischer and Clayton 1983; Mueggler and Stewart 1980). Little damage is incurred by low intensity spring burns that fail to kill the root crown (Wasser 1982), particularly on wet or rocky sites. Plants regenerate rapidly by sprouting from root crowns, rhizomes, and stem layering (Wasser 1982). Severe burns occur when dense mature stands burn in late summer, particularly under droughty conditions. Some soil seed reserves may also be lost under such circumstances with the result that recovery occurs very slowly.

Plant Culture

Seed collection is difficult. Fruits are scattered over the crown of the plant and ripen unevenly during the growing season. Plants are not shade tolerant and produce little seed when shaded (Scotter 1975). Little seed is mature at any given time and hand collection proceeds slowly. Consequently, seed is rarely available commercially (Ferguson 1983). Seed is cleaned with a debearder and fanning mill. It may be stored in a warehouse for 5 years. Seventy percent is considered an acceptable level for both purity and germination for seed purchases (see chapter 24). Seed quality is highly variable, but often rather low (Elkington and Woodell 1963; Wasser 1982).

Little information is available regarding germination requirements of shrubby cinquefoil seed. Vories (1981) reported the species is difficult to grow from seed. Belcher (1985) and SEAM (1976) found no germination pretreatment was required although a water soak at 86 °F (30 °C) for 18 hours did enhance germination. McDonough (1969) applied an 11-minute soak in sulfuric acid and obtained 73 to 87 percent germination at 90/72, 72/63, and 63/53 °F (32/22, 22/17, and 17/12 °C). Light is required during incubation (Young and Young 1986). Tetrazolium and x-ray testing instructions were provided by Belcher (1985).

Direct seeding information is scarce, but seeding can be successful on sites with good soil water. Babb (1959) recommended planting as soon as seed ripens. Planting before mid-July or in late fall was recommended by Wasser (1982). Seeding may be accomplished by drilling, broadcasting, or spot seeding on prepared sites (Wasser 1982). Seeds are small and should be covered lightly, about 0.25 inches (6 mm) deep or less (Wasser 1982).

Bareroot and container stock can be produced from seed. Container stock started from germinants or small transplants requires a 3 to 5 month cropping season (Landis and Simonich 1984). Wildings are an alternative source of planting stock.

Production of shrubby cinquefoil for the commercial ornamental market generally involves vegetative propagation of horticultural varieties. Plants are capable of natural root sprouting following disturbances (Wasser 1982). Stem layering also occurs and may be effective in spread and survival where inundation occurs (Elkington and Woodell 1963). Vegetative propagation is accomplished by rooting softwood or semihardwood stem cuttings in a greenhouse. Root cuttings, layers, and crown divisions are also propagated (Doran 1957; Mahlstede and Haber 1957; Toogood 1980).

Uses and Management

Shrubby cinquefoil is an indicator of heavy grazing; it may become more abundant when other species are depleted. It is outcompeted by grasses and declines if grazing is eliminated. Although its palatability is often low due to its coarse, astringent foliage (Dayton 1931), game and livestock will use shrubby cinquefoil when other species are not available (Wasser 1982). Young plants are generally more palatable than mature shrubs (Wasser 1982). In general, it is more palatable to sheep and goats than to cattle and horses (Sampson and Jesperson 1963). Because of its higher elevational distribution, it normally occurs on summer ranges, but where available in winter, it is sometimes used because of its semi-evergreen habit and dominance in some areas (USDA Forest Service 1937).

Kufeld and others (1973) found mule deer make light use of shrubby cinquefoil in winter and take only trace amounts in spring and summer. Elk and white-tailed deer make some use of the plant during all seasons. Bighorn sheep use it primarily in autumn (Van Dyke and others 1983). Seeds are consumed by birds and small mammals (Wasser 1982). Palatability of shrubby cinquefoil varies geographically and seasonally. It is generally more palatable in spring and summer (Plummer and others 1968). Although it is avoided by big game in Alberta, it is unusually palatable in parts of Montana and Arizona. Livestock also make greater use of it on scattered high altitude summer ranges of the southwestern states, southwestern Montana, southeast Idaho, and Utah (Dayton 1931; Ferguson 1983; USDA Forest Service 1937). Plants are moderately tolerant of browsing, but they can be damaged by repeated grazing, particularly during periods of drought when plants may become hedged and stunted and eventually lost (USDA Forest Service 1937; Wasser 1982).

Whether transplanted or grown from seed, shrubby cinquefoil is a useful soil stabilization species for disturbed sites with fairly wet soils. It is useful for mine reclamation, roadway plantings, and game range rehabilitation (Dittberner and Olsen 1983; Fedkenheuer and others 1980; Ferguson and Frischknecht 1985; Stark 1966; Wasser 1982). It is an excellent species for ornamental plantings because of its rapid growth rate, ease of cultivation, attractive semi-evergreen leaves, colorful flowers, and long flowering period.

Although shrubby cinquefoil seedlings have been described as weak, they begin to grow rapidly once established and are better able to survive herbaceous competition than most other rose species. Plants are cold, but not drought tolerant (Sutton and Johnson 1974). If planted in areas not heavily grazed by game or livestock, they develop to maturity in about 5 years (Wasser 1982).

Varieties and Ecotypes

Considerable natural variability has been observed in this species. Numerous ornamental varieties of shrubby cinquefoil are marketed commercially. However, the species has received little testing for wildland uses. Populations with a rapid growth rate, spreading growth habit, and low palatability should be of greatest value for soil stabilization and streambank erosion control. Numerous showy flowers, a long flowering period, low palatability, and evergreen leaves are desirable characteristics for populations used for landscaping in recreation areas.

Prunus americana ________________

American Plum

American or Pottawatami plum is an erect shrub or rarely a small tree. In the Great Plains it grows from 9 to 26 ft (3 to 8 m) in height (fig. 17) (Harrington 1964; Hitchcock and others 1961). In Utah plants are thicket-forming shrubs up to 16 ft (5 m) tall (Welsh and others 1987). Regeneration by rhizome sprouting is the main method of spread (McMurray 1987b; Welsh and others 1987). Branches are thornlike at the tip. Leaves are 1 to 2.8 inches (2.5 to 7 cm) long, elliptic to ovate or lanceolate and sharply long attenuate. They have pubescent, glandular petioles. Small umbels of white flowers are borne before the leaves on spur branchlets or axillary buds formed the previous season. Fruits are fleshy yellow to red drupes 0.8 inch (2 cm) in diameter, each with a single large stone. Some fruits may be hard and dry (Welsh and others 1987). Seed are dispersed by gravity and frugivorous mammals.

Plant Culture

American plum ranges from Manitoba through northeastern Canada and south to New Mexico and northwestern Florida (Grisez 1974; Hitchcock and Cronquist 1961). It occurs in the Rocky Mountain region and has been introduced into portions of the Intermountain area west of its native range. It will grow on deep soils in mountain brush, pinyon-juniper, and sagebrush grass habitat types receiving at least 16 inches (40 cm) of annual precipitation (Plummer and others 1968; Thornburg 1982). Within its native range it is often a climax dominant or codominant, but it may be an early seral species in some forested habitat types (Elkington and Woodell 1963). It acts as a colonizer on unstable sites along streams or rivers (Elkington and Woodell 1963; Mueggler and Stewart 1980). Where introduced in the Intermountain region, it often grows in sandy to loamy soils along ditch banks, drainage areas, and around home or farm buildings where supplemental water is available. Plants are capable of withstanding some salinity.

American plum does not establish well from direct seeding. However, it can be established from bareroot or container stock transplanted singly or in rows or clusters to meet planting objectives. Rootstocks are utilized for propagation of domestic plum in northern climates (Grisez 1974). American plum grows well in mixtures with other woody species. Herbs with some shade tolerance do well as understory species.

American plum will sprout when burned, trampled, or otherwise damaged. Spread also occurs from seed transported by animals. The species has good drought and excellent cold tolerance.

Figure 17—In the Intermountain area, American plum is a thicket-forming shrub that spreads from rhizomes.

Ecological Relationships and Distribution

American plum flowers in April or May and fruits ripen in September or October (Grisez 1974; Plummer and others 1968). Fruits are harvested, conditioned, and stored as described for common chokecherry. Seed requires a 60 to 150 day wet prechilling to relieve dormancy (Grisez 1974). There are about 810 seed per lb (1,786 per kg) at 100 percent purity. Acceptable purity is 98 percent and germination 70 percent for seed purchases (see chapter 24).

Uses and Management

American plum has been planted for many years in conservation plantings, windbreaks, and shelterbelts in the Midwest and Western States. It provides excellent escape, nesting, thermal, and travel cover for big game, livestock, and small mammals and birds. Leaves, twigs, and fruit are utilized by these animals.

American plum can be an important component of erosion control plantings and low maintenance landscape projects. It has excellent potential for use in recreation areas, roadside rest areas, roadways, and administrative sites. It is also used as an aesthetic screen for wildlife in areas requiring thermal and concealment cover.

Varieties and Ecotypes

A number of American plum cultivars have been selected, primarily for their fruiting characteristics. There are no selections specifically developed for wildland use. Available material varies considerably in its range of adaptability and suckering habit. Stock adapted to the planting site and suitable for the planting goals should be acquired.

Prunus andersonii

Desert Almond or Anderson Peachbrush

Mozingo (1987) described desert almond as "one of the most beautiful and probably the most unappreciated shrubs in the western Great Basin." Also known as desert peach, Anderson almond, or Nevada wild almond; desert almond generally occurs as low growing, densely shrubby, clonal plants. Each clone may cover several acres. Individual stems are evidently short lived, usually producing 6 to 8 annual rings (Kay and others 1977f; Young and Evans 1973, 1974). The plants have an average height of about 3 ft (1 m), but range from 1.5 to 6.5 ft (0.5 to 2 m) in height (fig. 18). They are intricately branched and densely thorny; each branch ends in a sharp spine. Narrow leaves develop in fascicles on short, lateral branches. Small pink to light red flowers appear in April to June and cover the shrub. The flowering period for separate clones within an area may vary by up to a month, ensuring that some flowers and fruits will survive late frosts (Kay and others 1977e). Fruits ripen in June or July. The drupes resemble small, dry, fuzzy greenish-orange peaches and have a thin, rather dry fleshy layer. The thick hard coat of the stone opens easily along one suture (Mozingo 1987). Fruits and seeds are dispersed by gravity and wildlife.

Figure 18—Desert almond is a clonal shrub valuable for soil stabilization, cover, and as a low water-use ornamental.

Ecological Relationships and Distribution

The native range of desert almond extends from northeastern California southward along the eastern slopes of the Sierra Nevada Mountains and eastward across western and southern Nevada at elevations from 3,450 to 7,400 ft (1,050 to 2,250 m) (Ferguson 1983; Munz and Keck 1959; Young and Evans 1973). It is a fairly drought tolerant species, most commonly found scattered through big sagebrush and pinyon-juniper communities on foothills, mesas, alluvial terraces, and in canyons. It is especially common on coarse sandy or gravelly to rocky soil derived from decomposing granite (Dayton 1931; Smith and others 1978).

Plant Culture

Seedling establishment apparently occurs only infrequently. Seedlings have been noted following removal of woody species in sagebrush/grass and pinyon-juniper sites (Young and Evans 1973, 1974); they develop from soil seedbanks or from off-site seed transported by mammals (McMurray 1987c). Plants resprout vigorously following fire (Young and Evans 1978b). Clones may survive into later seral stages of the community; maximum occurrence is on old burns that have reached mid-successional stages (Koniak 1985).

Fruits are hand collected. Conditioning involves macerating the fruits in a Dybvig or blender and floating the pulp. To relieve dormancy, Kay and others (1977f) recommended a 30 day wet prechilling; 60 days were recommended by SEAM (1976). Seed should be fall planted to provide for field prechilling. Container and bareroot seedlings have been used successfully. Planting stock can also be propagated from cuttings, although the success rate may not be high. Everett and others (1978a) recommended use of cuttings collected during the period of seed maturation. Rooting required approximately 6 weeks under a greenhouse mist system.

Uses and Management

Desert almond has good potential for use as a soil stabilization species on disturbed sites due to its low, dense growth form, clonal habit, and good establishment. Everett (1980) obtained second year survival of 77 percent and 25 percent for containerized desert almond seedlings planted on south- and north-facing roadcuts, respectively, near Reno, NV. Seedlings were tenacious, but tended to grow slowly. Smith and others (1978) obtained 3-year survival of 73 percent when desert peachbrush seedlings grown in containers 1.5 ft long (0.5 m) were transplanted in holes drilled into granitic bedrock near Mammoth Lake, California. They recommended the species for granitic sites within its range.

Desert almond foliage is somewhat palatable, accessible, and probably seasonally important. Livestock and wildlife make some use of the species, particularly in spring or when summer storms induce new leaf production (Dayton 1931). The dense patches provide good cover for birds and other small animals. Desert almond has good potential as a low maintenance ornamental for roadsides, parks, and campgrounds because of its colorful flowers and long flowering period.

Varieties and Ecotypes

No improved varieties are available for revegetation projects. Some variability among clones has been noted, but comparative testing of different populations has been limited. Desert almond has been grown as far north as Boise, ID, (Monsen n.d.).

Prunus besseyi

Bessey Cherry

Bessey cherry or western sand cherry is a low-growing shrub with numerous spreading basal stems 1 to 5 ft (0.3 to 1.5 m) tall (fig. 19) (Vories 1981; Welsh 1982). Leaf blades are 0.6 to 2 inches (1.5 to 5.0 cm) long and 0.2 to 0.7 inch (5 to 18 mm) wide, elliptic to oblanceolate, and acute to cuspidate apically. Leaves, sepals, petals, hypanthia, and fruits are glabrous. White flowers appear with the leaves in clusters of two to four. The black fruits are 0.5 to 0.7 inch (12 to 18 mm) in diameter. Flowering occurs in April or May; fruit ripening and dispersal occur from July to September in Nebraska (Grisez 1974), and from August to September in Utah (Plummer and others 1968).

Ecological Relationships and Distribution

Bessey cherry is native to the Great Plains and is distributed from Manitoba south to Wyoming, Colorado, and Kansas (Grisez 1974). The species is commonly used as a dwarfing rootstock for other *Prunus* species. It has been introduced into the Intermountain region in wildlife and conservation plantings and by dispersal from orchards. Bessey cherry has been successfully established on sites ranging from basin big sagebrush communities to openings in ponderosa pine forests. Adkins (1980) reported survival in conservation plantings in eastern Washington was 28 percent in the 9 to 12 inch (23 to 30 cm) precipitation zone; survival ranged from 3 to 61 percent when plants were fully established. He concluded that in low precipitation areas Bessey cherry produced inadequate growth to provide good cover and was unable to compete successfully with cheatgrass and other annual and perennial weeds.

Figure 19—Native to the Great Plains, Bessey cherry has been used in wildlife and conservation plantings in the Intermountain region.

Plant Culture

Seed collection, conditioning, storage, and planting practices are generally as described for common chokecherry. Seed is often collected from stock maintained at a nursery or from conservation plantings. Swingle (1939) found an average of 17 lb (7.6 kg) of seed could be recovered from 100 lb (45 kg) of fruit yielding 1,500 to 2,260 clean seed per lb (3,300 to 4,980 per kg). Babb (1959) obtained greatest germination following a 100 day wet prechilling at 41 °F (5 °C) or 120 days at 33 °F (1 °C); he noted a high degree of variability in requirements among seedlots. A 72 hour gibberellic acid soak (3.46 g Rootone F/ 1000 g H_2O) followed by wet prechilling for 20 days at 41 °F (5 °C) was recommended by SEAM (1976).

Bessey cherry can be direct seeded. Seed should be fall planted 0.5 to 1.0 inch (1.0 to 2.5 cm) deep on seedbeds cleared of competition. The species can also be established from container or bareroot stock (Monsen 1974). It can be propagated from buds, grafts, suckers, or root cuttings (Babb 1959). For windbreaks or conservation plantings, a 4 ft (1.2 m) spacing is recommended (Cook 1981).

Uses and Management

Monsen (1974) and Monsen and Christensen (1975) recommended use of Bessey cherry to provide good ground cover and soil stabilization on adapted sites in Utah and Idaho. It has been used extensively in the Midwest as a low growing erosion control and wildlife plant; it provides fruits and cover for birds and other small animals. Attractive flowers, fall leaf coloration, and its low, spreading growth habit make Bessey cherry a unique plant for landscaping.

Rodents and birds often collect planted seed and emerging seedlings. Severe damage to planted Bessey cherry seedlings has resulted from rodent girdling (Brown and Martinsen 1959). Plants developing from seed or planting stock should be protected from excessive grazing and competition with grasses and forbs.

Varieties and Ecotypes

Some selections have been developed for horticultural plantings, but no specific material has been developed for wildland uses.

Prunus emarginata ______________

Bitter Cherry

Hitchcock and others (1961) recognized two varieties of bitter cherry: *Prunus emarginata* var. *mollis*, an arborescent variety growing to 42 ft (15 m) in height and distributed west of the Cascade Mountains, and var. *emarginata*, a more shrubby form with an open growth habit and several crooked stems commonly 3 to 13 (26) ft (1 to 4 [8] m) tall that grows in and east of the Cascade Mountains (Hitchcock and others 1961). The deep reddish-purple bark on young twigs of both varieties turns gray to dark brown on older branches and stems. The entire, alternate leaves are 1.2 to 2 inches (3 to 5 cm) long, glabrous to pubescent, and oblong to obovate with crenulate to serrate margins. Stipules are caducous and attenuate to linear. Corymbs of 3 to 12 white insect-pollinated flowers (fig. 20) are produced from axillary buds on twigs of the previous season. Flowers are complete, regular, perigynous, and 5-merous. Sepals are produced on a turbinate, deciduous, disk-lined hypanthium that varies from glabrous to hairy. There are 12 to 20 exserted stamens and a single pistil. Only one of the two ovules develops. The fruit is a bitter tasting, red to black, one-seeded drupe from 0.3 to 0.5 inch (8 to 12 mm) in diameter. Bitter cherry flowers from April to June. Fruits ripen from July to September depending on elevation and local weather conditions (Grisez 1974; Plummer and others 1968). Fruits are dispersed in August or September. Seed are often distributed by birds and mammals.

Figure 20—Bitter cherry flowers from April to June, depending on elevation. Fruits are used by many birds and mammals.

Ecological Relationships and Distribution

Bitter cherry occurs from the Pacific Coast of British Columbia east to northern Montana, and south to southern California and southwestern New Mexico (Ferguson 1983; Hitchcock and others 1961). Its elevational range varies with latitude. In the north it grows from sea level to 3,000 ft (915 m); in the southwest it occurs from 5,000 to 9,000 ft (1,525 to 2,745 m) (USDA Forest Service 1937).

Bitter cherry is most frequently found in the upper portion of the ponderosa pine belt. It is frequently found on well drained, moderately fertile, rocky sites such as ridge tops and southwest slopes in mountain brush communities. It is capable of resprouting following burning and often dominates other shrubs in seral brushfields. Bitter cherry grows along watercourses in grasslands and sagebrush communities.

Plant Culture

To maximize the number of viable seed obtained, fruits should not be harvested until they are bright red and fully mature (Grisez 1974). Fruits are collected by hand stripping or by placing tarps under trees to catch them following natural dispersal. They may also be harvested with a mechanical tree shaker. Swingle (1939) reported that about 25 lb (11.4 kg) of seed can be obtained from 100 lb (45.5 kg) of fruit yielding 1,800 to 5,471 seeds per lb (3,965 to 12,050 per kg).

A Dybvig or commercial blender may be used to macerate the fruit. All pulp and juice should be cleaned from the stones. Part of the pulp and some low quality seeds can be removed from the mixture by flotation, the rest by drying and fanning. Dried fruits are cleaned by hammermilling at a low speed, followed by fanning. Specific storage requirements have not been ascertained for bitter cherry (Grisez 1974); seeds are commonly stored as described for common chokecherry.

Bitter cherry seed fill is generally low. Filled seeds are difficult to germinate. Treatments to increase germination give inconsistent and generally poor results. Germination of treated seed is generally less than 20 percent (Monsen and Davis 1985). Poor germination has discouraged use of this species in direct seedings. The species can be intertransplanted using bareroot or container seedlings on favorable sites. Seedlings grow remarkably well on dry and exposed sites with shallow soils where few other shrubs establish. Wildings and root cuttings are alternative methods of propagation.

Uses and Management

Bitter cherry is frequently planted to provide browse for wildlife and livestock. Elk, deer, and moose eat twigs and buds of plants growing on ridges and open slopes of winter ranges. The species is ranked as highly valuable for elk in summer and fall (Kufeld 1973). Mule deer use trace amounts in winter and make moderate use of the plant during other seasons (Kufeld and others 1973). Its palatability has been ranked as poor to fair for cattle and fair to fairly good for sheep. Major livestock use occurs primarily in late summer or fall when other vegetation is no longer available. In many areas dense thickets of bitter cherry grow out of reach of grazing animals, but provide good cover. Lower growing forms may be heavily browsed. Fruits are consumed by birds and mammals; rodents harvest the seed.

Bitter cherry may be planted on shallow soils of disturbed sites within its natural range to control erosion on roadways and other disturbances (Monsen and Davis 1985). Butterfield and Tueller (1980) and Everett and others (1980) concluded bitter cherry held considerable promise on acid mine spoils in Nevada. Establishment from seed or seedlings can be hindered by trampling and grazing; the seedlings develop slowly. Rodents consume seed and damage seedlings. Swihart and Yahner (1983) found rodents preferred *Prunus* species over the remaining 29 common windbreak and conservation species tested. For cottontails, *Prunus* fell into a neutral to preferred category. Seedlings develop slowly and must be protected from competition with more aggressive plants for up to 3 years following establishment.

Bitter cherry spreads by root sprouts; new shoots develop readily following burning. Leege and Hickey (1971), working near the Lochsa River of northern Idaho, found spring and fall burns increased bitter cherry sprouting about equally; mortality was slightly higher in fall than in spring. Spring burning was recommended for decreasing height of shrubs in seral brush fields and improving browse conditions for elk. Adequate regrowth occurred during the summer to provide fall forage.

Varieties and Ecotypes

There are no releases.

Prunus fasciculata ________________

Desert Peachbrush

Desert peachbrush is a low growing, intricately and divaricately branched deciduous shrub with a rounded growth form (fig. 21). Shoots may attain heights of 5 ft (1.5 m) and diameters of 8 ft (2.4 m). Plants have a deep taproot as well as a spreading fibrous root system. They are not rhizomatous (Harrington 1964; Welsh and others 1987).

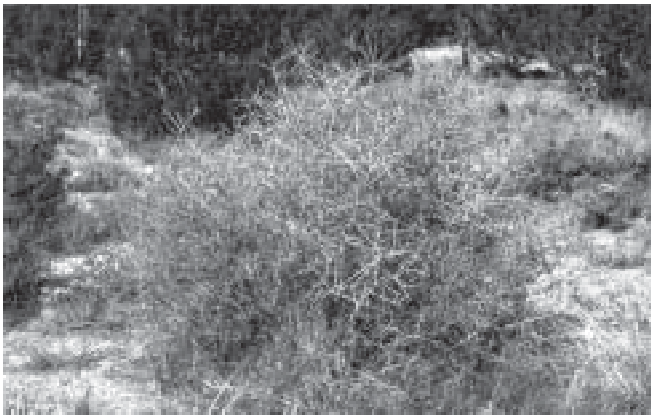


Figure 21—Desert peachbrush provides soil stabilization and cover for wildlife. Because of its unique branching habit, it has potential as a low maintenance ornamental.

Branches are grayish white, ending in pointed spines. The light green leaves are 0.1 to 0.2 inch (2.5 to 5 mm) long and 0.04 to 0.2 inch (1 to 5 mm) wide, cuneate to spatulate, and entire to few toothed at the apex. Flowers are small with five cream colored petals. Fruit is a pubescent greenish-orange drupe with a rather dry fleshy layer.

Ecological Relationships and Distribution

Desert peachbrush occurs in central and southern Nevada, southwestern California, and western Arizona on valley floors and foothills at elevations from 2,050 to 5,800 ft (625 to 1,770 m) (Ferguson 1983; Welsh and others 1987). Desert peachbrush occurs in association with chaparral, basin big sagebrush, Wyoming big sagebrush, sand sage, blackbrush, creosotebush, fourwing saltbush, quailbush, and lower pinyon-juniper communities. It can be found on well drained to heavy soils ranging from basic to neutral. Greatest area of occurrence is on sandy to rocky loam soils in depressions along drainage areas, intermittent streams, and creeks. Within these areas plants occur as individuals or more typically in small groups, usually with a rather sparse understory. Following fire, desert peachbrush sprouts readily and profusely from the root crown. Seed dispersal and seedling establishment may be heavily dependent on rodents that gather and cache seed.

Plant Culture

Harvestable seed crops are produced in about 1 of every 5 years. Fruits are gathered by hand stripping or by beating them into a container. The pulp attached to the stony endocarp is thin and dry and does need not be extracted. Leaves and sticks are separated by screening. Fruits are then dried and stored or seeded. There are about 4,500 seed per lb (9,900 per kg). Viability is generally good and is retained for 5 to 10 years of storage following harvest (Stevens and others 1981a). Seed retained in storage for 20 years exhibited fair viability. Acceptable germination for seed purchases is 90 percent and purity 70 percent (see chapter 24).

Seed can be drilled or broadcast and covered. It must be placed 0.5 to 1 inch (1.25 to 2.5 cm) deep in a firm seedbed. Fall or winter seeding provides the wet prechilling period required to relieve dormancy. A strong, fast growing seedling is produced and good establishment is common if soil water conditions are favorable. This species can also be propagated and outplanted quite easily as bareroot or container nursery stock (Monsen and Davis 1985). Considerable numbers of seedlings sometimes establish naturally from rodent caches.

Uses and Management

Desert peachbrush is generally seeded in a mix with other shrubs to improve diversity. California quail and Gambel quail, chukar, nongame birds, and small mammals use it extensively for cover, nesting, and forage. With the exception of pronghorn (Smith and Beale 1980), livestock and big game make little use of the species. Although the shrubs are sometimes infested with tent caterpillars, they persist in spite of defoliation.

Desert peachbrush establishes and does well when seeded on disturbed sites. Individual plants can cover large areas. Branches contact the soil surface over most of the area and provide considerable ground cover and soil protection. Perennial forbs and grasses emerge and develop beneath and adjacent to the crown. Desert peachbrush can establish on roadcuts and fills, in sand and gravel pits, and on mined areas. It also has ornamental potential, especially for low maintenance landscaping projects. The intricate branching pattern, grayish-white stems, and light green leaves give the plant a unique appearance.

Seeded plants should be given 2 to 3 years to establish and attain reasonable size prior to grazing. Once established, this species is very hardy and can withstand considerable use.

Desert peachbrush has performed well when planted on big sagebrush sites. It can be interseeded or intertransplanted in crested wheatgrass or native perennial herb seedings. Growth of established seedlings is not suppressed by annual grasses. Because of its ability to persist, even with wildfires and invasions of annual weeds, increased study and use of desert peachbrush to improve diversity of plantings on desert shrublands within its range are warranted.

Varieties and Ecotypes

There are no subspecies or released varieties of desert peachbrush. Little selection work has been attempted, but the species is being tested as a drought tolerant rootstock for other *Prunus* species (Welsh and others 1987).

Prunus spinosa and *Prunus tomentosa* ____________

Blackthorn and Nanking Cherry

A number of introduced *Prunus* species from eastern Europe and Asia are adapted to mountain brush, upper pinyon-juniper, and big sagebrush communities of the Intermountain region. Blackthorn and Nanking cherry, both Asian species, have been successfully planted in the Intermountain West. Blackthorn grows to 13 ft (4 m) and Nanking cherry to 10 ft (3 m) in height (Grisez 1974). Flowers of both species are generally numerous and very showy. Blackthorn produces a fleshy, dark purple, glabrous fruit; fruits of Nanking cherry are semifleshy, light purple, and pubescent.

Both species have been used in shelterbelt, windbreak, and conservation plantings. They have high potential for use in and around recreational areas, administration sites, low maintenance landscaping projects, and on disturbed sites such as roadcuts and fills or mine disturbances.

Both species transplant very well. However, they are fairly difficult to establish from direct seeding. Fall planting is required as the seed require wet prechilling. Good diversity can be provided by including these species in mixtures with other shrubs. Grasses and forbs grow well in association with both species, but seedlings should be protected from herbaceous competition. They have excellent resistance to insects and grasshoppers, good cold tolerance, and are fairly drought tolerant. Livestock and big game make some use of twigs and leaves; fruits are taken by birds and rodents. Birds use these species for cover, nesting, and brood rearing.

Seed and bareroot or container stock of both species may be obtained from commercial nurseries in the Midwest and Intermountain regions.

Prunus virginiana ____________

Chokecherry

Chokecherry is a thicket-forming shrub or small tree with several deep roots and a well-developed, fibrous root system (fig. 22). Plants develop rhizomes that are 0.4 to 0.6 inch (1 to 1.5 cm) in diameter and extend laterally about 3 ft (1 m) from the stems. New stems sprout from the rhizomes and the root crown. Leaves are alternate and elliptic, about 0.1 to 4 inches (2.5 to 10 cm) long and finely serrate along the edges (Welsh and others 1987). Purplish-red glands are usually found near the tip of the petiole or along the leaf base. The leaves are bright green above and paler beneath. They turn bright red in early autumn.

Elongate racemes of fragrant white flowers develop from April to June. Racemes are about 3 to 6 inches (8 to 15 cm) long. The insect-pollinated flowers are perfect; five petals spread from a gland-lined hypanthium. Only one of the two ovules normally develops. The fruits are red to purplish-black cherrylike drupes about 0.4 inch (1 cm) in diameter; each contains a single seed with a stony endocarp (Grisez 1974; Welsh and others 1987). Seeds ripen from July to September. Fruit production is greater during years of average or better rainfall and on plants growing in full sunlight.

Hitchcock and others (1961) recognized three varieties of chokecherry. Common chokecherry is a large shrub or small tree growing to 50 ft (15 m) in height with bright to deep red fruits. Black chokecherry is a small to medium sized shrub or small tree 13 (20) ft (4 [6] m) tall with dark, nearly black fruits and thick leaves. Western chokecherry ranges from 7 to 13 (20) ft (2 to 4 [6] m) tall with dark, nearly black fruits and thick leaves.

Ecological Relationships and Distribution

Chokecherry occurs primarily in central and eastern United States. It ranges from Saskatchewan to Newfoundland and south to Kansas and North Carolina (Hitchcock and others 1961; USDA Forest Service 1937). Black chokecherry is distributed from eastern British Columbia to the Dakotas and southward east of the Cascades from northern California to New Mexico. Western chokecherry occurs primarily

Figure 22—Chokecherry provides palatable and nutritious browse that is used by many wildlife species.

along the west coast from British Columbia south to California (Hitchcock and others 1961; Welsh and others 1987).

Chokecherry is distributed from low elevation foothills into mountainous areas at elevations from sea level to 9,000 ft (2,750 m) on sites with annual precipitation of 12 to 30 inches (305 to 760 mm) (Thornburg 1982; USDA Forest Service 1937). It is often associated with sagebrush, mountain brush, pinyon-juniper, and dry conifer types. It grows on moderately acidic to basic or saline soils with silty to sandy textures that are moderately deep, fertile, and usually well drained. Scattered plants or small clumps may be found on talus slopes and other rather dry sites; larger thickets develop along streams and around springs, ditches, or roadsides in semi-arid areas. In higher elevation communities, common chokecherry tends to occur on more open sites and along riparian areas. It is not adapted to high water tables or prolonged flooding (Wasser 1982).

Plant Culture

Chokecherry spreads by seed. It also spreads vegetatively from buds produced on rhizomes and the root crown. However, it is not commonly propagated by vegetative means. Leafy softwood cuttings can be rooted, but hardwood cuttings are not recommended (Hartmann and others 1990; Marchant and Sherlock 1984).

The drupes fall soon after reaching maturity (Grisez 1974). Birds and mammals harvest and spread the seed. Germinability may be increased after seeds have passed through their digestive tracts (Grisez 1974). Fruits are collected either by hand picking or beating them into a canvas or into a container. Seed harvested too early may have low germinability. If harvested too late, many seeds may already have fallen and others will split while being cleaned, leaving the embryo vulnerable to mechanical damage (Grisez 1974; Marchant and Sherlock 1984). Harvested fruits should not be exposed to heat as mold may develop, and viability may be reduced. Fruits are cleaned by macerating the fleshy material with a Dybvig cleaner and flushing with water to remove the flesh from the seed. This is followed by drying and further cleaning with a clipper cleaner. Fermentation may facilitate cleaning, but may adversely affect germination (Grisez 1974). There are about 4,100 cleaned seed per lb (9,020 per kg) (see chapter 24). For seed purchases, acceptable purity is 90 percent and germination 70 percent.

Seed may be sown immediately after cleaning without further drying. Short-term storage for a few months requires only air drying. Optimal long-term storage conditions have not been determined, but warm, humid conditions result in rapid deterioration of seed quality. On the other hand, excessive drying can also be harmful. Belcher (1985) and Marchant and Sherlock (1984) reported that air dried seed stored in sealed containers at 37 to 41 °F (3 to 5 °C) will remain viable for 3 to 5 years.

Chokecherry seeds generally have fairly high viability, but germination of untreated seed is generally quite low. About one-half of the viable seed will germinate in 69 days (Wasser 1982). Western chokecherry generally germinates more readily than black chokecherry (Monsen and Davis 1985). Wet prechilling can increase both the rate and percent of germination. Seed is wet prechilled at 36 to 41 °F (20 to 23 °C) for 120 to 180 days (Wasser 1982). Thoroughly soaking the seed prior to wet prechilling may improve effectiveness of the treatment. Wet prechilling is adequate if the stones have cracked, but the radicles have not yet emerged. The rate of radicle emergence is normally rather low, but can be further reduced, if necessary, by lowering the prechilling temperature once the stones have broken open (Grisez 1974; Wasser 1982). Fracturing the endocarp, boiling, freezing, and various chemical treatments have provided inconsistent results and are sometimes detrimental (Grisez 1974). The Association of Official Seed Analysts recommended a 60 to 90 day wet prechill period at 37 to 41 °F (3 to 5 °C) for testing germination (Belcher 1985). They also provided tetrazolium testing and radiographic procedures.

Nonprechilled seed must be fall seeded, but artificially prechilled seed may be planted in spring. Seed should be planted 0.5 to 1 inch (1.25 to 2.5 cm) deep in a firm seedbed. Seed can be drill seeded or metered through a seed dribbler mounted on a crawler tractor. The former method has provided excellent results (Stevens 1992). This species can be seeded individually or as a component of a mixture of other shrubs and nonaggressive forbs and grasses. Seedlings establish most successfully when planted on sites that receive at least 15 inches (38 cm) of annual precipitation (Monsen and Davis 1985). They have often been planted on drier sites with poor success. Seedlings of black and western chokecherry are not highly competitive, but become more so after 2 to 3 years (Monsen and Davis 1985; Plummer and others 1968; Thornburg 1982). Once the root system becomes well established, plants can exist with other woody species or herbaceous vegetation and can withstand considerable grazing.

Bareroot stock of all chokecherry species may be grown in the nursery. However, seed and new seedlings are often gathered by birds and small rodents. One growing season usually provides stock of adequate size for transplanting (Shaw 1984). Although initial growth of germinants is very rapid, the rate sometimes drops off considerably during the growing season; a 2 year cropping period is often necessary

(Marchant and Sherlock 1984). Bareroot seedlings have a strong taproot system. Rhizome and new shoot development are initiated early in the season, often prior to lifting. New growth can easily be damaged during lifting and planting, thus reducing the success of establishment (Monsen n.d.). Seed, germinants, or small transplants can be used to propagate container stock. Seedling development requires a 3 to 5 month cropping period (Landis and Simonich 1984).

Uses and Management

Chokecherry has been extensively used to improve wildlife habitat. Plants typically form relatively open thickets that allow livestock and big game access to abundant amounts of nutritious and palatable browse. Despite its deciduous nature, chokecherry maintains relatively high nutrient levels in late fall and winter (Dietz 1972). Chokecherry provides fairly palatable browse for big game and is widely utilized by elk, moose, and bighorn sheep (Plummer and others 1968); it is also the preferred deer browse on many winter ranges throughout the Intermountain west (Dietz 1972; Kufeld 1972; Kufeld and others 1973). Chokecherry receives its greatest use in spring and fall, but elk and deer use it to some extent year around. It is moderately palatable to all classes of livestock, although it seems to be more heavily browsed by sheep than cattle (USDA Forest Service 1937; Wasser 1982). Fruits are taken by birds, bear, and many small mammals (Aune and Stivers 1985; Blauer and others 1975; Gullion 1964; Noste and Bushey 1987; Wasser 1982). Plants are productive and withstand moderate use. However, repeated heavy browsing results in highlining, hedging, and lower availability of forage. New sprouts may be killed by trampling or browsing. Grazing does not affect the next year's fruit production; flowers are borne on twigs of the season.

Chokecherry may be toxic if consumed in large amounts; leaves contain the glucoside amygdalin (Noste and Bushey 1987). Young shoots contain the greatest concentrations. Most problems occur in spring and early summer. Following fall frosts, the plants become essentially harmless. Livestock are not likely to consume fatal amounts of chokecherry except in areas of animal concentration.

Chokecherry is extremely valuable for watershed and streambank stabilization, restoration of mine and roadway disturbances, landscape plantings in recreation areas, and increasing diversity in conservation and windbreak plantings (Ferguson 1983; Plummer and others 1968; Shaw and Cooper 1973; Wasser 1982).

All chokecherries are edible, but have an extremely sharp and biting flavor if eaten before fully ripe. The fruits make excellent wine, jellies, syrup, honey, flavorings, and perfume oil. Native Americans used the dried fruits to make pemmican cakes for winter use (Welsh and others 1987). Tea was prepared from the stems and bark (Craighead and others 1963).

All species of chokecherry are well adapted to fire, particularly if burned when dormant or when soil moisture is high (Anderson and Bailey 1980; Tisdale and Hironaka 1981; Young 1983). Although top growth is easily killed, vigorous sprouting from rhizomes or the root crown provides for rapid recovery following the initial decline (Leege and Hickey 1971; Noste and Bushey 1987). After the first postburn season, numbers of stems and coverage by the species can exceed preburn levels for a number of years. Although establishment from seed is quite rare on undisturbed sites, the species may be dependent on seedbanks for postfire regeneration, at least in riparian areas or higher elevation communities (Kramer 1984; Wright and others 1979; Young 1983).

Varieties and Ecotypes

There are no releases.

Purshia glandulosa ________________

Desert Bitterbrush

Desert bitterbrush is an evergreen shrub resembling Stansbury cliffrose and frequently mistaken for it. Welch and others (1987) described desert bitterbrush as ranging from 5 to 9 ft (1.5 to 2.7 m) in height (fig. 23), generally upright, but sometimes low and

Figure 23—Desert bitterbrush is a stable hybrid derivative of Stansbury cliffrose and antelope bitterbrush.

spreading. Branchlets are prominently glandular. The glandular leaves are 0.1 to 0.4 inch (3 to 10 mm) long and up to 0.2 inch (5 mm) wide, cuneate, glabrous above, and slightly tomentose beneath. Petals are 0.2 to 0.3 inch (5 to 8 mm) long and creamy white to yellowish. Achenes are oblique and 0.8 inch (2 cm) long, including the elongate style. Glandular evergreen leaves and smaller, elongate achenes differentiate desert bitterbrush from antelope bitterbrush (fig. 24).

Ecological Relationships and Distribution

Desert bitterbrush is restricted to southern California, southern Nevada, southern Utah, and northern Arizona (Koehler and Smith 1981; McArthur and others 1983b; Nord 1965; Stutz and Thomas 1964). Koehler and Smith (1981) and Stutz and Thomas (1964) considered it to be a hybrid derivative of Stansbury cliffrose and antelope bitterbrush parentage that arose from hybridization and subsequent introgression between these two species (McArthur and others 1983b). This hybridization is a relatively recent development and populations remain genetically distinct. Welch and others (1987) transferred cliffrose, *Cowania,* to the genus *Purshia* because hybrids of cliffrose, antelope bitterbrush, and desert bitterbrush occur where the distribution of these species overlap.

In southern Utah, desert bitterbrush grows principally in the blackbrush type, and in pinyon-juniper extensions into this type, at elevations from 3,460 to 4,470 ft (1,055 to 1,363 m) (Welsh 1987). It is more common in southern Nevada and California than in Utah. It often occupies sites where cool and warm desert species interface and is often the dominant or codominant shrub when present.

Figure 24—Desert bitterbrush, (left) is distinguished from antelope bitterbrush (right) by its glandular, evergreen leaves.

Plant Culture

Seed production, harvesting, conditioning, and storage are similar for desert and antelope bitterbrush (Deitschman and others 1974c; Giunta and others 1978). When ecotypes of both species are grown at common garden sites in Idaho and Utah, desert bitterbrush is normally smaller in stature than the erect antelope bitterbrush growth form. It produces less seed than antelope bitterbrush and good seed crops occur less frequently. There are approximately 21,000 seed per lb (46,200 per kg). Seed retain viability for up to 25 years when stored under warehouse conditions (Stevens and Jorgensen 1994). For seed purchases recommended purity is 95 percent and germination 90 percent (see chapter 24).

A high percentage of desert bitterbrush achenes fail to mature normally. Commercially harvestable seed crops are produced once in every 2 to 6 years at native collection sites. Consequently, it is necessary to harvest adequate quantities of achenes in good years to fill anticipated needs (Plummer and others 1968). Desert bitterbrush seed orchards have been established at various locations in Utah and Idaho in an attempt to develop more consistent seed production centers.

Germination requirements of desert and antelope bitterbrush are similar. Both require short periods of wet prechilling to release dormancy. Desert bitterbrush seedlings are more difficult to establish than those of antelope bitterbrush. They grow more slowly and attain maturity later when grown together in common gardens. Seedlings also grow more slowly under nursery conditions with regular irrigation. Because of its slow growth, desert bitterbrush is less competitive with annual weeds than antelope bitterbrush.

Direct comparison of establishment attributes between the two species of bitterbrush may create a somewhat distorted picture. It is adapted to more xeric sites and when planted in such areas can perform well. It usually grows in areas receiving less than 14 inches (36 cm) of annual precipitation. Artificial plantings on these sites are often unsuccessful; the precipitation received may be too low or erratic to permit establishment. However, desert bitterbrush seedlings are relatively hardy and can survive adverse weather conditions if they once establish. Rodents quickly gather planted desert bitterbrush seed. Consequently, planting in late fall or winter is advised to reduce seed predation. Seeding directly into a weedy understory should be avoided. Seedlings normally require 1 to 3 years to fully establish. Both bareroot and container grown seedlings establish well and can be used to provide more rapid establishment.

Uses and Management

To date, most plantings of desert bitterbrush have been made on upland pinyon-juniper sites where antelope bitterbrush is native (Davis 1983a). In general, antelope bitterbrush ecotypes respond better than desert bitterbrush at most of these planting sites. However, desert bitterbrush plants have established and persisted on antelope bitterbrush sites in central and northern Utah, southern Idaho, and south-central Idaho. Desert bitterbrush plantings have also been successfully established on pinyon-juniper/blackbrush sites in southern Utah (Davis 1983a). Desert bitterbrush exhibits important vegetative traits such as production of semi-evergreen leaves, ability to resprout following fire, and good drought tolerance.

Desert bitterbrush demonstrates adaptability to disturbances and can be used to seed infertile mine spoils and roadways in adapted areas. Welch and others (1983a) reported that it reduces soil erosion and provides habitat for game and non-game animals. Roots may form symbiotic nitrogen-fixing relationships with the endophyte *Frankia* (Nelson 1983). Once established, desert bitterbrush grows well with herbaceous understory plants and can be managed to provide seasonal herbage, particularly winter forage for big game and livestock. Welch and others (1983a) found desert bitterbrush plants in a southwestern Idaho common garden retained a significantly greater quantity of leaves in winter than collections of antelope bitterbrush and cliffrose. Crude protein content of the desert bitterbrush accessions exceeded that of the other two species. Palatability may be somewhat lower than that of antelope bitterbrush. However, where desert bitterbrush occurs, variety, quality, and quantity of other browse species are often low. As a result, considerable use is made of the species, particularly by deer and cattle. Its growth habit provides much needed shade and cover for small game and birds. Seeds are collected, eaten, and cached by rodents, birds, and reptiles. Insect populations associated with desert bitterbrush are often high, especially during flowering and seed set.

Varieties and Ecotypes

No selections of desert bitterbrush have been developed for release (Davis 1983a). Ecotypes vary in growth form from decumbent to upright. Populations or ecotypes having good drought tolerance (Davis 1983a), fire tolerance, winter leafiness (Welch and others 1983a), and nitrogen-fixation capabilities (Righetti and others 1983) have been identified. Because desert bitterbrush, antelope bitterbrush, and Stansbury cliffrose hybridize freely, it may be possible to combine desired attributes of these three species.

Purshia tridentata ________________

Antelope Bitterbrush

Antelope bitterbrush is an intricately branched, deciduous shrub varying in growth habit from low decumbent spreading forms to upright arborescent plants over 13 ft (4 m) in height (fig. 25) (Blauer and others 1975; Welsh and others 1987). Leaves are alternate, simple, pinnatified or apically three-toothed and usually glandular. Flowers are borne on short spurs of previous year's growth. They are numerous, white to yellow, and about 0.3 inch (8 mm) in diameter (Harrington 1964; Munz and Keck 1959; Welsh and others 1987). The fruit is a cartilaginous achene 0.2 to 0.5 inch (6 to 12 mm) long (Young and Evans 1983) with a persistent tapering style and a black pyriform seed (Blauer and others 1975). Plants are reported to be long lived. Nord (1965) found the average age of decumbent plants growing above 8,000 ft (2,440 m) in northern California was 52 years; at

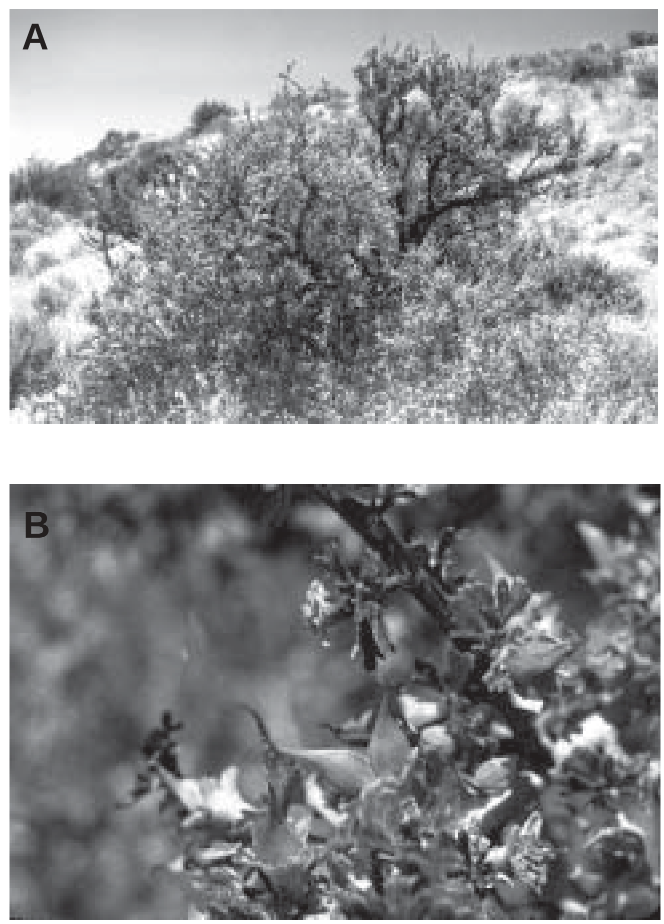


Figure 25—(A) Mature antelope bitterbrush plant and (B) fruit.

other locations the average age exceeded 150 years (Ferguson 1983a; Nord 1959).

Populations of antelope bitterbrush are extremely variable. Giunta and others (1978) described ecotypes with differing growth forms, fire tolerance, rates and periods of growth, seed production, drought resistance, nutritional qualities, heat tolerance, cold hardiness, climatic adaptation, resistance to disease or insect damage, palatability to game or livestock, evergreen habit, vegetative reproduction, and shade tolerance. Winward and Findley (1983) recognized similar variations in Oregon and California populations, but also noted marked differences in leaf size, shape, color, presence or absence of glands, flowering, and seed set. Many differences observed among populations are genetically influenced (Klemmedson and Ferguson 1969; Nord 1959a; Plummer and others 1968; Wagle and Vlamis 1961). Ecotypes maintain their native growth habits and morphological characteristic when planted over a wide range of sites. However, climatic and edaphic conditions alter growth response to some extent (Davis 1983a; Edgerton and others 1983; Nord 1965; Shaw and Monsen 1983a).

Ecological Relationships and Distribution

Cowania is derived from the neotropical Tertiary flora that emerged in the Sierra Madre region of Mexico during the Tertiary epoch (Axelrod 1958). McArthur and others (1983b) postulated that *Purshia* is an early derivative of *Cowania* that evolved in isolation. Chromosome number for both genera is n = 9 (Alderfer 1977; McArthur and others 1983b; Sanderson 1969). Present contacts between *Purshia* and *Cowania* are considered very recent; their partially separated flowering periods form a weak isolation barrier. Natural hybrids are found throughout most of Utah and Nevada where *Cowania* and *Purshia* overlap (Stutz and Thomas 1964). The hybrids backcross with the parental stock, producing genetic introgression in both genera. Introgression is considered to be the major process contributing to genetic differentiation of ecotypes (McArthur and others 1983b; Stebbins 1959; Stutz and Thomas 1964; Thomas 1957). Desert bitterbrush is a southern adaptive derivative resulting from this process. In addition, cliffrose characteristics are present in most populations of antelope bitterbrush that occur beyond the northern margins of cliffrose distribution (Stutz and Thomas 1964).

Antelope bitterbrush occurs from the Cascade Mountains eastward through the Rocky Mountains and from British Columbia south to Arizona and New Mexico (Ferguson 1983; Hitchcock and others 1961; Koehler and Smith 1981; McArthur and others 1983b; Stutz and Thomas 1964). It grows in big sagebrush, pinyon-juniper, and mountain brush communities and ponderosa pine forests. At lower elevations, in the southern portion of its range, it extends into blackbrush communities. It may also be encountered on high mountain exposures intermixed with aspen, limber pine, and Douglas-fir. It usually exists at elevations ranging from 200 ft (60 m) in the Pacific Northwest to 11,500 ft (3,510 m) in the Sierra Nevada Mountains in areas receiving 12 to 25 inches (30 to 64 cm) of annual precipitation (Nord 1965; Stanton 1959; Tew 1983).

Antelope bitterbrush is often a component of mixed shrub communities (Blaisdell 1953; Ferguson and Medin 1983; Holmgren and Basile 1956), and is frequently a dominant in the northwestern part of its range (Franklin and Dyrness 1973; Mueggler and Stewart 1980; Nord 1965). Prostrate and semi-erect growth forms of antelope bitterbrush occur most commonly as understory plants in forested communities or at high elevations (Nord 1965). Some low-growing types are also encountered at low elevations and under dry conditions, but the upright, tree-like forms usually dominate on more xeric sites (Nord 1965).

Some ecotypes are adapted to specific soil conditions. Prostrate growth forms occur on shallow, coarse textured soils in central Idaho, while tall, erect forms grow on deep productive soils where basin big sagebrush may also occur (Tew 1983a). Plummer and others (1968) reported that ecotypes from neutral or slightly acidic soils in Idaho are not adapted to calcareous soils of central Utah. Davis (1983a) found that only 24 of 259 accessions planted on pinyon-juniper sites in Utah scored performance index values that would recommend their use in these areas.

Antelope bitterbrush ecotypes vary in their response to burning. Adams (1980) suggested that antelope bitterbrush evolved as a fire climax. Edgerton (1983) reported rapid establishment of new seedlings following fire in ponderosa pine/antelope bitterbrush communities in the southern Cascade Mountains. Reestablishment from seed occurs erratically in response to climatic conditions and may be limited by grazing, rodent activity, presence of annual weeds, and other factors. Emergence from rodent caches is common in many areas.

Resprouting capabilities vary with ecotype. Some ecotypes in forested communities recover well by resprouting after burning (Martin 1983; Rice 1983; Sherman and Chilcote 1972; Zlatnik 1999). Driver and others (1980) found 100 percent resprouting of plants burned in a ponderosa pine/grass/antelope bitterbrush habitat type. Antelope bitterbrush plants recovered well from spring burning in ponderosa pine-antelope bitterbrush-pinegrass habitats, but little resprouting followed fall burning when soil moisture was low (Driver 1983).

Billings (1952), working in the western Great Basin, and Hormay (1943) in California found that antelope bitterbrush rarely resprouted following fire and suggested burning would permanently eradicate the species. Blaisdell (1953) found that not all plants growing on the Upper Snake River Plain in Idaho resprouted even after a light burn. Murray (1983) reexamined sites studied by Blaisdell and reported no antelope bitterbrush recovery 43 years after burning. Bunting (1985) and Bunting and others (1987) concluded that the columnar ecotypes growing in central Idaho do not recover from burning. At Wallsburg, UT, 80 to 90 percent of the antelope bitterbrush plants burned in a wildfire resprouted the first year following the fire. By the end of the third year mortality exceeded 90 percent. This pattern is commonly observed following wildfires in antelope bitterbrush stands in Idaho and Utah.

Plant Culture

Antelope bitterbrush was perhaps the first native shrub used for wildlife habitat and rangeland restoration in the Intermountain region. Since the early 1940s antelope bitterbrush has been seeded in many areas in the western United States. Holmgren and Basile (1956) reported that of approximately 50 species tested in Idaho, antelope bitterbrush was the easiest to establish from direct seeding.

Nord (1965) reported that young plants growing on native sites usually begin producing seed in about 10 years. By contrast, plants grown in cultivated nurseries, or in native stands managed for seed production, often begin producing seed when 2 to 4 years of age. Latitude, elevation, season, and site conditions influence vegetative phenology and the date of seed maturation (Nord 1965).

Leaf growth of antelope bitterbrush precedes the appearance of floral buds. At a common garden near Boise, ID, leaf growth of ecotypes from a wide geographic range was initiated between March 17 and 23 (Shaw and Monsen 1983b). Leaves reached mature size by about mid April when flower buds were beginning to develop. Leader growth of the different ecotypes was initiated during the first week of May, coinciding with anthesis. Most stem elongation occurred in June and early July. Stem growth rate diminished in July. Little elongation occurred in late summer or fall. All five ecotypes examined responded similarly.

Climatic conditions favorable to good seed production antedate the crop by at least 1 year; flower buds develop primarily on second year wood (Nord 1965). Plants that receive favorable moisture produce good leader growth and increased root reserves that support seed production the following year (McCarty and Price 1942) (fig. 25b).

Shaw and Monsen (1983b) reported that accessions of antelope bitterbrush growing in a common garden in southern Idaho set and matured seed in 42 to 48 days in 1979 and 57 to 60 days in 1980. Blaisdell (1958) found the period of flowering and seed maturation was slightly longer (66 days) at sites near Dubois, ID. Seed maturation dates can be predicted with reasonable accuracy. Nord (1965) developed an equation using elevation and latitude to predict mean dates of seed maturation for stands in California. Actual harvesting dates generally fell within 6 to 10 days of predicted dates.

Accurate determination of seed ripening dates is critical for commercial seed harvesters as seeds shatter quickly when mature. Achene development progresses through a number of recognizable stages. In southern Idaho developing achenes reach nearly mature size by mid June (Shaw and Monsen 1983b). During this period of rapid growth, the endosperm remains milky. About 10 to 16 days prior to maturation, the endosperm changes from white to dark red (blood stage). Achenes dry rapidly during the last 3 to 5 days of this period.

Achenes can wither and abort at any stage of development. Late frosts, poor or inadequate soil water, and insect damage are principal reasons for crop failure. Many failures occur during the “blood stage” just prior to achene maturation. Insects may destroy a large proportion of the seed crop (Basile and Ferguson 1964; Basile and others 1964; Ferguson 1967; Ferguson and others 1963; Furniss 1983; Furniss and Barr 1975). Shaw and Monsen (1983b) reported 50 to 60 percent of all flowers that initially appeared failed to develop a mature fruit in a southern Idaho seed orchard as a result of insect damage.

Prospective seed collection sites must be inspected frequently, particularly when seeds are in the blood stage to determine when and where harvestable crops will be available. Harvesting is accomplished by striking branches with a paddle to dislodge seeds into canvas or metal trays (Giunta and others 1978; Nord 1967). Most native sites produce 150 to 200 lb of seed per acre (168 to 224 kg per ha) although production may approach 500 lb per acre (560 kg per ha) (Nord 1965).

Few seed nurseries have been established on agricultural land. Cultivated plantings should be established on or near native sites. Plantings should be located in areas protected from high wind; flowers are cross pollinated by insects and seed shatter easily (Blauer and others 1975). In southern Idaho 6 to 10 year old plants of an upright ecotype planted at 6 ft (1.8 m) spacings produced more seed per acre than plants planted at 6 by 12 or 12 by 12 ft (1.8 by 3.7 or 3.7 by 3.7 m) spacings. However, as plants attained mature stature, those at 6 ft (1.8 m) spacings became so overgrown that seed harvesting became impractical. Depending on growth habit, shrubs should be spaced 12 to 15 ft (3.7 to 4.6 m) apart to permit good seed production and facilitate site maintenance and seed harvesting.

Maintaining a stand of native herbs as an understory is a practical approach for controlling weeds and supporting predatory insects. Field cultivated plants appear to benefit from cultural treatments, but response to fertilizer, water, and pesticides is not known. Native stands of antelope bitterbrush can also be managed for seed production. Plants respond favorably to pruning, thinning, weed control, and protection from grazing.

Annual collections of antelope bitterbrush from western rangelands have sometimes exceeded 40,000 lb (18,182 kg). Considerable seed is harvested annually from most Intermountain and Northwestern States. Demand varies considerably from year to year. Areas in south-central Idaho and northern California tend to produce more consistent seed crops than most sites within the Intermountain region. More seed is usually harvested from areas in central Idaho and the Pacific Northwest than is used in those regions. However, seed collected from central Utah and eastern Nevada is generally not sufficient to meet regional demands. Likewise, the quantity of seed harvested from arid regions and decumbent growth forms growing in ponderosa pine and aspen communities is generally inadequate.

Seed are easily hand harvested. Effective mechanical harvesters have not been developed (Nord and others 1967). Air-dried collections are cleaned by first screening to remove sticks and debris. The husks are then detached with a barley debearder, Dybvig, or other scarifier. Remaining material is again screened to separate seed from the detached husks (Giunta and others 1978). At 100 percent purity there are approximately 15,000 seed per lb (33,000 per kg). Seed are reasonably hard and are not easily broken, fractured, or damaged when cleaned or planted. Recommended purity for seed purchases is 95 percent and germination 90 percent (see chapter 24).

Cleaned seed can be stored under warehouse conditions for extended periods without loss of viability. Afterripening improves germination. Stevens and others (1981a) reported a significant increase (79 to 86 percent) in germination between the second and third year of storage. Seed germination remained unchanged after 20 years of warehouse storage, but decreased to 24 percent after 25 years. Antelope bitterbrush seed can usually be stored without suffering extensive insect damage, but storage areas must be kept rodent free.

Antelope bitterbrush seed are large, smooth, and fairly heavy. Consequently, they are easily carried through most seeders. When planted in mixtures, antelope bitterbrush can be used to carry other light-weight seed through seeding mechanisms. Seeds require a 2 week wet prechilling to release dormancy, thus they should be fall or winter seeded.

Recommended seeding rates for antelope bitterbrush vary considerably. The shrub may be drill seeded, interseeded in rows at various interspacings, or hand planted in clearings or selected spots. Hubbard (1964) recommended drilling at a rate of 3 lb per acre (1.4 kg per ha). Extensive pinyon-juniper chainings have been interseeded using a Hansen seed dribbler. Rows are usually spaced 8 to 12 ft (2.4 to 3.7 m) apart when mechanical interseeders are used (Stevens and others 1981b). Between 5 and 20 seeds are usually dispensed per linear ft (16 to 66 per m) in each interseeded row. At a rate of 20 seeds per ft (66 per m), approximately 87,000 seeds are planted per acre (214,974 per ha), if rows are spaced 10 ft (3 m) apart. This equates to 3 to 5 lb per acre (3.4 to 5.6 kg per ha) depending on the seed lot planted.

Hand seeding has been used extensively to plant steep or inaccessible slopes. Herbaceous vegetation must be cleared to enhance shrub seedling survival. Clearings amid annual or perennial vegetation should be between 2.5 to 3.3 ft (0.75 to 1 m) square to effectively reduce competition. Hand seeding antelope bitterbrush and other shrub seed into depressions created by uprooting pinyon-juniper trees following anchor chaining is also a successful planting technique.

Rodents actively gather planted seed (Evans and others 1983; Young and Evans 1978a,b), and forage on small seedlings. Rodent damage can be extremely serious and limit planting success. This problem can be reduced by planting late in fall after rodents hibernate. Coating seeds with a combination of Arasan and Endrin eliminates nearly all rodent predation (Medin and Ferguson 1980), but the toxic effects of Endrin on other animals have eliminated its use. Everett and Stevens (1981) found thiourea treatments reduced deer mouse predation. However, the compound is now classified as a carcinogen. No other chemical has been developed that effectively diminishes rodent predation.

Evans and others (1983) and Reichman and Oberstein (1977) reported that size and depth of seed caches influenced detection by rodents. Rodents locate seed primarily by olfactory cues (Howard and Cole 1967; Johnson and Jorgensen 1981), thus edaphic conditions can affect seed discovery (Johnson and Jorgensen 1981). Rodents were better able to locate antelope bitterbrush seeds when two or more seeds were planted together. Rodents failed to locate individual seeds placed 0.4 inch (1 cm) deep, but removed 75 percent of the seeds if two seeds were placed together at this depth. Predation increased to 98 percent when more than 10 seeds were planted together. Evans and others

(1983) found that planting depth affected seed detection. Rodents consumed all seeds placed on the soil surface or planted at a depth of 0.4 inch (1 cm), but only about 50 percent of seeds planted between 0.8 and 1.6 inch (2 and 4 cm) deep.

Available cover also strongly influences seed predation. Evans and others (1983) reported significantly less rodent predation of seed caches in burned areas lacking plant cover than in unburned sites with considerable vegetative cover. Similar responses have been noted in seedings on mine and roadway disturbances. Rodents apparently cache antelope bitterbrush seeds in small openings, but are not likely to venture onto exposed sites for extended foraging.

Planting success of range and wildlife seedings in different plant communities also indicates considerable differences in rodent foraging habits (Basile and Holmgren 1957; Casebeer 1954; Holmgren and Basile 1959; Nord 1965). Success has generally been better in pinyon-juniper communities cleared of trees by anchor chaining than on burned antelope bitterbrush/bunchgrass ranges infested with cheatgrass.

Booth (1980) and Evans and others (1983) found pretreating antelope bitterbrush seeds with a fungicide reduced damping-off problems and ultimately increased the number of successfully established seedlings. Cutworms and wireworms can also destroy newly developing seedlings of antelope bitterbrush (Hubbard 1956), but outbreaks are usually limited to isolated situations.

Compared to most shrub and many herb species, antelope bitterbrush seedlings establish quite successfully even under harsh circumstances. Consequently, the shrub can be used to revegetate roadways, mine disturbances, and other infertile sites. If protected from browsing, young plants grow rapidly and provide considerable forage and ground cover within 3 to 5 years.

Antelope bitterbrush is often interseeded with a combination of grasses and broadleaf herbs. However, Monsen and Shaw (1983c) reported that intermediate wheatgrass and crested wheatgrass planted as an understory can significantly reduce or minimize natural seedling recruitment of this shrub. It is essential that the shrub be seeded with less competitive herbs. Interseeding antelope bitterbrush onto sites dominated by cheatgrass is not recommended unless remedial treatments are employed to reduce or replace the cheatgrass understory.

Bareroot or container seedlings are frequently used to circumvent seed predation by rodents and speed establishment. Dormant or carefully hardened seedlings should be planted before native antelope bitterbrush shrubs at or near the planting site break dormancy (Carpenter 1983). Establishment success is usually quite high. Antelope bitterbrush seedlings and young plants are often browsed heavily. Project seedings or plantings should be large enough to dissipate animal browsing or establishment may be adversely affected.

Uses and Management

The broad genetic base of antelope bitterbrush and its wide geographical distribution (Stutz and Thomas 1964; Thomas 1957), provide considerable opportunity to promote the use of natural and artificial populations and hybrids with specific traits. Few other shrub species are so diverse.

Antelope bitterbrush is widely regarded as an important browse plant for big game and domestic livestock. It has been planted extensively in big game habitat improvement projects throughout the Intermountain and Pacific Northwest regions to provide a forage base in areas where game and livestock use may be seasonally heavy. Numerous seeding and transplanting projects have been conducted to improve sites where shrub populations have been depleted or eliminated. Antelope bitterbrush grows well with a wide number of native understory species and other shrubs and is often planted in mixtures to reestablish plant diversity. It forms important associations with various conifers, mountain brush species, and bunchgrasses. However, in certain areas this plant exists with few other species and may be the dominant plant encountered. In either situation, reestablishing the shrub improves wildlife habitat, watershed resources, and community and structural diversity.

A wide array of ecotypes exists within the broad geographic range of antelope bitterbrush. Numerous ecotypes have been propagated and planted at various study sites in the western United States. Some collections exhibit adaptation to a rather broad range of site conditions; others require rather specific edaphic and climatic conditions. An upright growth form from Sanpete County, UT, for example, performed much better than any other source when seeded on a broad array of Utah sites (Davis 1983). A natural hybrid of antelope bitterbrush and Stansbury cliffrose displayed better survival, persistence, and herbage yield than most other antelope bitterbrush ecotypes when seeded on a number of Utah sites.

Planting failures sometimes result when antelope bitterbrush ecotypes are planted on similar parent materials but at elevations about 2,000 ft (610 m) higher than the native stands. In addition, ecotypes have failed to persist if sources from strongly basic soils are planted on acidic sites, or vice versa. Selective grazing by livestock, big game, rodents, and insects has also eliminated specific ecotypes when they were planted in small test plots (Edgerton and others 1983; Giunta and others 1978). If nonfire-tolerant ecotypes are planted on sites subjected to burning, entire stands can be eliminated in a single fire. Land managers should be very selective when considering the use of seed collections obtained from areas differing from the prepared planting site in edaphic or climatic conditions.

Antelope bitterbrush is particularly well adapted to harsh sites and frequently acts as a pioneer species. Consequently, it is frequently seeded on mines, roadways, and similar sites. Decumbent and semi-erect growth forms can be used to control erosion; they provide a dense, spreading ground cover capable of spreading by stem layering.

Plants may form symbiotic nitrogen-fixing relationships with the endophyte *Frankia* (Nelson 1983). Antelope bitterbrush is more frequently nodulated than other rosaceous nitrogen-fixing species, but the degree of nodulation varies considerably among antelope bitterbrush populations. The significance of nitrogen fixation in arid land rosaceous species is poorly understood.

Fire-tolerant ecotypes have been utilized to plant areas subjected to frequent burning. Most ecotypes planted for this purpose retain their resprouting characteristics when planted on adapted sites. Consequently, selection programs have been conducted to identify populations that are capable of resprouting.

Antelope bitterbrush possesses many attributes that contribute to its widespread use. Seed are large, easy to collect, process, store, and plant with conventional equipment. Sufficient seed crops are produced with frequent regularity to provide satisfactory amounts of seed for most project plantings. In addition, nursery and greenhouse-grown transplants are easily produced and establish well when outplanted. Commercial growers produce good quality stock, and with careful planning, land managers can normally contract production of adapted ecotypes.

The broad array of available growth forms provides a useful assemblage of material for planting disturbances. With proper selection, adapted ecotypes can be used to provide windbreaks, serve as conservation and wildlife plantings, or be used for more formal maintenance landscape purposes. Different growth forms can be used to enhance recreational sites, summer homes, and parkways.

Because antelope bitterbrush is a major wildlife species and establishes quite well, some grasslands and shrublands have been converted to antelope bitterbrush by artificial seedings. Some plantings have failed when the shrub was not well suited to the problem area. Attempts to convert wildland sites to antelope bitterbrush stands should be carefully evaluated. Unless adapted ecotypes of antelope bitterbrush exist, more suitable species should be selected for planting.

Varieties and Ecotypes

Numerous populations of antelope bitterbrush with distinctive attributes have been recognized and are commercially harvested and sold (table 2). Ecotypes from central Utah are widely used for big game habitat improvement, but are best adapted to calcareous soils. Decumbent growth forms commonly found as an understory in lodgepole pine or ponderosa pine forests are used in revegetation of forested sites. Upright ecotypes from southern Oregon and central Utah are used to stabilize sandy soils and restrict human activity.

‘Lassen’ antelope bitterbrush, the only release to date, is a robust, upright ecotype that produces and maintains moderate quantities of overwintering leaves that provide a source of protein for fall and winter grazing (Shaw and Monsen 1986; Welch and others 1983a). This selection is native to Lassen County, CA, where it grows on coarse textured, granitic soils. It has done well throughout the Pacific Northwest and the Intermountain regions when planted on sandy, slightly acidic or neutral soils in areas receiving 14 to 18 inches (36 to 46 cm) of annual rainfall. Seedlings are vigorous and grow rapidly.

Rosa woodsii ultramontana ________

Woods Rose

Hitchcock and others (1961) and Welsh and others (1987) described Woods rose as a deciduous shrub with a growth habit ranging from nearly prostrate to upright and height from 3.3 to 10 ft (1.0 to 3.0 m). Its root system is dense and fibrous. Thick briar patches of arching branches are formed by heavy suckering from spreading rhizome systems. Branches are armed with straight to curved infrastipular spines. They may produce internodal prickles, but are occasionally unarmed. The alternate leaves are odd pinnate with five to nine ovate to obovate or elliptic leaflets. The leaves are 0.6 to 5.1 inches (1.5 to 13 cm) long and 0.2 to 1 inch (0.4 to 2.5 cm) wide, singly to doubly serrate, and pubescent to glandular or rarely stipitate glandular. The fragrant flowers are solitary or in few-flowered corymbs or corymbiform cymes that terminate lateral branches of the season (fig. 26). Each flower has five persistent erect to spreading sepals and five white to deep rose petals. Numerous stamens are inserted on a disk lining the throat of the calyx. Carpels are numerous. The “hips” are globose to ellipsoidal and 0.2 to 0.5 inch (6 to 12 mm) in diameter. They turn a bright orange red at maturity. Each contains 15 to 30 straw colored to white achenes 0.1 to 0.2 inch (3 to 5 mm) long with long stiff hairs along one side.

Woods rose blooms from late spring to summer depending on water availability. Fruits ripen in late fall and remain on the shrub through winter (Blauer and others 1975; Hitchcock and others 1961).

Table 2—Principal ecotypes of antelope bitterbrush used in wildland restoration projects.

Ecotype/origin	Elevation	Mean annual precipitation	Growth form	Attributes	Areas of adaptability	Availability: Seed[a]	Availability: Transplants[b]	References[c]
	feet	*inches*						
Boise Front Ada Co., ID	2,800	17	Erect	Highly productive, good seedling vigor, excellent cover	Neutral to acidic soils, south-central Idaho	4	3	2,3,4
Bryce Canyon Garfield Co., UT	7,000	16	Spreading to semi-erect	Leafy, highly available forage, resilient to heavy browsing, excellent ground cover	Colorado River drainage, but widely adapted	2	1	3,4
Columbia Basin, eastern Washington		12-16	Spreading	Excellent drought tolerance, highly available forage, good ground cover	Columbia River, western and central Idaho			2,3
Elko Elko Co., NV	5,200	14	Semi-erect	Excellent drought tolerance, persistent responds well following fires, widely adapted	Northern Nevada, western Utah, big sagebrush and pinyon-juniper sites	3	2	3,4
'Lassen' Lassen Co., CA	4,200	14	Erect	Good winter leaf retention, seedling vigor, palatability	Mid-elevations, northern California eastern Oregon, southern Idaho	4	2	5
Maybell Moffat Co., CO	6,000	14	Spreading to semi-erect	Stem layering, adapted to sandy soils, good ground cover	Specifically adapted to sandy soils	3	2	3
Panguitch Lake Garfield Co., UT	8,250	20	Decumbent	Cold tolerant, excellent summer forage, resists browsing, excellent ground cover	Spruce-fir,aspen, and mountain brush types, exposed sites, windblown exposures	2	1	
Pinto Washington Co., UT	6,000	14	Upright	Drought tolerant, productive, good forage, excellent wildlife habitat, consistently good seed crop	Adapted throughout the pinyon-juniper type within the Great Basin	2	1	
Sanpete Sanpete Co., UT	5,000	14	Erect, upright	Excellent seedling vigor, highly productive, good seed producer, persistent	Most widely adapted ecotype tested throughout the pinyon-juniper type within the Intermountain area	4	2	1,3,4
Shoshone Lincoln Co., ID	4,200	10	Decumbent	Drought tolerant, spreader, adapted to rocky lava substrates	Southern Idaho, basalt soils	1	1	
Snowville Box Elder Co., UT	5,100	15	Semi-erect	Cover and forage for big game and upland birds,excellent seed producer	Adapted to big sagebrush and pinyon-juniper communities	3	2	
Starvation Canyon Wasatch Co., UT	8,124	18	Decumbent, spreading	Highly palatable, excellent summer forage, resistant to heavy grazing	Adapted to high elevations, aspen openings	2	2	3,4
Salt Lake Salt Lake Co., UT	5,525	17	Erect, upright	Good seed producer, forage available	Well-drained soils, mountain brush and upper elevations of pinyon-juniper communities	3	2	3,4

[a]Seed availability: (1) Erratic producer - limited amounts available; (2) Fair to good producer - limited amounts collected; (3) Fair to good producer - moderate amounts collected most years; (4) Fair to good producer - large collection sites, seed usually available; (5) Good producer - seed normally available.
[b]Transplant availability: (1) Produced only on request; (2) Produced mainly on request; (3) Produced mainly on request, some speculative rearing; (4) Produced for speculative sales.
[c]References: (1) Davis (1983a); (2) Edgerton and others (1983); (3) McArthur and others (1983b); (4) Plummer and others (1968); (5) Shaw and Monsen (1986).

Figure 26—Woods rose flowers in late spring or early summer. Fruits ripen in fall and contain about 15 to 30 achenes.

Ecological Relationships and Distribution

Rosa is a difficult genus taxonomically. It occurs throughout the Northern Hemisphere, and exhibits a high degree of intraspecific variability. There are approximately 115 species of *Rosa* in temperate North America (Young and Young 1986). About 10 of these occur in the Rocky Mountains and most will hybridize (Hitchcock and others 1961). Chromosome number for this group is n = 7. The genus *Rosa* was represented in the western American element of the Arcto-Tertiary Flora (Axelrod 1950).

The native range of Woods rose extends from British Columbia to southern California and east to Saskatchewan, Minnesota, Missouri, and Texas. There are two varieties. The eastern variety, *Rosa woodsii* var. *woodsii* occurs on plains and prairies as far west as eastern Montana. Plants are about 3.3 ft (1 m) tall with crowded leaves. The leaflets are 0.4 to 0.8 inch (1 to 2 cm) long and gland tipped. The cordilleran variety, *Rosa woodsii* var. *ultramontana*, covers the western portion of the species range. It is taller than var. *woodsii*, often reaching heights of 3.3 to 6.6 (9.9) ft (1 to 2 [3] m). Its leaves are also larger, up to 2 inches (5 cm) long by 1 inch (2.5 cm) wide with coarse teeth that are not gland tipped. It exhibits tremendous variation in height, spininess, vegetative spread, and drought tolerance. This variety occurs from plains to alpine areas along marshes, lake shores, and in other riparian communities of the sagebrush, juniper, mountain brush, aspen, and spruce-fir zones. Plants may be found in well drained, wet to dry, loamy to sandy soils on all aspects, and in moderate shade to full sunlight. Woods rose grows at elevations from 2,800 to 11,000 ft (850 to 3,355 m) (Welsh and others 1987), generally in areas receiving 16 to 20 inches (41 to 51 cm) of annual precipitation (Monsen and Davis 1985; Wasser 1982).

Woods rose invades disturbed areas along roadways, eroded drainages, fence rows, irrigation canals, and abandoned fields. It is intolerant of poor drainage, high water tables, and prolonged flooding (Wasser 1982). Ecotypes vary in drought tolerance; flowering is more adversely affected by drought than is rhizome growth.

Woods rose resprouts following fire. However, intense fires or repeated burns can damage or kill the shallow root crown. Annual growth may increase following light to moderate burns (Wasser 1982).

Plant Culture

Woods rose begins flowering when plants are 2 to 4 years old. Plants growing in full sunlight produce more flowers than those growing in shade. Good seed crops are produced at about 2 year intervals (Gill and Pogge 1974b). The hips of Woods rose are harvested by hand as soon as they ripen and before the flesh begins to soften. Achenes are extracted by macerating the hips in water in a blender or Dybvig and floating off the pulp and empty achenes. Achenes should be dried thoroughly prior to storage. Acceptable viability is retained for 2 to 4 years by sealing the dry achenes in containers at 34 to 38 °F (1 to 3 °C) (Gill and Pogge 1974b). There are about 45,300 seed per lb (99,868 per kg) at 100 percent purity. Acceptable germination for seed purchases is 95 percent and purity 70 percent (see chapter 24).

Dormancy of Woods rose seed is caused by inhibitors in the seed coverings and mechanical restriction of the pericarp wall (Jackson and Blundell 1963). In nature, consumption and digestion of seeds by animals disperse the seed and alleviates dormancy (Morris and others 1962; Shaw 1974). Overall seed viability is decreased by digestion, but dormancy of unharmed seed is reduced. A wet prechilling at 34 to 41 °F (1 to 4 °C) for 30 to 365 days is recommended to relieve dormancy of planted seeds (Gill and Pogge 1974b). Warm pretreatment for 60 days at room temperature preceding the wet prechilling may also be helpful. Hot water and acid treatments have been used prior to wet prechilling with mixed results (Gill and Pogge 1974b).

In the field, seed may be broadcast or drilled at a rate of about 0.5 to 1.0 lb per acre (0.6 to 1.1 kg per ha). It should be covered with 0.25 to 0.75 inch (0.6 to 1.9 cm) of soil. Seed can be mixed with other shrub seed, but it should be seeded separately from grasses; seedlings are only poorly to moderately competitive with herbs. Seed may also be spot planted in areas cleared of competition. Due to variability in seed dormancy among seed collections, and the extremely long wet prechilling requirements, results of seedings have been quite erratic.

Transplanting, although more expensive than direct seeding, is often recommended, at least for small planting sites. Bareroot stock is usually lifted after one growing season. Seedlings produce an extensive root system during the first growing season in the nursery. They may initiate new rhizome growth prior to lifting. Rhizome growth is initiated early in spring. New rhizomes are easily damaged during lifting and outplanting. Large bareroot seedlings with shoots 2 to 3 ft (0.6 to 0.9 m) tall are grown at some nurseries. These are useful on unstable or dry sites; the large root system provides anchoring and a greater water absorption area, and the long shoots are not easily buried by soil sloughing. Augers or other special planting tools may be required to properly plant these seedlings. Wildings may be dug when dormant and kept in cold storage for later transplanting. They should be handled and planted like bare root stock.

Containerized seedlings may be grown as tublings or as larger plants. Seedlings may be started from seed, small transplants, or cuttings (Landis and Simonich 1984). They require at least a 3 to 5 month cropping time.

Hardwood cuttings collected when dormant may be stored at 34 °F (4 °C) and rooted in the nursery in areas with mild climates or under a greenhouse mist system in other areas. Softwood cuttings of partially mature wood root quickly (10 to 14 days) under a mist system. Rooted cuttings may be transplanted in fall, overwintered in a shadehouse or cold frame, or transferred to a nursery bed (Gill and Pogge 1974b). Everett and others (1978a) recommended the use of hardwood rather than softwood cuttings. They used a mist system and 0.8 percent indole-3-butyric acid to induce rooting in a greenhouse. Layers or suckers may also be propagated in the nursery or greenhouse and field planted when adequate root systems have developed (Hartmann and Kester 1990).

Uses and Management

Because of its wide geographic distribution and revegetation values, Woods rose is a candidate for use in a wide variety of planting situations. High survival rates of transplanted seedlings make Woods rose a desirable and reliable addition to many projects. Livestock, game animals, and rodent populations may require control during the period of establishment. Rodents consume planted seed and young seedlings sometimes suffer serious debarking and girdling (Spencer 1958; Wasser 1982). Plants are sometimes attacked by leaf spots, rusts, downy mildews, blights, and cankers. Periodic close use, mowing, or burning under safe conditions may improve the appearance and stimulate production of plants along roadways or in recreation areas.

Woods rose is an extremely useful plant on disturbed sites such as roadcuts and fills, gullies, riparian areas, and mining disturbances where soil stabilization is essential (Monsen 1974, 1975; Plummer and others 1968). At the Leviathan Mine in western Nevada, Woods rose and mountain snowberry provided the highest third year survival and cover of the species tested (Everett and others 1980). Suckers were produced the third year. Plants survived in spite of a low soil pH (4.1) and low nitrogen. Liming and other amendments were recommended. Although natural seedlings may invade disturbances, they are easily buried by soil sloughing. However, seedlings do develop quite rapidly if established from rooted cuttings or nursery stock. The fibrous, rapidly developing root system and rhizomes provide soil stabilization. Rhizomatous spread has been noted by the third year after transplanting, augmenting the stabilization process. In addition, the brushy habit, thorniness, and low palatability of some ecotypes permit development of impenetrable thickets that reduce livestock and wildlife trampling on unstable sites. Many ecotypes, however, are grazed rather heavily. Planting them in a mixture with other shrubs is advised to take advantage of differing growth habits and microsite requirements and maximize the diversity obtained.

Woods rose obtained the highest assessment of suitability of 18 shrubs tested on forest roads in northwestern Montana (Hungerford 1984). The assessment was based on growth, spread, vigor, survival, flowering, and regeneration. Overall survival after 4 years was 62 percent with similar survival on south, west, and east aspects. Plants spread by root sprouting and were indistinguishable after 4 years. The plant was recommended for use in this area to hold soil against wind and water erosion in open to light shade and in dry to moist soil. Everett (1980) found Woods rose and antelope bitterbrush were among the best species tested for revegetating roadcuts in Nevada. After 3 years, Woods rose survival remained high and the species was among the best for both north and south slopes when ranked by the amount of cover produced. The species also exhibited the highest survival of species tested on forest roadcuts at 14 locations on two forests in eastern Washington (Tiedemann and others 1976). Overall survival of Woods rose was 56 percent on the Colville National Forest and 63 percent on the Okanogan National Forest. Plants were generally of rather low vigor and on these sites may have required fertilization. Successful planting required stems tall enough that they were not buried by raveling.

Woods rose is used by big game during most seasons; it generally receives heaviest use in early spring and fall (Blauer and others 1975; Wasser 1982). Plants are moderately grazing tolerant, particularly on moist soils. Palatability of leaves and stems varies with ecotype, density of prickles, and availability of other forage. Wood rose is rated as valuable in winter and highly valuable in summer and fall for elk (Kufeld 1973). Mule deer make light use of it in winter and fall (Kufeld and others 1973). In a cafeteria style study, Smith (1953) found Woods rose was one of the most preferred shrubs for mule deer throughout the summer (May 1 to September 30) in northern Utah.

Woods rose provides food and excellent nesting, escape, and thermal cover for birds and small mammals during all seasons (Blauer and others 1975; Thornburg 1982; Young and Young 1986). Although not highly preferred, the hips remain on the shrubs well into the winter and provide an excellent energy source for many species when the ground is covered with snow (Mace and Bissell 1986; Monsen and Davis 1985; Plummer and others 1968; Welch and Andrus 1977).

Nutritive value of Woods rose varies considerably by season. In the Black Hills of South Dakota, protein value varied from 4.9 percent in summer to 12.0 percent in spring for stems and from 5.7 percent in fall to 16.4 percent in spring for leaves (Dietz 1972). Rose hips have high digestibility and are moderately high in crude protein in winter; they provide food for many birds and rodents.

Rose hips have been used as preserves and as an ingredient in herbal tea and candy. They are high in vitamin C. American Indians used the bark, roots, and stems to produce a dressing for wounds, sores, and burns. Roots were used for treating diarrhea (Craighead and others 1963). Woods rose has high ornamental value for recreation areas, parks, and campgrounds. The dense growth habit can also be used to direct pedestrian traffic and provide low maintenance shrubbery. The attractive fruits, flowers, and fall coloration also contribute to its landscape value.

Varieties and Ecotypes

No populations of Woods rose have been released for commercial production. Tremendous variability occurs in growth habit and many other characteristics. Some accessions have a wide range of adaptability.

Several additional *Rosa* species are used in wildlife plantings. *Rosa nutkana* is distributed from Alaska south to northern California and the Blue Mountain region of Oregon. It also extends south into Colorado and Utah at moderate elevations. *Rosa acicularis*, a circumpolar species, extends south from Idaho and Montana to northern New Mexico. *Rosa gymnocarpa* occurs from sea level to 6,000 ft (1,830 m) from British Columbia to northwestern Montana, south to the Sierra Nevada Mountains of California and the Blue and Ochoco Mountains of eastern Oregon (Hitchcock and others 1961). It is a larger shrub with a more erect and less thicket-like growth habit than Woods rose. Uses and culture of these species are generally as described for Woods rose.

Rubus leucodermis

Black Raspberry, Blackcap

Black raspberry or blackcap is a sprawling, deciduous shrub with arching biennial canes ranging from 3 to 10 ft (1 to 3 m) in length (Hitchcock and others 1961). Prickles of the leaves, petioles, and stems are retrorsely curved. The pinnate leaves are petiolate with linear, caducous stipules, and three to five doubly serrate leaflets. Leaflets are green and nearly glabrous above and white tomentose beneath. They are about 2.4 to 5.6 inches (6 to 14 cm) long; the terminal leaflet is 1 to 3 inches (3 to 7.5 cm) long. Perfect, 5-merous white flowers are produced in racemes in groups of two to seven. Stamens and pistils are numerous. Fruits consist of aggregates of black drupelets on a convex receptacle. Each drupelet contains a hard seed. Flower and fruit development occur unevenly through the summer. Seed is dispersed by birds and mammals.

Ecological Relationships and Distribution

Rubus is distributed worldwide, but is most common in temperate regions of the Northern Hemisphere. There are several hundred species. Many taxa are interfertile; most are polymorphic, and a few are apomictic. *Rubus* belongs to the subfamily Rosoideae and has chromosome number n = 7 (McArthur and Sanderson 1985).

Black raspberry is distributed from British Columbia east to Montana and south to California and New Mexico (Davis 1952). Although commonly a plant of moist environments such as riparian zones and forest openings, black raspberry also exists on dry, open slopes of mountain brush communities and on talus slopes or roadbanks. It spreads by layering and rhizome sprouting as well as from seed and may be one of only a few species growing on some rocky sites.

Uses and Management

Ferguson (1983) considered black raspberry the most likely of the *Rubus* species to be used for revegetation purposes. It is easily propagated vegetatively and transplants readily. On roadcuts, drainageways, or other disturbed sites it grows rapidly, spreads vegetatively, and provides soil stabilization as well as dense cover and food for birds and other small animals. Black raspberry grows rapidly and is used only lightly as a summer forage by big game and livestock, thus its establishment is normally not hindered by excessive use.

Plant Culture

Seed dormancy and cultural practices for black raspberry are similar to those described for thimbleberry. Time requirements for wet prechilling and scarification have not been determined. Fruits are collected when they are black and detach easily from the receptacle. Use of planting stock rather than seed on disturbed sites may provide better and more rapid success; these sites offer poor conditions for seed germination and early seedling establishment. Planting stock may be grown from seed. Root cuttings, suckers, layers, stem cuttings, and leaf-bud cuttings are easily started (Hartmann and Kester 1990). Root cuttings may be treated as wildings, particularly on moist sites. Seedlings grow fairly rapidly, but are sensitive to dense competition and shading.

Varieties and Ecotypes

There are no releases.

Rubus parviflorus ________________

Thimbleberry

Thimbleberry is a low growing, rhizomatous, thicket-forming shrub. It is unarmed, deciduous, and 2 to 7 ft (0.5 to 2.0 m) tall (Hitchcock and others 1961). Bark of the main stems is gray to brown and shreddy. Stems, petioles, and leaves are unarmed and stipitate glandular. The large leaves are long petioled with membranous lanceolate stipules. They are alternate, simple, palmately lobed, and veined from a cordate base. Leaves are 2 to 6 inches (5 to 15 cm) long and 0.6 to 2 inches (1.5 to 5 cm) wide. The showy, white flowers are perfect and 5-merous, in groups of two to seven in flat-topped cymes or terminal corymbs (fig. 27). Stamens and pistils are numerous. Fruits are approximately 0.5 to 1 inch (1.2 to 2.5 cm) wide aggregates of coherent red drupelets that are thinly fleshy and almost dry at maturity. Fruit aggregates form over a conical receptacle, thus the common name “thimbleberry.” Each drupelet contains a single hard beige to pink seed about 0.1 inch (2 mm) long. Flowering and fruit ripening continue through the summer. Seeds are dispersed by birds and mammals.

Figure 27—Thimbleberry spreads by seed or resprouting in natural forest openings and disturbed areas.

Ecological Relationships and Distribution

Thimbleberry is distributed from Alaska east to Ontario and south to Chihuahua, Mexico. It grows in all western States from elevations near sea level on the Pacific Coast to near 10,000 ft (3,050 m) in Colorado (Harrington 1964; Sutton and Johnson 1974; USDA Forest Service 1937). Thimbleberry forms dense patches in natural forest openings or disturbed areas, but it is also fairly common in areas shaded by forest canopies, brushfields, or woody riparian plants, particularly in the southern portion of its range. It is a particularly common understory species in the humid forests of the Pacific Northwest.

Thimbleberry grows on moist, sandy loam soils rich in organic matter, but may also be found on rocky talus slopes, road banks, and creek bottoms. It regenerates rapidly from rhizome and root crown sprouting following burning or logging (Cholewa and Johnson 1983; Leege and Hickey 1971; Mueggler 1966; Noste and Bushey 1987). Buried thimbleberry seeds have been reported in a number of forest seed bank studies

(Kramer 1984). Although Kramer (1984) found low densities and low viability of thimbleberry seeds in soil banks for three forest habitat types in central Idaho, he concluded that the rhizomatous nature of the species would allow even isolated seedlings to spread over significant areas.

Plant Culture

Good seed crops are produced almost every year but fruits are difficult to collect in large quantities as they are scattered over the crown of the plant and ripen unevenly. Ripe fruits are bright red and detach easily from the receptacle. They are dispersed by gravity and by animals that consume them.

Fruits are hand collected. Seeds are extracted by macerating the fruits in water in a Dybvig or blender and floating off the pulp. Remaining debris and light seed are removed by drying and fanning. Dried seeds may be stored at 41 °F (5 °C) for several years (Brinkman 1974h).

Dormant embryos and an impermeable endocarp prevent rapid seed germination. In nature, dormancy is overcome by warm pretreatments and wet prechilling occurring between early summer seed fall and spring germination, although seeds are capable of remaining viable in the soil for more than 1 year if germination conditions are not met (Brinkman 1974h). A 2-hour soak in sulphuric acid or a 7-day soak in 1 percent sodium hypochlorite are commonly used germination pretreatments. However, results of acid scarification have been erratic (Marchant and Sherlock 1984).

Swingle (1939) and Babb (1959) recommended planting the seed immediately after it is harvested. Summer seeding in the nursery provides warm pretreatments and wet prechilling that relieve both blocks to germination for many *Rubus* species (Babb 1959; Brinkman 1974h). A 90-day warm pretreatment at 68 to 86 °F (20 to 30 °C), followed by a 90 day wet prechilling at 41 °F (5 °C) in the laboratory, prepares seed for spring sowing.

Thimbleberry is easily established from seed-grown bareroot or container stock. Plants are also easily propagated from layers or suckers. Sprigging, the collection and planting of dormant rhizomes, provides a means of quickly obtaining large quantities of plants.

Uses and Management

Rubus was ranked first among 18 genera of shrubs in terms of the number of wildlife species using them (Martin and others 1951; Robinette 1972). The drupelets are sought by birds and many other animals; leaves are used to varying degrees in summer. The dense sprawling plants provide cover for small animals during all seasons. Kufeld and others (1973) reported that mule deer take trace amounts of thimbleberry in fall and moderate amounts in summer. Thimbleberry is ranked as highly valuable and valuable for elk in summer and fall, respectively (Kufeld 1973). Palatability for livestock varies with geographic location and plant association. In general, it is considered worthless to poor for cattle and fair for sheep, although it may be heavily used if other vegetation is scarce or unpalatable (USDA Forest Service 1937).

Primary values of thimbleberrry in revegetation plantings are to provide soil stabilization and thickets for wildlife food and cover on disturbed forest sites, sand dune areas, and streambanks. Seedlings are not likely to be browsed heavily unless other more palatable vegetation is unavailable. They are susceptible to white fly and spider mite infestations (Marchant and Sherlock 1984).

Thimbleberry is a common plant of seral shrub communities; it resprouts following logging or burning, and establishes in natural forest gaps. Burned plants resprout from root crowns and rhizomes. Intense fires might destroy these structures, but permit germination of seed banked in the soil (Noste and Bushey 1987). Gratkowski (1978), Leege and Hickey (1971), and Miller and Kidd (1983), discussed the response of thimbleberry to burning and herbicide treatments, practices used to kill shrubs and permit conifer regeneration or rejuvenate overgrown shrub fields to improve browse availability for wildlife.

Varieties and Ecotypes

None.

Sorbus scopulina ________________

Greene's Mountain Ash

Greene's mountain ash is an attractive semi-erect shrub, branching from the base and forming thickets by suckering or layering (fig. 28). Bark of younger stems is smooth and yellowish gray becoming grayish red on older stems. Young growth is sparingly to densely grayish strigillose pilose. Winter buds are glutinous and white hairy to glabrous. The alternate deciduous leaves are glossy dark green above and pale and glabrous beneath, turning a showy red orange in autumn. They are pinnately compound with 7 to 13 serrate leaflets each, short cuneate to acute at the base, and acuminate at the tip. Stipules are green, membranous, and caducous to persistent. The inflorescence is a 70 to 200 flowered flat-topped corymb. The creamy-white flowers are perfect, 5-merous, and regular (Preston 1968). Hypanthium lobes are triangular, persistent, and white hairy externally. There are 15 to 20 stamens and two to five carpels and styles. Fruits are fleshy scarlet to orange pomes that dry to a purplish color. Each contains four seeds

Figure 28—Greene's mountain ash fruits persist into winter and are consumed by birds and other wildlife species.

(Harris and Stein 1974; Hitchcock and others 1961; Welsh and others 1987). The shrubs flower from May to July and fruits mature from August through October. Many fruits remain on the plant through winter. Seeds are spread primarily by birds.

Ecological Relationships and Distribution

Approximately 50 species of *Sorbus* are distributed through temperate and subarctic areas of the Northern Hemisphere (Hitchcock and others 1961). The chromosome number n = 17 is typical of woody Pomoideae genera in the western United States (McArthur and Sanderson 1985). Greene's mountain ash is distributed from Alaska east to Alberta and south to California, New Mexico, and the Dakotas (Welsh 1982). It grows in openings in conifer forests from foothills to subalpine or alpine sites at 4,000 to 9,000 ft (1,200 to 2,700 m) (Davis 1952; Stark 1966; Welsh 1982). Greene's mountain ash grows in sun or partial shade on well-drained, neutral to acidic soils forming dense patches or intermixed with other shrub species (Van Dersal 1938). It is common in mountain brush communities of forest openings, riparian areas, and on disturbed sites.

Plant Culture

Fruit should be gathered immediately when ripe to prevent losses to birds. Seeds are collected by hand or shaken onto a canvas. Maceration of fruits in water in a Dybvig or commercial blender separates seeds from the remainder of the fruit. The pulp contains germination inhibitors and is removed by flotation and by fanning and screening the dried seed and trash (Hartmann and Kester 1990; Heit 1968). Seed quality is often low. Seed should be dried to a 6 to 8 percent water content and stored dry in sealed containers at 34 to 38 °F (1 to 3 °C) (Harris and Stein 1974). Properly stored seeds remain viable for 2 to 8 years.

Seed requires wet prechilling for germination. A 72-hour soak in gibberellic acid (3.46 g Rootone-F/1000cc/distilled H_2O) followed by a 90-day wet prechilling at 41 °F (51 °C) was recommended by SEAM (1976) and Belcher (1985). Seed can also be given a 115-day warm pretreatment at 77 °F (25 °C) followed by a 75-day wet prechilling at 41 °F (5 °C), although exact requirements vary widely between and within seedlots. Laboratory germination tests require extended incubation periods. Excised embryo tests and tetrazolium chloride tests are frequently used alternatives; both can be completed rapidly (see Belcher 1985). Results of both tests are generally higher than laboratory germination test results (Harris and Stein 1974).

Greene's mountain ash may be established by sowing untreated seed in late summer to provide warm and cold wet pretreatment periods. Laboratory prechilled seed may be spring planted. Seed should be covered lightly. Even when wet prechilled, seed lots often germinate in the field over a 2 to 3 year period. Seed should be planted in areas where it will be protected from competing vegetation.

Production of planting stock may be necessary if seed supplies are limited or more rapid establishment is desired. Container and bareroot stock are usually grown from seed. Bareroot stock develops slowly and may require two growing seasons before lifting. Propagation by cuttings and layering is difficult. Wildings may be used as alternative sources of planting material if only small quantities of plants are needed.

Cook (1981) recommended use of Greene's mountain ash on adapted sites below 6,500 ft (2,000 m) in Wyoming, and suggested that it be planted at 4 ft (1.2 m) spacings. Young plants develop rather slowly and require protection from competition with grasses and forbs. Seedlings are tenacious and evidently not very vulnerable to insect and disease problems. They are taken by deer (USDA Forest Service 1948).

Uses and Management

The persistent fruits of Greene's mountain ash are taken by bears and birds in the fall and into the winter. Moose often browse the shrubs heavily in winter. Twigs are eaten by game and livestock. Dayton (1931) reported that Greene's mountain ash produces good sheep feed. It provides good cover and soil stabilization on steep sites within its range as it spreads to form dense thickets. As an ornamental, it offers attractive foliage, flowers, and fruits for mass plantings in full sunlight or partial shade. The foliage and berries are brightly colored in fall, and clusters of berries remain on the plant through the winter (Sutton and Johnson 1974).

Miller (1981) and Miller and Kidd (1983) examined the response of Greene's mountain ash on seral shrub fields in northern Idaho to various herbicide treatments. Lyon (1966) found that plants were eliminated by burning.

Varieties and Ecotypes

Various selections are used for horticultural plantings, but none have been developed for wildlife or wildland uses.

Sorbus sitchensis ________________

Sitka Mountain Ash

Sitka mountain ash grows from 3 to 13 ft (1 to 4 m) tall with a rounded crown. It may be distinguished readily from Greene's mountain ash; leaves consist of 7 to 11 leaflets, each semitruncate to rounded at the tip and usually at least one-third as broad as long. The winter buds, young growth and inflorescences are rufous hairy; the calyx is glabrous externally. Stipules are persistent and the fruits are red with a slight bluish cast (Hitchcock and others 1961; Preston 1968). They are dispersed by birds, but some persist on the tree through winter.

Sitka mountain ash is distributed from Alaska and the Yukon south to the Cascades in northern California and east to British Columbia and northwestern Montana at elevations from 2,000 to 10,000 ft (610 to 3,050 m) (Hitchcock and other 1961). Although it frequently grows in wet soils along streams, it may also be found in forest openings created by natural forest gaps, logging, burning, or other disturbances.

Sitka mountain ash produces abundant seed crops. Harvesting, cleaning, storage, germination, and planting requirements are similar to those described for Greene's mountain ash. Seeds sown late or without adequate wet prechilling do not germinate. Approximately 1 to 5 lb (0.45 to 2.25 kg) of seed may be extracted from 100 lb (45 kg) of fruits (Harris and Stein 1974).

Marchant and Sherlock (1984) considered the species a useful high altitude shrub for rocky sites. Management and use of the species are as described for Greene's mountain ash. It is frequently cultivated as an ornamental.

Spiraea betulifolia ________________

Bridal Wreath

Bridal wreath spiraea, birchleaf spirea, or white spiraea is a low, glabrous, deciduous shrub or subshrub ranging from 0.5 to 2 ft (0.2 to 0.6 m) in height (Hitchcock and others 1961). Plants occur singly or in dense patches interconnected by rhizomes. Stems are slender and yellowish brown to brownish with few branches. The simple, alternate, oval to obovate leaves range from 1 to 2.8 inches (2 to 7 cm) in length; the largest leaves occur near the tips of vegetative and flowering branches. The leaves immediately subtending the inflorescence tend to be slightly smaller. Leaves are short petiolate, exstipulate, strongly veined, and coarsely or doubly serrate to shallowly lobulate along the upper one-half to two-thirds of the leaf. Upper leaf surfaces are smooth and shiny; lower surfaces are pale.

Inflorescenses are dense, flat-topped terminal corymbs 1 to 3.2 inches (3 to 8 cm) in diameter (fig. 29). The tiny, white to pinkish 5-merous flowers are perfect, perigynous, and regular. Stamens are numerous and exceed the petals. Fruits consist of five light brown, dehiscent, several-seeded follicles. Flowering occurs from June to early August; fruits ripen from mid July to early September. Fruits normally dehisce in October and seeds are shed over time as winter

Figure 29—Bridal wreath spiraea produces flat corymbs of white flowers.

storms dislodge them from the follicles (Hitchcock and others 1961; Stickney 1974c; USDA Forest Service 1937).

Ecological Relationships and Distribution

The genus *Spiraea* includes about 70 species distributed through temperate and cooler areas of the Northern Hemisphere. About 10 species are found in the western United States, concentrated in mid-elevations of mountainous areas. They are particularly abundant in the Douglas-fir region of the western United States. The genus is a member of the subfamily Spiraeoideae. Chromosome number of the North American species is n = 9. Asian species commonly have chromosome numbers of n = 9 or n = 7 (McArthur and Sanderson 1985).

Bridal wreath spiraea occurs from sea level to 11,000 ft (3,300 m) and is distributed from British Columbia to north-central Oregon and east to Saskatchewan and South Dakota. It grows on a wide range of sites from riparian areas to open or wooded valleys, hills, and rocky slopes. It is particularly abundant on logged, burned, or otherwise disturbed mesic forest sites at intermediate elevations. It is the dominant understory for a number of forest habitat types and community types in the Rocky Mountains where ponderosa pine, lodgepole pine, grand fir, subalpine fir, and aspen are the dominant overstory species. Common shrub associates include roses, huckleberries, willows, and snowberries.

Plant Culture

Bridal wreath spiraea grows in full sun or shaded areas, although most seed is produced on shrubs growing in full sunlight. Cleaning involves rubbing the follicles to release the seeds and sieving to separate the seeds from the trash. The tiny seeds are nondormant. Germination reportedly occurs following 120 days of wet prechilling at 32 to 34 °F (0 to 1 °C) (Stickney 1974b); this mechanism permits emergence shortly after snowmelt. Bridal wreath spiraea may be planted by spot seeding disturbed sites in fall or spring. Seed may be mixed with other shrub seeds, but should be planted separately from grasses and forbs.

Propagating and planting bareroot or container stock provides for better utilization of the normally limited seed supplies and more rapid development of cover on disturbed sites than does direct seeding. Bareroot stock may be propagated from seed. Hand seeding may be required in the nursery; it is difficult to clean the seed to a high level of purity and the light seed does not flow well through a drill. Seed should be covered very lightly and mulched. Bareroot stock may also be obtained by lining out hardwood cuttings in the spring. Container stock is grown from germinants or from hardwood or softwood cuttings (Babb 1959). Hartmann and Kester (1990) recommended the use of leafy softwood cuttings taken in summer. Cuttings are treated with a root-promoting substance and rooted under high humidity. Container and 1-0 or 2-0 bareroot seedlings develop rapidly and are easily handled and transplanted.

Uses and Management

Although it produces abundant available forage, bridal wreath spiraea has been rated as worthless for cattle and poor to fair for sheep (USDA 1937). The dried leaves persist on the plant in fall and may receive moderate use after leaves have fallen from other species. Kufeld and others (1973) reported bridal wreath spiraea receives light winter use and heavy summer and fall use by mule deer. Because of its low palatability, livestock and wildlife rarely damage established stands of bridal wreath spiraea. Consequently, it may become abundant in heavily grazed sites (USDA Forest Service 1937), spreading vegetatively and from seed.

Spiraeas, particularly those species that spread rhizomatously, are valuable plants for soil stabilization along waterways. Adapted species or varieties may be selected for specific areas and conditions. Bridal wreath spiraea has also been used to stabilize roadways, burns, and logged areas. It develops rapidly, producing a spreading root system and rhizomes. The value of this and other spiraea species for site stabilization is increased by its typically low palatability to game and livestock.

A largely unexploited potential of native spiraea is their use as landscape plants. They are easily established and maintained and produce attractive foliage and showy flowers, although flowering is normally restricted to a short period.

Plants developing from seed or transplants mature rapidly. Those growing in full sunlight may flower and produce seed during the first or usually the second growing season. Although seedlings are reasonably vigorous, their growth may be restricted by competition with weeds or seeded grasses. Young seedlings may be trampled by game or girdled by rodents.

Most horizontal rhizomes and fibrous roots are located beneath the mineral soil surface. After fires or other injury, rhizomes sprout vigorously just behind the damaged tissue. Roots beneath the surface of mineral soil also resprout (Bradley 1984; McLean 1967; Fischer and Clayton 1983). Merrill (1982) reported white spiraea achieved a greater volume and biomass on burned sites relative to unburned sites 1 year after burning. This difference was maintained over a 4 year study. Rate of recovery was related to moisture conditions.

Varieties and Ecotypes

None.

Spiraea densiflora

Subalpine Spiraea

Subalpine spiraea occurs from British Columbia south to northern California, Idaho, and Wyoming at elevations ranging from 2,000 to 11,000 ft (600 to 3,300 m) (Hitchcock and others 1961). It grows along lakes and waterways and on wooded to open rocky slopes, frequently in association with lodgepole pine and western white pine. It is a low, highly branched shrub 1.6 to 3.3 ft (0.5 to 1 m) tall with strong root stocks (fig. 30). Flowers develop in small flat topped to rounded pink to rose corymbs 0.8 to 1.6 inches (2 to 4 cm) wide. Young stems, inflorescences, and lower surfaces of leaves are thickly puberulent. Most material in the Intermountain region belongs to var. *splendens*.

Spiraea douglasii

Douglas Spiraea

A relatively tall species, Douglas spiraea grows from 3 to 8 ft (1 to 2.4 m) in height with erect stems branching primarily below the center. The species spreads by rhizomes, often forming thickets in openings along lake and stream margins, bogs, and swamps. It grows on boggy or peaty ground and wet heavy soils subject to annual flooding (Marchant and Sherlock 1984). Stems are pubescent to glabrous. The oblong-elliptic leaves are serrate above the center. They are 1.6 to 4 inches (4 to 10 cm) in length, dark green above, and woody beneath. The inflorescence is a pyramidal rose to pink panicle 1.6 to 11.8 inches (4 to 30 cm) long with numerous tiny flowers (fig. 31). Dry flower parts are retained as brown tufts overtopping the shrub in winter. Fruits are dry, glabrous, beaked follicles. Seeds are green to brown and less than 0.1 inch (2 mm) long.

Figure 30—Subalpine spiraea inflorescences are thickly puberulent, flat to rounded corymbs of pink to rose flowers.

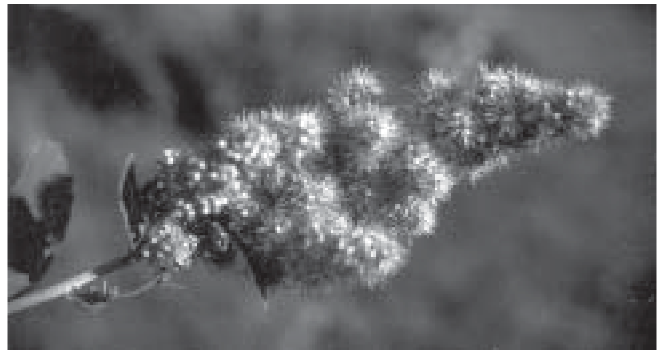


Figure 31—Elongate panicles of pink to rose flowers characterize Douglas spiraea.

Ecological Relationships and Distribution

Douglas spiraea is distributed from Alaska south to northern California and Montana, occurring primarily in coastal areas (Davis 1952; USDA Forest Service 1937).

Plant Culture

Douglas spiraea is easily propagated from cuttings. Marchant and Sherlock (1984) obtained 98 percent rooting of softwood cuttings under mist in June and 98 percent rooting of hardwood cuttings in fall. They recommended lining out hardwood cuttings in spring and lifting them the same fall for outplanting. Stock could also be spring lifted and outplanted. Sprigs or chunks of rhizomes can be dug when dormant and spring planted in areas with moist soils.

Uses and Management

Because of their large size, rhizomatous habit, and ease of propagation, both varieties of Douglas spiraea are prime candidates for revegetation of riparian areas, where adapted. They also have potential for use as ornamentals.

Varieties and Ecotypes

Spiraea douglasii var. *menziesii* is separated from var. *roseata* by its tomentulose inflorescence. It occurs from southern Alaska to northwestern Oregon and northern Idaho. It is one of the most palatable spiraeas and is rated as fair to good fall forage for cattle and sheep (USDA Forest Service 1937). The variety *roseata* occurs primarily in central Idaho (Hitchcock and others 1961). It is a smaller and less palatable shrub.

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Chapter
23

Shrubs of Other Families

Introduction

Numerous genera and species of shrubs occur throughout the Intermountain region in addition to those included in the Asteraceae, Chenopodiaceae, and Rosaceae families. Although shrubs are widespread throughout this region and dominate many areas, species richness is low compared to the shrub flora of the Pacific United States, Chile, western Australia, and South Africa (Stebbins 1975). Generally, evolution proceeds most rapidly when populations are isolated from one another and exposed to different environmental conditions (Dobzhansky 1970; Stebbins 1950); this is the case in the Intermountain region. However, fewer numbers of species within this region are, in part, due to the relatively recent advance and retreat of continental seas, drastic environmental changes, and instability that result in a high rate of extinction (Stebbins 1975).

Most species included in this chapter have been used in revegetation programs. Many other shrubs are recognized as important, but information related to their propagation, seed production, germination, or establishment by direct seeding is not available.

Chapter Contents by Species

Consequently, they are not widely used in large-scale seedings where uniform stands are expected. A number of important species could be more widely utilized in artificial revegetation and increased through management if more information related to their culture was available.

Sixty-seven species representing 20 families are discussed in this chapter. These species occur over a wide range of conditions and habitats. Certain species are common and widespread; others are less abundant and often restricted to localized conditions. However, all are important. In combination, these shrubs offer a diverse range of material for planting and management. *Eriogonum* and *Ceanothus* are examples of two widespread genera discussed in this chapter. Approximately 130 species of *Eriogonum*, including shrubs and broadleaf herbs, occur within the Intermountain region (Welsh and others 1987). Of these, fewer than 10 have been evaluated or used for range or wildland plantings (Miles and Meikle 1984; Plummer and others 1968; Sampson and Jespersen 1963). By contrast, about two dozen species of *Ceanothus* are reported in this same region and slightly more than half have been studied for wildlife, watershed, or horticultural uses. In most instances only one or two species of any genus discussed in this chapter have been studied as potential revegetation species. Seed or planting stock of most species is often relatively scarce.

Shrubs discussed in this chapter occupy rather specific sites. Mountain snowberry, Rocky Mountain maple, and Gambel oak are confined to specific elevations and climatic conditions, yet occupy rather large acreages, often as the dominant species. Other shrubs, including green ephedra and singleleaf ash, are common throughout the southern portion of the Intermountain area but do not extend into the colder northern section. By contrast, red elderberry and dwarf snowberry occupy only mountainous situations.

A characteristic of many shrubs discussed in this chapter is their close association or relationship to soil or site conditions. Rather extensive areas of willow occur through many vegetative communities but are most often confined to moist soils. The relationship of blue elderberry, bush penstemon, and other shrubs that are also adapted to specific soil conditions is less well understood.

Introduced grasses have not been found to be as specifically adapted as many of these shrubs. This is an important consideration; some shrub-dominated associations have been planted to introduced species, mostly grasses. Attempts have been made to substitute other species for native shrubs. Many substitute plants do not provide the forage or cover values expected or simply are not adapted for long-term persistence on some sites. Thus, it is important to learn restoration and management practices required to perpetuate endemic shrub associations.

Some shrubs are particularly important during various stages of succession. Species of redstem ceanothus, snowbrush ceanothus, and red elderberry recover well following fires and assume dominance after coniferous forests have burned. These shrubs provide important habitat, but unless they are able to perpetuate during cyclic fire events, game and livestock habitat may eventually diminish as conifers gain dominance.

Many shrubs occur as components of associated forest and herbaceous communities. Considerable fluctuation in species composition often occurs as a result of fires, and from extremes in climatic events, grazing, and disease. The opportunity to reestablish plants on these disturbances is, in part, dependent upon use of ecotypes with appropriate adaptive features. In an attempt to enhance the shrub component where desirable species have been lost, planting in some situations, has been very successful. Characteristics that ensure the survival of shrubs under adverse conditions are important in selecting plants to rehabilitate mine disturbances and other harsh sites.

Some shrubs are often the only or dominant species to occur on harsh and disturbed sites. Soils throughout many areas of the Intermountain region are infertile and do not support large numbers of species. It is unlikely that successional changes will result in the replacement of many shrubs with other, equally adapted species in such areas. Certain species of buckwheat and penstemon are able to populate harsh, exposed sites. Many of these sites are important midwintering areas where high quality forage is essential for big game animals. In addition, these exposed sites are often invaded by weeds that may enter and, subsequently, spread to adjoining locations. Without the presence of adapted species, weedy plants can invade open and seemingly harsh situations.

Many shrubs are important forage plants. Some are browsed readily throughout the year; others are selectively grazed during certain seasons. For example, Gambel oak, Rocky Mountain maple, redstem ceanothus, and Martin ceanothus are often heavily browsed and can contribute a considerable amount of forage throughout the entire year. Green ephedra, Utah juniper, and Oregon grape usually are grazed during specific seasons.

Woody plants provide not only forage, but are equally important as cover and concealment for wildlife. Utah juniper, Gambel oak, skunkbush sumac, Rocky Mountain maple, and willows are very important for this purpose. Many shrubs discussed in this chapter are also useful for soil stabilization, watershed protection, and ground cover. Deerbrush ceanothus, Scouler willow, mountain snowberry, thinleaf alder, and golden currant are examples of species useful for conservation plantings. The native shrub communities provide aesthetic and cultural resources that are unique to the Western United States.

Important characteristics of a number of shrubs are listed in table 1. Seeding recommendations for major vegetative types and conditions are discussed in chapter 17. Shrubs adapted to these situations are included in the seeding recommendations. Seed characteristics are found in chapters 24 through 27.

Family Aceraceae

Acer glabrum
Rocky Mountain maple

Description—Rocky Mountain maple is a long-lived, shade-tolerant, deciduous shrub or small tree native to North America (Van Dersal 1938). Plants vary in height from 6 to 20 ft (1.8 to 6.1 m) (Harrington 1964), and also demonstrate considerable variation in stature, leaf form, and fruit shape (Kartesz and Kartesz 1980). Some plants reach 20 to 30 ft (6.1 to 9.1 m) in height with multiple trunks up to 1 ft (0.3 m) in diameter, but they occur most often as shrubby plants with multiple stems less than 15 ft (4.6 m) tall (Haeussler and Coates 1986; Hitchcock and Cronquist 1973). Leaves are simple, opposite (Alexander and others 1987), palmately three- to five-lobed or three foliate, and mainly 0.8 to 3.2 inches (2 to 8 cm) wide (Welsh and others 1987) (fig. 1). The herbage is glabrous.

Figure 1—Leaves of Rocky Mountain maple are opposite and palmately five-lobed.

Table 1—Species characteristics of selected Intermountain shrubs.

	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	Vegetative types[a] to which the species is adapted
Alder, thinleaf	3[b]	2	5	4	4	5	4	4	4	5	4	3	4	2	4	3	5	5	5	4	5	A,WM,PP,MB,R
Apache plume	1	3	3	4	2	3	4	3	2	3	4	3	4	4	5	2	4	4	2	3	4	MB,JP,BS,WS,BB
Ash, singleleaf	4	3	2	2	2	3	5	2	2	3	4	2	4	4	5	2	4	4	1	2	4	MB,JP,BS,WS
Barberry, creeping	3	4	4	2	2	3	4	4	2	2	2	3	3	5	4	2	3	4	4	3	4	A,PP,MB,JP,MS,BS
Bearberry	3	4	4	2	1	3	4	3	2	2	4	2	2	4	4	2	5	4	4	2	4	A,PP
Birch, bog	3	2	3	3	3	4	4	4	4	4	3	3	4	3	4	2	4	4	4	4	3	SA,A,PP,WM,R
Birch, paper	3	2	5	4	4	4	4	4	5	4	3	2	4	2	4	3	4	4	4	4	3	A,PP,WM,MB,R
Birch, water	3	2	5	4	4	4	4	4	5	4	2	2	4	2	4	3	4	4	4	4	3	A,PP,WM,MB,R
Bitterbrush, antelope	4	5	5	5	4	5	4	4	4	4	4	3	4	4	5	5	4	5	4	2	4	PP,MB,JP,MS,BS,BB
Bitterbrush, desert	4	5	3	5	4	3	3	3	3	4	4	3	3	4	5	4	3	4	2	2	4	MB,JP,BS,BB
Blackcap	3	2	5	2	2	4	5	5	4	4	4	2	3	2	4	1	5	4	5	4	3	A,WM,PP,MB
Blackbrush	3	5	2	4	1	1	4	3	1	3	3	3	4	3	5	1	3	3	1	2	5	BS,WS,BB
Buckthorn, cascara	3	5	4	3	3	3	4	3	4	4	4	3	4	3	4	3	4	4	4	4	4	A,PP,MB,MS
Buffaloberry, roundleaf	3	4	2	2	2	3	3	2	2	3	3	3	3	4	4	1	4	3	1	2	4	MB,JP,BS,WS,BB
Buffaloberry, russet	3	4	4	2	2	4	4	3	3	3	4	3	4	4	4	2	4	3	5	3	4	SA,A,PP
Buffaloberry, silver	3	4	4	3	3	4	5	4	4	4	4	3	4	3	4	3	4	4	4	3	4	WM,MB,JP,BS,WS,BS,IS,R
Ceanothus, deerbrush	5	5	5	4	4	4	4	4	5	5	5	3	4	3	5	3	5	4	3	3	4	A,PP,MB
Ceanothus, Fendler	5	5	3	3	2	3	3	3	3	4	3	3	4	4	5	2	4	3	2	1	4	A,PP,MB,PJ,MS
Ceanothus, Martin	2	4	4	3	3	5	5	4	3	4	3	3	4	3	5	2	5	4	4	2	4	A,MB,PJ,MS,BS
Ceanothus, prostrate	3	5	4	4	3	3	5	4	2	2	2	3	4	4	5	2	5	3	4	2	4	A,PP,MB,MS
Ceanothus, redstem	3	5	5	4	4	5	5	5	5	5	5	3	4	3	5	3	4	4	4	3	4	A,PP,MB,R
Ceanothus, snowbrush	3	5	5	4	4	5	5	5	5	5	5	3	4	4	5	3	5	4	4	3	4	A,PP,MB,MS
Ceanothus, wedgeleaf	3	5	5	4	3	4	4	4	4	5	5	3	4	4	5	3	5	4	3	2	4	A,PP,MB,MS
Cherry, Bessey	3	4	5	4	4	4	4	1	4	3	4	4	4	2	4	4	4	4	4	3	3	A,WM,PP,MB,JP, MS,BS
Cherry, bitter	3	5	4	2	2	4	5	3	3	4	4	5	4	3	5	3	5	4	3	2	4	A,PP,MB,JP,MS
Chokecherry, black	3	3	4	3	2	4	5	4	4	5	4	5	4	3	5	4	5	4	4	3	3	SA,A,PP,MB,JP,R,MS
Cinquefoil, bush	4	3	4	2	2	4	5	3	3	3	4	4	4	3	4	2	4	4	4	4	4	SA,A,WM,R
Cliffrose, Stansbury	2	4	3	4	3	3	4	4	3	4	4	3	4	5	5	4	3	5	1	2	4	PP,MB,JP,MS,BB
Currant, golden	3	5	5	4	4	4	5	4	4	4	5	5	5	2	4	3	4	4	4	4	3	WM,PP,MB,JP,MS,R,BS,R
Currant, sticky	3	3	4	3	2	3	3	2	3	4	4	4	4	3	4	3	3	4	4	3	4	SA,A,PP,MB

(con.)

Table 1 (Con.)

	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	Vegetative types[a] to which the species is adapted
Currant, wax	3	4	4	2	2	4	4	3	3	3	4	4	4	3	4	2	3	4	3	3	4	A,PP,MB,JP,BS
Cypress, Arizona	2	4	3	3	3	4	4	1	3	3	3	3	5	4	4	3	3	3	2	3	4	MB,JP,MS,BS
Dogwood, redosier	3	4	5	3	3	4	4	4	5	4	4	4	4	3	4	3	4	5	4	4	4	A,PP,WM,MB,JP,R
Elaeagnus, autumn	3	5	5	3	3	4	5	3	4	4	4	4	4	3	4	3	4	4	4	3	4	PP,MB,MS,WM
Elderberry, blue	3	4	4	1	2	5	5	3	5	5	4	5	5	2	5	3	4	5	3	3	5	A,PP,MB,JP,MS,BS,R
Elder, box	3	2	5	5	4	2	2	3	4	2	2	4	4	1	4	4	3	3	2	4	4	A,MB,JP,MS
Elderberry, red	3	4	4	1	2	5	5	3	5	5	4	5	5	2	5	3	4	4	4	4	5	SA,A,PP,MB
Ephedra, green	5	5	2	5	4	3	4	2	2	3	4	4	5	5	5	3	3	4	1	1	5	MB,JP,MS,BS,WS,SS,BB
Ephedra, Nevada	5	5	2	5	4	3	4	2	2	3	4	4	4	5	5	2	3	4	1	1	5	MB,JP,BS,WS,SS,BB
Eriogonum, sulfur	3	5	3	4	4	5	3	5	4	3	3	4	4	4	4	3	3	3	3	2	3	PP,MB,JP,MS,BS,WS
Eriogonum, Wyeth	3	5	3	4	4	5	4	4	4	3	4	4	4	4	4	3	3	4	4	2	4	SA,A,PP,MB,JP,MS,BS,WS
Forestiera, New Mexico	2	4	4	3	2	4	5	2	4	2	3	2	5	3	4	4	3	4	2	2	4	MB,JP,BS,WS
Greasewood, black	3	4	3	4	1	4	5	2	3	3	3	3	5	2	5	3	3	4	1	5	5	BS,WS,SS,BG,IS
Hackberry, netleaf	3	4	4	2	2	4	5	3	2	4	3	3	4	3	4	2	4	4	3	3	4	WM,PP,MB,MS,R
Hawthorn, Douglas	3	3	4	1	2	4	5	5	2	3	4	2	3	3	4	2	3	4	3	4	3	WM,PP,MB,MS,R
Honeylocust	3	4	5	3	3	4	5	4	4	3	3	2	4	2	2	3	3	3	3	2	2	PP,MB,JP,MS
Honeysuckle, bearberry	3	3	5	2	1	4	5	3	3	4	4	5	5	4	4	2	4	4	4	3	4	SA,A,WM,MB
Honeysuckle, Utah	3	4	5	4	2	4	5	3	4	4	4	4	4	2	4	2	4	4	4	3	5	A,PP
Honeysuckle, orange	3	4	5	3	2	4	5	4	4	4	4	3	3	4	4	2	5	3	3	2	4	A,PP,MB
Hopsage, spineless	3	4	4	4	4	2	4	3	3	3	3	4	5	3	5	3	4	3	1	3	5	JP,BS,WS,SS,BB
Hopsage, spiny	3	4	2	4	1	2	5	1	2	2	2	5	1	1	5	2	3	3	1	3	5	JP,BS,WS,SS,BB
Indian apple	3	5	3	3	3	3	5	3	3	4	4	5	4	2	5	3	4	3	3	2	3	PP,MB,JP,MS,WS
Juniper, creeping	5[c]	5	3	1	1	4	5	2	2	2	4	2	2	5	5	2	4	2	3	2	4	A,PP
Juniper, Rocky Mountain	5[c]	5	3	2	1	4	4	5	2	3	4	3	2	5	5	3	3	2	3	3	4	A,MB,JP,MS,BS
Juniper, Utah	5[c]	5	1	1	1	5	5	5	2	2	3	2	3	5	5	2	1	4	2	2	4	MB,JP,MS,BS,WS,SS,BB

(con.)

Table 1 (Con.)

	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	Vegetative types[a] to which the species is adapted
Kochia, gray-molly	3	4	3	3	2	4	5	3	2	2	2	4	5	4	5	2	4	4	1	3	4	WS,SS,BG
Kochia, forage	3	4	4	4	2	4	5	4	3	4	4	4	5	4	5	4	4	4	2	2	4	MB,PJ,MS,BS,WS, SS,BB, C,AW
Locust, black	3	3	4	3	4	4	5	4	4	3	3	2	4	3	3	3	3	3	3	2	3	PP,MB,JP,MS
Maple, bigtooth	3	3	3	4	2	2	3	3	3	4	4	5	4	2	3	4	4	4	4	3	4	A,MB,JP
Maple, Rocky Mountain	3	2	2	2	1	2	3	3	3	2	3	4	4	2	3	3	3	5	5	3	3	A,PP,MB
Mockorange, Lewis	1	2	3	4	3	3	4	4	4	4	4	3	2	4	4	3	3	2	2	3	2	A,PP,WM,MB,MS
mountain ash, Greene's	3	4	3	3	2	3	4	4	2	3	3	3	2	3	4	3	2	2	2	3	3	A,WM,PP,MB
Mountain lover	2	3	2	2	2	2	4	3	3	4	3	4	2	3	4	2	2	4	2	4	4	SA,A,PP,WM,MB
Mountain mahogany, curlleaf	2	4	3	4	3	3	4	3	3	3	3	3	5	5	4	3	3	3	3	1	3	PP,MB,JP
Mountain mahogany, littleleaf	2	4	3	4	3	2	4	3	3	3	4	3	4	4	4	3	4	2	2	1	3	PP,MB,JP
Mountain mahogany, true	2	4	3	4	4	3	4	4	4	3	4	4	4	2	4	3	4	3	3	2	3	A,PP,MB,JP,MS
Ninebark, mallowleaf	3	4	4	4	3	3	4	4	3	4	4	4	2	4	4	2	3	4	3	3	4	A,WM,PP,MB,MS
Oak, Gambel	5	2	1	4	3	2	4	2	3	4	4	1	5	2	5	3	5	3	4	3	4	A,MB,JP
Oceanspray, creambush	4	4	4	3	3	4	4	3	3	3	4	2	2	5	5	2	3	3	3	4	3	A,WM,PP,MB,MS,R
Peachbrush, desert	5	4	4	5	4	4	4	4	3	3	3	5	4	1	4	3	3	3	1	3	3	MB,JP,BS,WS,SS,BB
Penstemon, bush	4	5	5	4	4	4	4	3	3	5	4	4	4	3	3	3	2	3	4	3	1	A,PP,MB,MS
Plum, American	3	2	3	3	2	4	4	4	3	3	3	4	4	1	4	3	4	3	3	4	4	WM,MB,R
Rabbitbrush, Douglas	4[d]	2	4	3	3	4	4	5	3	3	3	3	4	3	4	3	3	4	2	2	4	A,PP,MB,JP,MS, BS,WS,SS
Rabbitbrush, dwarf	4[d]	2	5	4	4	4	5	5	3	2	3	4	4	4	5	3	5	4	1	1	4	MB,JP,MS,BS,WS,BB
Rabbitbrush, low	4[d]	2	4	3	3	4	5	4	4	3	4	4	4	5	3	4	4	2	3	4	4	A,MB,JP,MS,BS,WS, SS,BG,BB,IS
Rabbitbrush, Parry	4[d]	2	5	4	3	4	4	4	3	5	3	4	4	4	5	3	4	4	2	2	4	SA,A,MB,SS
Rabbitbrush, rubber	4[d]	2	4	4	4	4	4	5	5	5	5	3	3	5	5	4	5	4	2	2	3	SA,A,PP,MB,JP, MS,BS,WS,SS, BG,IS
Rabbitbrush, small	4[d]	2	5	4	4	4	5	5	4	3	3	3	4	4	5	3	4	3	1	1	5	JP,MS,BS,WS,SS
Rabbitbrush, spreading	4[d]	2	5	4	4	5	4	4	4	4	4	5	3	4	4	3	5	3	2	3	4	BS,WS,SS,BG,BB
Rockspirea	4	4	3	2	3	4	4	2	3	4	4	2	3	5	4	2	4	3	2	4	3	SA,A,WM,PP,MS
Rose, Woods	3	4	5	2	3	4	5	3	4	4	3	4	4	2	5	2	4	4	4	4	4	SA,A,PP,MB,JP,MS

(con.)

Table 1 (Con.)

Vegetative types[a] to which the species is adapted	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	
Sagebrush, basin big	4[d]	3	5	5	4	5	5	5	5	5	5	3	3	5	4	4	4	3	2	3	3	JP,BS,SS,BG,BB,C,AW
Sagebrush, Bigelow	4[d]	3	5	5	4	4	4	5	4	3	4	3	3	4	4	3	3	3	2	3	3	JP,BS,WS,SS,BG,BB
Sagebrush, black	4[d]	4	5	5	4	5	5	5	4	3	3	3	5	5	4	4	4	3	1	1	4	MB,JP,MS,BS,SS
Sagebrush, bud	4[d]	2	2	2	1	3	3	2	2	2	2	5	1	2	5	2	2	4	1	2	4	BB,WS,SS
Sagebrush, early	4[d]	3	3	4	4	4	4	4	3	3	3	3	3	4	5	2	3	2	1	4	4	MB,MS
Sagebrush, fringed	4[d]	3	4	3	4	4	4	4	3	3	3	2	5	4	4	3	3	4	4	4	4	MB,JP,MS,BS,SS
Sagebrush, low	4[d]	3	4	5	4	5	5	5	4	3	3	2	2	3	5	2	3	2	2	4	4	JP,BS,WS,SS,BG
Sagebrush, mountain big	4[d]	3	5	4	4	5	5	5	5	5	5	3	4	5	5	3	4	4	3	3	3	SA,A,WM,PP,MB
Sagebrush, pygmy	4[d]	2	2	3	2	2	2	2	2	2	2	3	3	3	4	2	3	4	2	3	4	WS,SS,BB
Sagebrush, silver	4[d]	4	5	5	4	5	5	5	4	5	5	3	4	5	5	4	4	3	3	4	4	SA,A,MB,MS,WS
Sagebrush, stiff	4[d]	2	3	3	2	3	3	3	2	2	3	3	4	3	5	2	3	3	2	2	4	MS,BS,WS
Sagebrush, threetip	4[d]	3	5	5	4	5	5	5	5	5	5	3	3	5	4	4	4	4	3	3	4	MB,MS,BS,WS,JP,MS
Sagebrush, Wyoming big	4[d]	3	5	5	4	5	4	4	4	4	4	3	3	5	4	3	4	3	2	2	3	JP,BS,WS,SS,BG,BB,C,AW
Saltbush, Castle Valley clover	4	4	3	4	3	3	4	3	4	4	4	5	5	4	3	3	2	1	3	4	3	WS,SS,BG
Saltbush, fourwing	4	5	4	4	4	3	4	3	5	5	4	3	5	5	5	5	4	5	1	2	2	MB,JP,MS,BS,WS,SS, BG,BB,IS
Saltbush, Gardner	5	4	4	3	3	3	3	4	3	3	4	4	5	4	5	3	4	3	1	3	3	MB,JP,BS,WS,SS,BG,IS
Saltbush, mat	5	4	4	3	2	3	4	3	2	4	4	5	5	5	3	2	1	1	3	4	3	WS,SS,BG,BB
Saltbush, quailbush	4	4	3	2	2	3	4	5	4	4	4	5	4	2	3	4	3	1	3	4	3	WS,SS,BG,BB
Saltbush, shadscale	4	4	2	2	1	2	3	3	2	3	3	3	5	3	5	2	4	4	1	2	3	JP,BS,WS,SS,BG,BB
Sandsage	4[d]	3	5	4	4	5	4	4	4	3	3	3	3	4	4	3	4	4	2	2	4	JP,BS,WA,BB
Serviceberry, Saskatoon	3	5	3	3	3	3	4	3	3	3	4	4	4	3	4	3	4	4	4	2	3	SA,A,PP,MB,JP,MS
Serviceberry, Utah	3	5	3	3	3	4	4	3	3	3	4	4	4	3	4	3	4	4	3	2	4	PP,MB,JP,MS,BS,BB
Silverberry	3	4	5	3	3	4	4	2	3	3	4	2	3	3	4	4	3	4	3	4	4	WM,PP,MB
Snowberry, common	3	5	5	3	3	4	3	3	4	4	4	4	4	2	4	2	4	3	4	4	4	MB
Snowberry, longflower	3	5	5	2	3	3	4	3	4	4	4	5	3	2	4	1	4	4	2	2	4	A,JP,BS,WS,BB
Snowberry, mountain	3	5	5	3	3	4	5	4	4	4	4	5	4	2	5	2	5	5	4	4	4	SA,A,PP,MB,JP,MS
Snowberry, western	3	5	5	3	3	4	4	3	4	3	4	4	4	2	4	2	4	4	4	3	4	WM,MB,BS
Spiraea, birchleaf	3	3	4	4	3	5	5	3	4	4	5	2	2	5	4	2	4	4	3	4	3	A,WM,PP,MB,MS
Sumac, Rocky Mountain smooth	2	5	5	2	2	4	4	3	4	4	4	3	4	3	4	4	4	4	2	2	4	PP,MB,JP,MS
Sumac, skunkbush	2	5	5	2	2	4	5	3	3	4	4	3	4	3	5	3	4	3	2	3	4	PP,MB,JP,MS,BS,BB

(con.)

Table 1 (Con.)

	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	Vegetative types[a] to which the species is adapted
Thimbleberry	3	2	5	2	2	4	5	5	3	3	4	2	3	2	4	1	5	4	5	4	3	A,WM,PP,MB
Virginsbower, western	1	2	4	3	2	3	4	4	3	3	3	4	4	1	4	2	4	4	3	2	4	A,PP,MB,JP,MS,BS,BB
Willow, Booth	2	2	4	4	2	4	4	5	5	4	5	5	3	5	4	3	4	4	4	4	5	A,WM,PP,R
Willow, coyote	2	2	4	4	2	4	4	4	5	5	5	3	3	4	4	5	3	4	3	3	4	WM,A,PP,IS,R
Willow, Drummond	2	2	4	4	2	4	4	5	5	4	5	5	3	5	4	3	2	4	4	4	5	SA,A,PP,WM,R
Willow, purpleosier	2	2	5	4	2	4	4	2	5	4	5	4	4	4	4	4	5	4	4	4	4	A,WM,PP,MB,R
Willow, Scouler	2	2	5	4	2	4	4	4	5	5	5	4	4	4	4	4	5	4	4	3	4	A, WM,PP,R
Willow, whiplash	2	2	5	4	2	4	4	4	5	4	5	4	4	4	4	3	4	4	4	4	4	A,PP,P-J,WM,R
Winterfat, common	3	2	5	5	4	4	4	4	5	3	3	4	4	4	5	3	3	5	1	2	4	MB,JP,BS,WS,SS,BG,BB,IS
Wormwood, oldman	4[d]	3	5	1	1	4	2	3	5	3	3	3	5	3	4	1	5	4	2	1	5	SA,A,PP,MB,MS

[a]Vegetative type or community to which the species is adapted: SA = Subalpine; WS = Wyoming big sagebrush; A = Aspen-conifer; SS = Shadscale saltbush; WM = Wet and semiwet meadows; BG = Black greasewood; PP = Ponderosa pine; BB = Blackbrush; MB = Mountain brush; IS = Inland saltgrass; JP = Juniper-pinyon; R = Riparian; MS = Mountain big sagebrush; C = Cheatgrass; BS = Basin big sagebrush; AW = Annual weeds.

[b]Key to ratings: I = Poor–difficult; 2 = Fair; 3 = Medium; 4 = Good; 5 = Excellent–easy.

[c]In the flesh.

[d]Less than 15 percent purity.

Twigs are usually gray with smooth, reddish-brown bark. Flowers are monoecious or dioecious, appearing in loose, racemose corymbs (Harrington 1964). Fruits consist of two fused samaras about 1 to 1.5 inches (2.5 to 3.8 cm) long, with widely divergent wings, each containing a single seed (Harrington 1964; Hitchcock and Cronquist 1973; Olson and Gabriel 1974).

Ecological Relationships and Distribution— Rocky Mountain maple occurs from Alaska south to California, Arizona, New Mexico, and Nebraska (Little 1979; Welsh and others 1987). In the Pacific Northwest, Rocky Mountain maple is primarily a coastal species, but it is distributed eastward into Idaho, Montana, and western Colorado at elevations between 5,000 and 10,500 ft (1,500 and 3,200 m) (Hitchcock and Cronquist 1973; Harrington 1964). It occurs at elevations of 5,000 to 9,000 ft (1,500 to 2,700 m) in conifer forests of the Sierra Nevada Mountains, northern Coast Ranges, and into western Nevada (Munz and Keck 1959). Welsh and others (1987) reported the plant occurs in all Utah counties at elevations between 5,440 and 10,300 ft (1,700 and 3,100 m).

Rocky Mountain maple is frequently a seral species, but it is able to persist as an understory in climax conifer stands due to its shade tolerance (Mueggler 1965; Ryan and Noste 1985). It occurs intermixed with Douglas-fir, lodgepole pine, ponderosa pine, spruce-fir, and quaking aspen. However, it does not occur as a common understory species with aspen in Utah (Mueggler 1988). It occurs along streambanks in mountainous areas, in moist canyon bottoms, and on slopes (Mozingo 1987; Wasser 1982), primarily in moist habitats (Lotan 1986). This species is frequently associated with mallowleaf ninebark, Saskatoon serviceberry, Scouler willow, Greene's mountain ash, chokecherry, mountain lover, and Utah honeysuckle (Atzet 1979; Johnson and Simon 1987; Mauk and Henderson 1984; Steele and others 1981; USDA Forest Service 1973; Wasser 1982).

Within the Intermountain region, Rocky Mountain maple occurs primarily in mountain brush communities. The species exists over a wide range of sites from well-drained to moist situations. Plants grow intermixed with Gambel oak, chokecherry, and Woods rose in mesic, brushland sites. At lower elevations, its range overlaps with pinyon and juniper, although it usually does not grow in mixtures with these conifers. Where pinyon or juniper occur with maple, the conifers are usually restricted to the more arid sites. In arid regions it is restricted to streams and moist canyons (Mozingo 1987; Wasser 1982), existing as an important species in riparian communities (Brown and others 1977; Mozingo 1987; Myers 1987). It occupies both warm and cool wet areas.

In some situations, Rocky Mountain maple appears to be dependent on the presence of a well-developed soil, with high concentrations of organic matter in the upper portions of the soil profile (Krajina and others 1982; Mueggler 1965). Plants also occur on rocky and gravelly soils and on steep slopes with shallow soils, where a considerable amount of litter has accumulated. At both upper and lower elevation limits, the distribution of Rocky Mountain maple is influenced by topographic features and aspects.

Rocky Mountain maple usually grows on sites that receive between 16 and 30 inches (400 and 760 mm) of annual precipitation. Mature stands will usually persist with limited dieoff during periods of extended drought. A decrease in herbage production may occur if the precipitation level falls below normal, but stand density usually remains unchanged.

Rocky Mountain maple may occur in dense, restricted patches or clumps; yet, open diverse stands often occupy an entire slope or small drainage (fig. 2). When found on south or west aspects, it may be confined to small patches surrounded by bunchgrasses or more xeric species. Mountain brome and slender wheatgrass frequently occur as an understory with this species. These two grasses may increase or decline dramatically from year to year, but the density of overstory maple remains quite consistent.

Grazing, wildfires, and other impacts have not seriously reduced the distribution or density of Rocky Mountain maple. Cutting and burning temporarily reduce some stands, but natural recovery is quite rapid. Weedy species have not seriously affected the presence or vigor of Rocky Mountain maple even though heavy grazing has removed the native understory in some areas.

Figure 2—Rocky Mountain maple may occur as individual shrubs, or more often in small thickets in mountain brush communities.

Rocky Mountain maple is particularly important in many of the conifer forest communities. It is not seriously diminished by a closing canopy (Antos 1977; Habeck 1970; Stickney 1985). It can recover immediately following fire (Cholewa and Johnson 1983; Mueggler 1965) or logging due to its resprouting capabilities. Recovery is from stem resprouting, not by root suckering or rhizome formation (Haeussler and Coates 1986).

Plant Culture—Seeds usually mature in August or September (Olson and Gabriel 1974). Some stands produce seeds once every 2 to 3 years (Olson and Gabriel 1974). However, individual plants scattered throughout a stand usually produce some seeds each year. In addition, certain plants have been observed to produce a viable crop of seeds every year for 3- to 5-year periods. Individual plants often produce an extraordinary amount of seeds. Seeds also tend to ripen more uniformly on certain plants; consequently, seed collection is usually confined to a few plants. Seeds often ripen over a period of 1 month.

Seeds usually remain on the plants for 2 to 4 weeks before being dislodged by wind. When mature, the fruits turn from green to yellow or reddish brown. Seeds can be collected by hand stripping or flailing the bush. Green or immature seed should not be collected. Seeds should be inspected for insect damage and immature embryos before collection. Some collections exhibit about 50 percent germination (Swingle 1939). This percentage can be improved, however, if care is taken to collect mature, well-developed seeds. There are about 13,430 seeds per lb (29,600 per kg) (Olson and Gabriel 1974).

The wings are usually detached from the fruits to aid in handling and planting. Once the wings are removed, empty seeds can be removed by flotation. This is advisable to permit regulation of seeding rates. Seeds should be dried to a water content of 10 to 15 percent before storage (Olson and Gabriel 1974). Seeds can be stored for 1 to 2 years in sealed containers at 35 to 41 °F (1.7 to 5 °C) without serious loss of viability (MacArthur and Fraser 1963). Seeds have dormant embryos that require 6 months of wet prechilling to release dormancy (Shaw 1984). Consequently, fall seeding is advised. However, wet prechilled seeds can be spring planted, particularly under nursery conditions. Seeds dispersed on the soil surface do not maintain viability (Kramer 1984).

Cleaned seeds can be planted with most conventional seeders, but most plantings have been restricted to small, carefully prepared areas where hand seeding has been employed. Seeds should be planted at a depth of 0.5 to 1.5 inches (1.3 to 3.8 cm). Broadcast planting without any followup methods for covering the seeds is not advised. Planting weedy sites should be avoided. Seedlings have grown well and attained considerable size in 1 to 2 years.

To date, most seedings have been confined to sites where the species previously existed. When seeded "offsite," weak and erratic stands have developed. Plants appear to be quite dependent on soil conditions to survive and flourish. When seeded or transplanted on mine wastes, plants have done poorly. However, if sites are top soiled, better stands have established and persisted.

Natural seedlings are usually not abundant. When found, they are encountered in shady areas with little competition (Steele and Geier-Hayes 1992). Under these conditions seedlings have been reported to grow slowly.

Rocky Mountain maple is easily cultured and has been planted in commercial landscape programs. Transplants or wildlings are used in conjunction with other species in formal plantings.

Transplanting 1- to 3-year-old nursery stock has improved stand establishment in areas with poor soils or where some understory competition exists. Older transplants are able to establish and begin growth quite rapidly without a prolonged period of adjustment.

Uses and Management—Rocky Mountain maple has been planted to provide diversity and enhance wildlife habitat. Though it is often confined to small areas, it provides valuable thickets for protection and concealment. It is a useful forage species and occurs in important winter habitats for big game animals (Arno and Hammerly 1977; Beetle 1962; Gaffney 1941; Keay 1977; Martinka 1976; Young and Robinette 1939). Rocky Mountain maple normally supports a productive complex of understory herbs. These sites are important areas for summer grazing by big game and livestock. Stands of Rocky Mountain maple that recover following burning provide considerable forage for big game, livestock, and nongame animals. In most situations plants may grow too tall to be reached by animals, yet they provide excellent cover (Johnson and Simon 1987; Larson and Moir 1987). In more arid situations, the shorter growing forms remain available to browsing animals. Rocky Mountain maple is a palatable species, particularly to big game (Beetle 1962; Keay 1977; Martinka 1976; Mitchell 1950; Smith 1953), but is also used by other animals, including ruffed and blue grouse (Steele and others 1981) and small mammals (Martin and others 1951).

Rocky Mountain maple grows in moist areas. When disturbed, these sites can produce sediment and increase runoff. These sites are important for watershed stability and may require immediate attention if disturbed. Rocky Mountain maple is able to recover following disturbances and can provide soil and streambank protection.

Both Rocky Mountain maple and bigtooth maple are attractive plants, particularly during the fall when leaves turn red and yellow. Certain plants and clumps exhibit early fall coloration, others are particularly brilliant in color, and some may retain their leaves for extended periods. Also, considerable differences in growth habit and mature size occur among ecotypes. Many native stands have high aesthetic appeal and are important viewing areas and recreational sites. These areas are frequently managed for scenic use. Rocky Mountain maple has not been used as extensively in windbreaks and conservation plantings as other maples.

Varieties and Ecotypes—None.

Family Anacardiaceae

Rhus aromatica
Skunkbush sumac

Description—Skunkbush sumac is an unusually persistent and highly variable species (fig. 3). Welsh and others (1987) described two varieties of this species complex that occur in Utah. *Rhus aromatica* var. *simplicifolia* has simple leaves and occupies xeric sites in southeastern and southwestern Utah. *Rhus aromatica* var. *trilobata* leaves are trifoliolate, and plants grow on mesic sites including streambanks, seeps, and riparian communities. Shrubs occur singly or in dense patches and may be connected by woody rhizomes, which often exceed 20 ft (6.1 m) in length (Sanford 1970). Root systems are deep and extensively branched. Plants are deciduous, woody, spreading, and moundlike to erect, often forming clumps or thickets. They normally range from 2 to 7 ft (0.6 to 2.1 m) in height (Hitchcock and others 1961; Welsh and others 1987); some may reach heights of 15 ft (4.6 m) (Thornburg 1982). Crown diameter often exceeds the height and may be more than 30 ft (9.1 m) (Plummer and others 1968; USDA Forest Service 1976c). Stems are numerous, woody, spreading, highly branched, and brown hairy when young; they develop a gray bloom with age (Barkley 1937; Wasser 1982). Leaves are 1 to 3 inches (3 to 7 cm) long, trifoliate, petiolate, and puberulent beneath. The terminal leaflet is fan shaped, shallowly to deeply incised or lobed, and coarsely crenate. Lower leaflets are half as large and shallowly crenate. The resinous, acrid sap of the twigs and leaves is nonpoisonous, but produces a disagreeable odor, hence the common name, skunkbush sumac (Stubbendieck and others 1986). Plants are polygamo-dioecious. The inflorescence consists of a cluster of spikes located near the branch apex (Goodrich and Neese 1986). Buds and flowers are inconspicuous, pale yellow, and mostly imperfect. Fruits are orange red, sticky, berrylike drupes, each containing a single bony seed (Brinkman 1974g; Stubbendieck and others 1986; Welsh and others 1987).

Figure 3—Skunkbush sumac established from a direct seeding provides important wildlife habitat.

Ecological Relationships and Distribution— Skunkbush sumac is widespread and highly variable; it ranges from Alberta south to Iowa and Mexico, and west to southeastern Oregon and California (Harrington 1964). It is found at elevations from 3,500 to 8,000 ft (1,100 to 2,400 m) (Hitchcock and others 1961; USDA Forest Service 1937) on sites with annual precipitation between 10 and 20 inches (250 and 510 mm) (Wasser 1982). It grows in the mountain brush and pinyon-juniper types of the Intermountain region and the plains and foothills of eastern Wyoming and Montana (Welsh and others 1987). It is a primary or secondary species growing in sand hills of the plains and Southwest (Wasser 1982). At lower elevations it may be found with blackbrush, basin big sagebrush, or Wyoming big sagebrush. It also occurs in openings in oakbrush and ponderosa pine forests (Vories 1981). Plants growing in rocky foothills are usually smaller in stature and less productive than the more typical upright forms of the mountain brush communities (Welsh and others 1987). Skunkbush sumac is generally drought and cold tolerant, but these characteristics vary among ecotypes.

Skunkbush sumac is commonly found along stream courses where it occurs intermixed with other shrubs or as an understory with cottonwoods. Although dense stands are usually not encountered, scattered plants or thickets may be widely distributed in openings along riparian areas; plants require full sunlight to partial shade. On dry sites it occurs in swales and drainageways where it may receive extra moisture. It requires well-drained soils with deep water tables (Wasser 1982), and although it tolerates short-term flooding where it occurs along streams, it is not capable of surviving long-term flooding.

Skunkbush sumac occurs on a wide range of soils ranging from sandy textured soils to heavy clay-textured materials (Johnson and others 1966). In Utah, it is particularly well adapted to heavy shale outcrops, and sometimes salty outcrops, where few other shrubs are adapted (Plummer 1977). It grows on both acidic and basic soils including slightly alkaline soils (Johnson and others 1966; Vories 1981). It occurs on deep fertile soils and also on shallow, rocky, less-developed soils.

Plant Culture—Fruits of skunkbush sumac form dense clusters near the ends of small branches. The clusters are scattered over the surface of the entire bush. Flowers appear from March to April (Brinkman 1974g). Fruits ripen from June to September (Plummer and others 1968; Van Dersal 1938), and many remain on the shrub until midwinter. Most seeds are removed by birds or other animals (Brinkman 1974g).

Fruits may be harvested over a period of 2 to 3 months during early fall and winter, but they are more difficult to clean if they have been allowed to dry on the shrub. Fruits are collected by hand picking or flailing the stems after leaves have fallen in early winter. Fruits adhere to the plant and are not easily dislodged. This characteristic interferes with seed collection and results in high seed costs. Harvested fruits are macerated using a Dybvig cleaner and flushed with water to remove the pulp. The remaining material, including the seeds, is then dried and fanned to remove small debris. Seeds can be cleaned to purities exceeding 90 percent. There are approximately 20,000 cleaned seeds per lb (44,100 per kg) (Brinkman 1974g; Plummer and others 1968; USDA Forest Service 1948). Recommended laboratory standards for seed purchases are 40 percent germination and 95 percent purity. Cleaned seeds remain viable for up to 5 years under open, dry storage.

Seed production varies among sites and ecotypes. Most upland populations produce some seeds each year, but abundant crops must be produced to justify commercial harvesting. Seeds from many useful ecotypes or collection sites normally are not harvested or sold because production is quite low. Consequently, poor seed-producing ecotypes are not collected and used in restoration programs. Seeds from more limited, but productive, stands are normally harvested and sold for extensive plantings. Thus, the most adapted ecotypes are not always used.

Seed germination may be restricted by the presence of a hard, impervious seedcoat and embryo dormancy. Both forms of dormancy vary widely among seedlots. Seedcoat permeability may be increased by a 20-minute to 2-hour sulphuric acid scarification (Babb 1959; Brinkman 1974g; Glazebrook 1941; Heit 1968a). A wet prechilling for 30 to 120 days is required to release embryo dormancy (Babb 1959; Heit 1970; Swingle 1939). Duration of acid treatment and wet prechilling periods required vary among seedlots. Physical rupturing of the seedcoat using mechanical methods also increases germination (McKeever 1938), but procedures have not been developed to treat large seedlots. Fall seeding often provides the necessary cold treatment to release embryo dormancy (Brinkman 1974g), but very erratic results have occurred, possibly due to differences in seedcoat imposed dormancy (Boyd 1943; Monsen 1987; Monsen and McArthur 1985).

Erratic seed germination is the principal factor preventing extensive seeding of this shrub. Differences in germinability are not entirely related to ecotypes or site of collection. Plants from sites in north-central Wyoming and south-central Montana are in considerable demand for mine restoration, but these ecotypes are difficult to germinate. Means to stimulate or assure field germination are not well understood, and until these problems are corrected, use of skunkbush sumac will be adversely affected.

Seeds that have been properly pretreated will normally germinate in 30 to 45 days, once germination begins (Monsen and Christensen 1975). Germination is usually completed in 30 days under nursery conditions (Brinkman 1974g). This long germination period can adversely affect survival of wildland plantings. Soil at many sites does not remain moist long enough to ensure germination and seedling establishment.

Different ecotypes of skunkbush sumac occur throughout its range. Adapted seed sources must be selected for range seedings or transplanting projects. Scarified seed should be fall planted to provide overwinter wet prechilling; scarified seeds sown in the spring must first be wet prechilled. Seed should be planted approximately 0.5 inch (1.3 cm) deep or slightly deeper in dry, coarse-textured soils. Skunkbush sumac may be seeded at the rate of 2 to 4 lb per acre (2.2 to 4.5 kg per ha), depending on row spacings. It may be broadcast on rough surfaces or in pits. If drill seeded, it should be planted with other slow-growing shrub species in rows separate from faster growing species.

Seedlings grow moderately well, but young plants are not highly competitive with herbs (Monsen 1987). Consequently, this species should not be seeded together with grasses. Young plants can be stunted by herbaceous competition and may not recover (Monsen 1987). Established seedlings are quite hardy and resilient. Range or wildland seedings normally require 2 to 5 years to fully establish.

In the bareroot nursery seed should be planted about 0.5 inch (1.3 cm) deep. A seeding density of 25 viable seeds per linear ft (82 viable seeds per linear m) was recommended by Brinkman (1974g). At the Los

Lunas Plant Material Center seeds are planted at a density of 182 per linear ft (600 per linear m) of row to yield 23 usable plants per linear ft (75 per linear m) (Frazier 1979). Beds should be mulched to prevent excessive drying. Plants may be lifted as 1-0 or 2-0 stock, depending on their growth rate. Field transplanted seedlings should be at least 8 to 11 inches (20.3 to 28 cm) tall. Container stock is most easily established from germinants and requires a 4- to 6-month cropping time (Landis and Simonich 1984). Ferguson and Frischknecht (1981) and Stevens (1981) reported that large, well-rooted stock is easily transplanted. Skunkbush sumac is grown by many commercial nurseries, and wildland plantings of bareroot stock have been highly successful.

Doran (1957) reported that cuttings of *Rhus* root well when taken in July and potted in a sand-peat media. This provides a means of propagating collections from specific locations that are difficult to rear from seed.

Field cultivation of skunkbush sumac has been successful in improving seed production. Producing seed from agricultural fields or nursery sites could undoubtedly provide a means of marketing desired ecotypes and providing a more stable market.

Uses and Management—Skunkbush sumac has been extensively used in windbreaks, shelterbelts, and conservation plantings (Brinkman 1974g; Hassell 1982; Swenson 1957). As an ornamental, it grows rapidly and develops dense foliage (Johnson 1963; Olson and Nagle 1965; Steger and Beck 1973). The leaves and berries turn brilliant shades of red and orange in the autumn. Mature plants withstand burial by drifting sand and sprouting from the crown. Plants are also able to survive when soil is eroded from the upper portions of the root system. These characteristics, along with its cover value, low palatability, ability to resprout after fire, longevity, and ability to withstand climatic extremes, qualify sumac as a valuable species for revegetation (Johnson 1963; Olson and Nagle 1965; Swenson 1957).

Skunkbush sumac requires little maintenance in conservation plantings. Plants do not become decadent with age, but remain healthy and robust. Many other shelterbelt species often decline in vigor or are subject to crown damage from wind, insect attack, or snowfall. Skunkbush sumac is generally not adversely affected by these agents, but persists and becomes a major species in older plantings.

Skunkbush sumac has been widely used in recreation sites, parkways, campgrounds, and roadway rest areas. It frequently recovers by sprouting following disturbances, and can be managed to assure the presence of native species in recreational sites. It withstands traffic and campground activity; consequently, it is used to screen landscape trails, roadways, and structures. The plant is particularly important for recreational sites in semiarid areas in the Intermountain region and the Southwest.

Selected ecotypes of skunkbush sumac have proven well adapted to unstable disturbances. It has been used to stabilize sand dunes (Kozlowski 1972), roadways, and mine sites (Hassell 1982; Monsen and Christensen 1975). However, direct seedings and transplants establish and grow at only moderate rates for the first few years. Although survival is often high, plants do not provide extensive ground cover during the establishment period. Once well established, annual growth increases, and the plants begin to provide considerable ground cover and soil protection.

Skunkbush sumac can be used to stabilize disturbed watersheds, including riparian sites. Its growth habit provides excellent ground cover, and plants are able to resist soil deposition. It is particularly useful for restoration of meadows and other riparian sites where erosion and gully cutting have drained wetlands and lowered water tables.

The spreading moundlike growth form of some ecotypes and the ability of the shrub to form dense thickets by root sprouting cause skunkbush sumac to be a valuable cover plant for birds (Adkins 1980). In addition, the fruits of skunkbush sumac are consumed by many bird species (Brinkman 1974g), particularly during winter months, as berries remain on the bush (Swenson 1957). Consequently, the shrub has been selectively planted in windbreaks and associated conservation plantings to provide forage and cover for birds.

Skunkbush sumac has been most widely planted in the Intermountain area for big game habitat. It is often planted in mixtures with other more preferred forage plants. The shrub is selectively planted on less fertile sites in big sagebrush, pinyon-juniper, and mountain brush communities where ground cover and big game habitat are required (Plummer and others 1968). It grows slowly, normally requiring 10 to 20 years to attain mature stature (Monsen 1987), but it is one of the most successful shrubs established from rehabilitation plantings. Initial establishment and ratings of young plantings are regarded as only fair, but long-term performance ratings are good to excellent. Swenson (1957) and Adkins (1980) also reported good to excellent survival for 20-year-old cover and windbreak plantings of skunkbush sumac in eastern Colorado and eastern Washington.

Palatability of skunkbush sumac is rated low for livestock and fair to good for big game, depending on the ecotype and other browse species available (Dayton 1931; Stanton 1974). It has been planted in mixtures for range and wildlife habitat to provide forage and cover. In Montana and Wyoming it is considered a preferred browse species and receives heavy winter use (Mueggler and Stewart 1980; Tweit and Houston 1980) and moderate use in the summer (Sanford 1970). Throughout other portions of its range, the plant is only lightly grazed (Sanford 1970). Sheep often browse the shrub at all seasons. Skunkbush sumac is a particularly important forage plant in midwinter during periods of deep snow cover. It occupies windblown slopes that often remain open and available for browsing. Skunkbush sumac recovers well from wildfires, sprouting vigorously from underground rhizomes (Dwyer and Pieper 1967; Wright and others 1979). It is an important shrub in areas where fires can be used to enhance vegetative conditions.

Varieties and Ecotypes—"Bighorn" skunkbush sumac, developed by the Los Lunas Plant Materials Center, is a tall, upright variety selected from trials conducted at locations from New Mexico to Montana and North Dakota (Thornburg 1982). Seed of this variety does not exhibit embryo dormancy and requires only a 10 to 25 minute acid scarification (Frazier 1979). Populations of skunkbush sumac vary widely in size, growth habit, leaf characteristics, and range of adaptation; they provide many opportunities for future selection work.

Family Anacardiaceae

Rhus glabra
Rocky Mountain smooth sumac

Description—Rocky Mountain smooth sumac is a small, little-branched, thicket-forming shrub (Van Dersal 1938). Mature plants usually do not exceed 3 to 6 ft (0.9 to 1.8 m) in height. Root suckers develop from the parental plant, and new shoots may appear 10 to 13 ft (3.0 to 4.0 m) from the base of the shrub (fig. 4). Branchlets are glabrous and glaucous. The leaves are mostly 4 to 12 inches (10 to 30 cm) long with 7 to 21 leaflets. Leaves are lanceolate, mainly 0.6 to 3 inches (1.5 to 8 cm) long, acuminate, serrate, and range in color from dark green to light green. The inflorescence consists of a panicle about 4 to 8 inches (10 to 20 cm) long, containing many white flowers. The fruit is a globular, red, thinly fleshy drupe. It is about 0.2 inch (4 mm) long and covered with a dense layer of short red hairs (Harrington 1964; Welsh and others 1987).

Ecological Relationships and Distribution—Rocky Mountain smooth sumac is widespread in North America (Welsh and others 1987). It occurs from British Columbia to California, Oregon, and Arizona, and eastward to the Atlantic Coast (Munz and Keck 1959). It is common from Nevada and Mexico to New Hampshire and Georgia (Davis 1952; Hitchcock and Cronquist 1973). In Utah it occurs on a variety of sites including desert shrub, riparian, pinyon-juniper, and mountain brush communities at altitudes between 3,590 and 7,710 ft (1,100 and 2,350 m) (Welsh and others 1987). Harrington (1964) reported that the shrub occupies valleys and slopes throughout the western portion of Colorado at elevations between 5,500 and 7,500 ft (1,700 and 2,300 m).

Rocky Mountain smooth sumac often exists in disjunct stands in dry places, usually in open areas without overstory shade. Large patches or clumps often occur alone without other shrubs, but intermingled in groupings with other plants. It grows on a variety of soils including sandy as well as heavy-textured materials. It is a climax species with various bunchgrasses in the Northwest, although the native grasses have often been replaced by annual cheatgrass (Daubenmire 1970; Franklin and Dyrness 1973). This species grows along streams and canyon bottoms aligning riparian communities, but does not occur in wet areas. It occupies steep slopes and streambanks intermixed with numerous upright trees and shrubs, but not as an understory in dense patches of vegetation. It is extremely drought tolerant, and is encountered on open south- and west-facing slopes with big sagebrush, antelope bitterbrush, and mountain brush species. Rocky Mountain smooth sumac also forms thickets in the prairie grasslands (Weaver and Fitzpatrick 1934).

Plant Culture—Rocky Mountain smooth sumac normally produces an abundant seed crop. If grown on favorable sites, plants usually produce heavy seed crops each year. Even under arid situations, plants produce some viable seeds. Plants flower from June to August, and are not subjected to late spring frosts that

Figure 4—Rocky Mountain smooth sumac produces distinctive clusters of red drupes.

damage seed crops of many shrubs. The flowers are small and borne in terminal or axillary clusters (Brinkman 1974g). Initially, the developing fruits do not appear to be very abundant, but as fruits ripen in fall or early winter, large, dense clusters of red fruits develop (Lovell 1964; Plummer and others 1968; Radford and others 1964; Van Dersal 1938). The fruits are easily collected by handpicking or beating the shrub to dislodge them. Fruits are usually collected in fall after the leaves have dropped and the fruits are more visible. Fruits can persist on the bush until late winter without loss of seed viability. Consequently, seed collection may be delayed until late winter.

Once the fruits are harvested they should be cleaned to remove the fruit coat and dry pulp. The fruit is a small drupe having a single bony nutlet (Brinkman 1974g). The fruit is normally dry at the time of harvest, and the flesh is often left on the seed; however, the dry fruit makes planting more difficult, particularly when mixed with other seeds. When cleaned, the seeds are more easily stored or seeded.

Seeds are cleaned using a macerator to grind away the pulp. Water is used to float and separate the pulp from the seeds (Brinkman 1974g; Swingle 1939). If the fruits are dry, soaking with water is often required before maceration. High yields of good seed are normally obtained from most seed collections. Cleaned seeds consist of from 45 to 75 percent of the fruit or material initially collected (Brinkman 1974g). Seed numbers range between 23,000 and 48,000 per lb (50,700 and 105,800 per kg) (Johnson and others 1966; Lovell 1964; McKeever 1938; Plummer and others 1968; Swingle 1939).

Seed germination may be erratic (Monsen and Christensen 1975), and inhibited by a hard impervious seedcoat (Heit 1967a; Johnson and others 1966) and a dormant embryo. Pretreatment using sulfuric acid or hot water to increase seedcoat permeability has been employed (Johnson and others 1966), but mixed results have occurred due to differences in structure of the seedcoat (Brinkman 1974g; Heit 1967a; Lovell 1964). Seeds can be wet prechilled at 40 °F (4.4 °C) for 2 months (Brinkman 1974g) to relieve embryo dormancy.

Seeds should be planted in late fall or early winter at a depth of 0.75 to 1.5 inches (2 to 4 cm). Some seedlots germinate much better than others, particularly if pretreated. Attempting to predetermine planting success from new seedlots is difficult. Nursery seedings are often heavily sown to assure establishment of satisfactory stands.

Success from seeding wildland sites has been extremely erratic due to poor or very erratic germination. Excellent quality transplant stock can be grown as bareroot or container stock. One-year-old bareroot stock is easily cultured and field planted with good success. Consequently, harsh sites can be successfully planted with transplant materials. Rooted suckers can be field dug and transplanted with good results if lifted when dormant. Doran (1957) recommended root cuttings be taken in December.

Uses and Management—Rocky Mountain smooth sumac is a highly useful shrub. It is important for wildlife habitat, ground cover, and conservation plantings. However, its usefulness in large-scale restoration plantings has been limited by low or erratic seed germination.

Plantings of Rocky Mountain smooth sumac on wildland sites have been enhanced by seeding the shrub alone or with a few other species in well-prepared seedbeds. Planting in late fall in areas free of competitive herbs has improved stand establishment. Once established, small seedlings and young plants are very hardy and survive periods of drought. New plantings are not damaged by moderate grazing, insects, or disease, and are able to develop normally under most circumstances.

Seedling survival can be quite erratic. Some small seedlings are quite vigorous and grow at moderate rates, but natural thinning usually results in the loss of a number of young plants. Plummer and others (1968) ranked this shrub as low to fair for the development of mature stands from direct seedings. Seedling losses usually result from erratic seed germination; many seedlings emerge in late spring when soil water is rapidly being depleted. Such seedlings usually do not survive.

Plants form a single main stem during the first and second growing seasons. During this time an extensive root system is developed. Plants that survive the first growing season are quite persistent, and few plants succumb after that date. Plants reach maturity quickly; within 6 years the shrub is sufficiently developed to produce flowers and seed. Spread by underground rooting usually begins within 10 years after planting. Thereafter, root suckering may occur each year, but the pattern is somewhat erratic. Numerous suckers may appear in some years, but not in others. The size and area occupied by a clump of plants tend to stabilize within 20 to 30 years. Natural spread may continue after this time, but maximum spread is usually attained within this time span. Natural spread is not always restricted by the presence of other species. New shoots often emerge in areas occupied by closed stands of native bunchgrasses, big sagebrush, and antelope bitterbrush.

Rocky Mountain smooth sumac is an important forage plant for wildlife. The fruits are eaten by a large number of birds (Miller and others 1948; Stanton 1974). It is moderately browsed by big game in the spring, fall, and winter months, but is more heavily grazed in the summer (Hill and Harris 1943; Kufeld and others 1973; Nemanic 1942; Plummer and others

1968; Smith 1953; Snyder 1937). When this shrub occurs on big game wintering ranges and is available, it is heavily browsed when access to other species is restricted by deep snow. Some populations are more heavily grazed each year than others.

Rocky Mountain smooth sumac is relatively easy to establish by transplanting on harsh, unstable sites (Plummer and others 1968). Consequently, it has been successfully used to plant mine disturbances, roadways, and unstable watersheds. Although it establishes well and spreads to provide soil stability, erect open stands usually develop on semiarid sites. Plants growing on more mesic sites develop dense protective ground cover. Under most conditions, this species can be used to provide soil protection, particularly if understory herbs are also planted.

Rocky Mountain smooth sumac is a useful shrub to plant on unstable slopes, streambanks, and roadfills where mass movement may occur. Plants naturally spread by roots to furnish excellent site stability. Unstable soils can be quickly stabilized by transplanting large stock (2-year-old plants) 2 to 3 ft (0.6 to 0.9 m) apart. The plants spread rapidly and fully occupy the area in 1 to 3 years.

Rocky Mountain smooth sumac has been used to revegetate mine disturbances, as it will grow in soils with low fertility. It does not establish or compete very well if sites are heavily seeded to herbs and fertilized at high rates.

This shrub is widely used as an ornamental because of its low growth form, attractive fruits, and fall coloration. It is used to stabilize and beautify steep banks, roadways, parks, and recreation sites. It has been cultivated since 1620 (Brinkman 1974g). Rocky Mountain smooth sumac is also useful in windbreak and conservation plantings. It withstands extreme cold temperatures, and can be used on exposed, windblown sites to protect soils and entrap snow.

Rocky Mountain smooth sumac survives wildfires, and is an important plant where burning may create erosion and watershed problems. This species can recover quickly from fire, and provides needed cover the first year after burning. Along with Gambel oak, maples, Saskatoon serviceberry, and chokecherry, the species readily resprouts and protects steep watersheds.

Varieties and Ecotypes—None.

Family Berberidaceae

Mahonia aquifolium
Shining barberry

Description—Mature plants are 0.3 to 6.6 ft (0.1 to 2.0 m) or more tall. Leaflets are more than twice as long as broad, glossy on the upper surface and dull beneath (fig. 5), with more pronounced spiny tips than Oregon grape. The species frequents moist, rich humus soils on the floor of conifer forests, but sometimes grows on exposed rocky slopes, brushy hillsides, and in aspen or alder stands. Marchant and Sherlock (1984) report that it is rather slow growing during the first season and slow to establish on wildland sites. The species integrates with Oregon grape in northeast and north-central Washington, thus the two taxa may be varieties of a single species.

Distribution—Shining barberry is distributed from British Columbia and northern Washington to northeastern Idaho, and south from the eastern edge of the Cascade Mountains to the coast, as far as the southern Willamette Valley.

Plant Culture—Shining barberry has not been extensively used in wildland plantings. Transplants have been grown for small plantings, but direct seedings are rare. Plants normally produce some fruits or berries each year, and seeds can be collected and processed as described for Oregon grape. Seeds are difficult to germinate uniformly, and information is needed to properly culture this species.

Uses and Management—Shining barberry is infrequently used for low-maintenance landscaping, erosion control, and conservation plantings. It is grown by some commercial nurseries, but is not commonly used in most wildland restoration projects.

Varieties and Ecotypes—None.

Figure 5—Glossy, elongate, spine-tipped leaves characterize shining barberry.

Family Berberidaceae

Mahonia fremontii
Fremont barberry

Description—Fremont barberry is a large shrub of dry slopes and ridges in pinyon-juniper types of the Southwest. It grows 3 to 12 ft (0.9 to 4 m) tall and produces small, compound, spiny leaves and dark blue or red berries. This shrub has yellow wood (fig. 6).

Ecological Relationships and Distribution—Fremont barberry is distributed across the Southwest from western Texas through Sonora to Baja California and north, and from California through southern Utah and Colorado. It grows on deep sandy soils in valley bottoms and draws. It is also encountered amid rocky outcrops and steep canyon slopes. A number of individual bushes often grow together in small patches, although this shrub does exist interspaced with other woody species. It is found in the warmer drier regions of southern Utah and northern Arizona. It grows intermixed with Utah juniper, Stansbury cliffrose, blackbrush, and Nevada ephedra. It is common in draws and washes that may receive infrequent runoff.

Plant Culture—Berries are generally not produced each year. Special climatic conditions must occur to promote flowering and seed production. However, bushes planted in more mesic situations in central Utah have consistently produced abundant crops most years.

Seeds are formed in a berry that dries at the time of maturation. Seeds are large and easily extracted and separated from the dry fruit. A hard seed coat restricts exchange of water and air. In addition, most seeds require some wet prechilling to germinate.

Both container and bareroot nursery stock have been grown for restoration plantings. Plants have been reared and used in cultivated gardens and nursery sites. With some irrigation and culture, plants attain large stature, provide distinct gray-green foliage, and form an attractive display of red fruits.

Uses and Management—This shrub has been used in some recreation plantings, but has potential to restore disturbances in the southwest shrub complex.

Varieties and Ecotypes—None.

Family Berberidaceae

Mahonia repens
Oregon grape, creeping barberry, mountain holly, creeping mahonia

Description—Oregon grape is a perennial creeping shrub with evergreen hollylike leaves (fig. 7). It seldom grows taller than 1 ft (30 cm). The shrub spreads by stolons, rhizomes, and stem layering; individual plants sometimes attain a diameter of 4 to 6 ft (1.8 to 3.3 m). Leaves are evergreen, leathery, and pinnately compound with five to seven (rarely three or nine) leaflets that are less than twice as long as broad. Leaflets are spinulose, glossy to dull on the upper surface, and dull to glaucous on the lower surface. Perfect, regular flowers develop in fascicled bracteate racemes in the leaf axils. The perianth consists of five alternate whorls of three members each; all are yellow. Those in the outer whorl are tiny bracts; the next two whorls are the sepals, and the

Figure 6—Fremont barberry produces attractive red fruit and small, leathery evergreen leaves. It grows in a variety of southwestern shrub communities.

Figure 7—Oregon grape, a perennial creeping shrub, occurs on well-developed soils as an understory in conifer forests.

inner whorls are the petals. Petals are bilobed with two glands at the base. There are six stamens and a one-celled ovary. Fruit is a one- to several-seeded, deep blue, glaucous berry about 0.3 inch (8 mm) in diameter (Harrington 1964; Welsh and others 1987).

Oregon grape growth is intermittent in winter and more active in spring (Wasser 1982). Flowering occurs from March to July. Fruits ripen from September to October and may remain on the plant into winter. Seeds are dispersed by birds and mammals (Rudolf 1974).

Ecological Relationships and Distribution— Oregon grape ranges from British Columbia to Alberta and North Dakota and southward on the east side of the Cascade and Sierra Mountains through the Great Basin, Arizona, and New Mexico. It grows with junipers, pinyon, aspen, mountain brush, lodgepole pine, spruce-fir, and ponderosa pine at elevations ranging from near sea level to 10,000 ft (3,000 m) (Harrington 1964; Hitchcock and others 1964; Wasser 1982; Welsh and others 1987). It is abundant in coniferous forests receiving more than 15 inches (38 cm) of annual precipitation, and is fairly common on north-facing slopes and other moist sites in plains, foothill shrublands, and low-elevation woodlands. Oregon grape tolerates full sun and partial to deep shade of shrubland and coniferous forests. It requires well-drained, more-or-less neutral (pH 5.5 to 7.0) soils, and is only weakly tolerant of salinity (Stark 1966). Oregon grape is intolerant of poor drainage and high water tables. Although it grows in deep, medium-textured soils, it is also common on shallow, rocky sites (Bailey 1949; Harrington 1964; Plummer and others 1968; Wasser 1982).

Plant Culture—Good fruit crops occur erratically. Fruits are most often collected by hand. Berries of more upright populations can be beaten into containers (Rudolf 1974). Pulp is removed by macerating the fruit in a Dybvig cleaner. The seeds and pulp are dried, lightly chopped, and separated by screening. Seed may be stored dry in air-sealed containers at 34 to 37 °F (1 to 3 °C) for 4 to 8 years without significant loss of viability (Heit 1967c). Seeds kept under uncontrolled warehouse conditions have remained viable for 13 years (Stevens and Jorgensen 1994). There are 71,000 seeds per lb (156,600 per kg) at 100 percent purity. Minimum purchasing standards are 95 percent purity and 85 percent germination.

Seed dormancy is complex and variable. A wet prechilling period of 1 month at 34 °F (1 °C), followed by 2 months at 70 °F (21 °C), and 6.5 months at 34 °F (1 °C) relieves dormancy of some seedlots (Rudolph 1974; Wasser 1982). In some cases a 5-day water soak may successfully substitute for wet prechilling (USDA Forest Service 1972). Incubation of excised embryos at 68 °F (20 °C) for 10 to 14 days is recommended as a relatively rapid means of testing germination.

Seed and dried berries may be fall sown in the field or nursery, or wet prechilled seed may be planted in spring. Fall seeding is preferred. Seedlings are vigorous. Bareroot seedlings may be transplanted after one or two seasons of growth in nursery beds. Container plants can also be established from seed (Landis and Simonich 1984).

Seed germination is erratic and may lead to unpredictable stands, although establishment from planting stock is usually quite good. Creating depressions for water catchments around planted seedlings, and watering immediately following planting may be helpful, particularly on rocky sites.

Plants may be propagated vegetatively from cuttings taken from spring through fall and rooted on mist benches (Hartmann and others 1990). Best results are obtained if basal cuts are made between the nodes about 1.2 inches (3 cm) above the base of the current year's growth (Doran 1957). Rooting may be hastened by treatment with 5,000 ppm IBA. Layers are occasionally used for vegetative propagation.

Transplants are generally used instead of direct seeding for landscape and erosion control purposes to reduce the time until plants reach mature size. Nursery-grown stock and wildings are easily transplanted. Large stock is more difficult to transplant due to the development of thick stolons. Commercial planting stock is widely available, but the seed or transplants should originate from an area with characteristics compatible with those of the planting site.

Uses and Management—Oregon grape has been used in landscape planting as an evergreen ground cover. It is quite useful because of its colorful flowers, berries, and leaves. Under cultivation Oregon grape will grow 2 ft (61 cm) tall. The prickly, hollylike leaves are brilliantly red to bronze colored in winter and are used in Christmas decorations. Its spreading habit and ability to grow on fairly dry, exposed, rocky slopes, make it a good candidate for mined lands, game ranges, highways, and recreation areas. Ecotypes growing as an understory with ponderosa pine and other conifers are, however, not well suited to dry, exposed sites.

The forage value of Oregon grape has been rated as nearly worthless for livestock and wildlife in summer (USDA Forest Service 1937). Smith (1953) ranked it last of 33 shrubs tested as summer forage for mule deer in northern Utah. However, both livestock and wildlife use the plants when other vegetation is scarce, particularly during winter (Monsen and Christensen 1975). Kufeld (1973) found Oregon grape valuable for Rocky Mountain elk in fall and winter but of low value in spring and summer when other vegetation was available. Mule deer use it to a moderate extent in winter, spring, and fall (Kufeld and others 1973). Patton and Ertle (1982) reported that in the Southwest it receives greatest use by elk in winter; mule deer use it in the spring and fall. Plants are quite tolerant of browsing. Once frosted in fall, Oregon grape berries become more palatable and are used by birds and small mammals (Thornburg 1982). The species is also considered desirable for honey production. Plants contain several alkaloids, including berberine, which has medicinal uses (Suess and Stermitz 1981). The inner bark and wood of barberris species are yellow and were used by Native Americans to prepare a yellow dye.

Seedlings grown on adapted sites may be vigorous, but require several years to reach mature size. Control of rodents and rabbit populations has been necessary to establish young plants in shelterbelts in the Midwest, as Oregon grape is preferred by cottontail rabbits (Swihart and Yahner 1983). Mature plants resprout following burning, and are resistant to browsing.

Improved Varieties—None. A number of released varieties have been developed for the ornamental trade.

Family Betulaceae

Alnus incana
Thinleaf alder

Description—Thinleaf alder is a deciduous, multistemmed shrub or small tree (fig. 8). Plants are usually 3 to 13 ft (0.9 to 4 m) tall (Welsh and others 1987), but may attain heights of 40 ft (12.2 m) (Arno and Hammerly 1977; Patterson and others 1985). The bark is gray to brownish (Patterson and others 1985; Preston 1948); twigs are puberulent and commonly glandular (Welsh and others 1987). Leaves are broadly elliptic or ovate-oblong, 0.4 to 1.2 inches (1 to 3 cm) long with a dull green color and doubly dentate margins (Hitchcock and Cronquist 1973; Patterson and others 1985). Male and female flowers are borne in separate catkins on the same plant. The staminate catkins are clustered at the ends of twigs, each 1 to 4 inches (2.5 to 10 cm) in length (Hitchcock and Cronquist 1973). The pistillate catkins arise from branches of the previous season (Welsh and others 1987) and occur in groups of three to nine on the ends of branches. These eventually develop into small cones that are 3.6 to 5.2 inches (9 to 13 cm) in length (Hitchcock and Cronquist 1973; Patterson and others 1985). The fruit is a small single-seeded nutlet with narrow wings (Haeussler and Coates 1986; Mozingo 1987; Schopmeyer 1974a).

Ecological Relationships and Distribution—Welsh and others (1987) recognized thinleaf alder as a portion of a huge circumboreal complex, with *Alnus incana* spp. *rugosa* var. *occidentalis* being the Old World portion and *Alnus incana* spp. *rugosa* var. *rugosa* representing the American plants. Thinleaf alder, also referred to as mountain or river alder, is one of approximately 30 species of this genus that occurs in North America, Europe, and Asia (Schopmeyer 1974a). It is widespread from Alaska and the Yukon south to New Mexico and California, usually growing at elevations between 5,000 and 10,000 ft (1,500 and 3,000 m) in the southern portions of its range (Harrington 1964).

Like most other alders, thinleaf alder occurs in mountainous regions, often growing along streams and in wetlands. It is adapted to drier sites and grows as an understory with various conifers. It spreads naturally onto disturbances and clearings caused by wildfires, road construction, and related activities. At lower elevations and on drier sites, thinleaf alder is more restricted to wet areas along streams, seeps, and moist mountain slopes (Arno and Hammerly 1977; Hansen and others 1988a; Komarkova 1986). It does

Figure 8—Small multistemmed trees of thinleaf alder border a small stream in eastern Idaho.

extend into big sagebrush communities at lower elevations growing along streams, seeps, and springs. It is most prevalent in the Douglas-fir, ponderosa pine, spruce-fir, and lodgepole pine communities within the Intermountain region. It occupies sites that may be seasonally flooded or where water tables remain near the soil surface. Although often restricted to areas with high water tables, it is also found on well-drained sites. It is often abundant as an understory with conifers, as it is shade tolerant (Haeussler and Coates 1986; Hansen and others 1988b; Kauffman and others 1985; Kovalchik 1987; Padgett and Youngblood 1986; Youngblood and others 1985).

Thinleaf alder grows on well-developed, highly organic soils (Kovalchik 1987), but occurs on well-drained, poorly developed, cobbly gravels and sandy textured soils (Hansen and others 1988a; Kovalchik 1987). This shrub is able to invade flooded or burned sites (Crane 1982; Zasada 1986). It responds as an early seral species (Kauffman and others 1985; Zasada 1986), and is very often abundant following disturbances. It is commonly encountered dominating disturbed sites including roadways and riparian habitats.

Plant Culture—Both staminate and pistillate catkins develop during the growing season and persist through most winter months. The catkins begin growth early in spring before leaves develop. Flowering occurs in early March and April, depending on elevation and site location. Fruits ripen in early fall (Schmidt and Lotan 1980). Fruits are small winged nutlets borne in pairs on bracts of small cones or strobiles—when dispersed they are spread by wind or water (Haeussler and Coates 1986; Mozingo 1987; Schopmeyer 1974a). Thinleaf alder normally produces abundant seed crops most years. Some individual plants bear heavy crops every year. There are about 675,000 cleaned seeds per lb (1,488,000 per kg) (Schopmeyer 1974a). Seed viability is quite variable. Schopmeyer (1974a) reported some collections contain less than 5 percent viable seed. However, good quality seed can be obtained by collecting from healthy bushes early in the season before seeds shatter. Bushes with disfigured cones or infested with disease should be avoided. Also, seeds from plants that are weakened by climatic stress should not be harvested. Seed samples should be cleaned and tested for germination before seeding rates are determined. Seeds should not be stored in open warehouses for more than 2 years because viability decreases rapidly after this time. If possible, air-dried seeds should be stored in sealed containers at 34 to 38 °F (1 to 3 °C) (Schopmeyer 1974a). Seeds are nondormant when collected and do not require wet prechilling to germinate (Haeussler and Coates 1986).

Thinleaf alder seeds are small, lightweight, and easily dispersed. Broadcast seeding, particularly using aircraft, may create irregular stands, as seeds can be carried considerable distances with strong winds. Seedlings developing from seeds broadcast on rough seedbeds establish well if the surface does not dry rapidly. Seedlings do not establish well on compacted surfaces and impervious soils. Thinleaf alder has been broadcast seeded in a slurry using a hydromulch, but with limited success. Better stands have been achieved by dry seeding.

Thinleaf alder seeds can be planted with most drill seeders. If seeded alone in nursery beds, the seedlot may require dilution with inert material to aid in regulating the seeding rate. However, many precision nursery seeders can plant pure alder seeds. Seeds should be placed about 0.25 inch (0.6 cm) deep on firm, but noncompacted, seedbeds. Planting on seedbeds having considerable surface litter has been quite successful.

Within its range of climatic adaptation, thinleaf alder will invade fresh disturbances. It responds as a pioneer plant capable of establishing in open areas (Zasada 1986). It is able to compete well with herbaceous species when seeded on both disturbed and undisturbed sites. Seedlings develop quickly and can establish amid considerable herbaceous competition. New shrub seedlings often invade roadway and mine disturbances where seeded herbs have previously established. On infertile soils, thinleaf alder may grow more vigorously than the herbs.

Thinleaf alder is not universally adapted to all soil disturbances and it is particularly sensitive to competition from some species. Although the shrub invades areas seeded to grasses, its growth can be suppressed by some herbaceous species, particularly smooth brome. Planted seedlings that do not become inoculated with soil organisms remain small and can be suppressed. Although these factors are not well understood, irregularities in plant performance on disturbed sites can be expected.

Thinleaf alder can be easily propagated and planted as bareroot nursery stock or container material (Platts and others 1987). Transplants usually establish quickly and grow considerably during the year of planting. One-year-old transplants develop fibrous root systems that greatly enhance survival. Thinleaf alder is reported to fix nitrogen (Haeussler and Coates 1986). Plants inoculated with nitrogen-fixing organisms begin growth soon after planting. Other plants that apparently lack these organisms grow slowly, but respond dramatically if inoculated. Adding soil containing natural microflora to containerized stock appears beneficial. When plants are established on harsh sites, fertilizer applications have benefitted initial growth.

Seedings of thinleaf alder on sites supporting a herbaceous cover are often successful in conifer forest communities. This shrub has frequently invaded roadways, logging disturbances, and mine sites that were first seeded to introduced and native herbs (Plummer 1977).

The shrub invades seeded areas where established herbs are weakened due to decreases in soil fertility. Its seedlings apparently are very competitive and vigorous. Once established, few other plants grow as rapidly.

Uses and Management—Thinleaf alder is particularly useful in providing cover and forage for wildlife. Abandoned logging roads and other disturbances that are seeded to grasses often are invaded by thinleaf alder, snowbrush ceanothus, chokecherry, and other important browse plants. Game animals seek these areas to graze the variety of plants. Animals also utilize thinleaf alder in burned and cutover lands; plants quickly recover and produce an abundance of herbage. Use by big game animals varies among sites. Light to moderate use has been reported by deer, elk, and moose (Heale and Ormrod 1982; Kauffman and others 1985; Knowlton 1960, Kufeld 1973). However, Kufeld and others (1973) reported that alder is an important browse for mule deer. Beaver and other small animals and birds also utilize this species (Arno and Hammerly 1977; Rue 1964). Thinleaf alder provides excellent cover for wildlife. It occupies riparian zones, wetlands, and brush fields where animals concentrate. The establishment and growth traits of this species cause it to be one of the most useful shrubs for revegetation of riparian sites in the Intermountain region.

Varying degrees of use by cattle and sheep are reported for thinleaf alder (Dittberner and Olsen 1983; Roath and Krueger 1982). Animals selectively graze certain stands more heavily than others. Use is somewhat regulated by access, acceptance of associated plants, and season of grazing. Livestock graze thinleaf alder very heavily in many riparian areas. The plant is frequently maintained in a stunted condition, but is able to recover when grazing is well managed. New plantings can be destroyed by heavy grazing.

Thinleaf alder is particularly useful as a ground cover and erosion control plant. It is one of a few shrubs that, as a seedling, is able to compete with seeded herbs, and can be seeded in mixtures. It grows rapidly and provides cover and herbage within a few years. It is well adapted to a wide array of soil conditions, particularly infertile sites. Its ability to fix nitrogen apparently contributes to its adaptability to harsh situations. The presence of thinleaf alder benefits the growth of understory herbs, and thus improves ground cover and stability on erodible sites. When transplanted onto open disturbances it grows rapidly and is able to stabilize sites where seeding is difficult.

Thinleaf alder has been used successfully to revegetate road and logging disturbances in the Idaho Batholith and on a number of mine sites. It has spread onto abandoned mine disturbances, including rocky dredge piles and exposed substrata.

Collections of thinleaf alder do not appear to be as site specific as many other shrubs. Plantings have been successful over a range of elevations and site conditions. The species should not be planted on sites where it does not normally occur, but it can be used on mine or road disturbances within its natural range of occurrence.

Thinleaf alder plants are not usually lost to insect damage, climatic stress, or herbivore grazing. The species is long lived and compatible with overstory trees. It is able to exist in open or shaded areas and can be used as a low maintenance species in recreational plantings. Thinleaf alder is an attractive shrub and can be used as a screen or specimen plant for horticulture plantings. It remains vigorous and green the entire summer and may be used to reduce fire spread around recreational sites.

This species has been overlooked in many wildland restoration programs. Although recognized as a rapid-developing species capable of producing considerable biomass, it has not been emphasized for watershed or wildlife plantings.

Varieties and Ecotypes—None.

Family Betulaceae

Betula glandulosa
Bog birch

Description—Bog birch is a deciduous, highly variable, spreading to erect monoecious shrub ranging from 0.3 to 19.7 ft (0.1 to 6 m) tall. Plants have one to many main stems and deep, spreading root systems. Alternative common names are glandular, resin, swamp, marsh, and dwarf birch. Young branches are densely puberulent and resinous with yellowish wartlike, crystalline glands. Bark is reddish-brown to gray or purplish and does not readily peel. Lenticels are rarely conspicuous. Leaves are alternate, oval to orbicular, elliptic, or sometimes obovate or ovate. They are 0.4 to 0.8 inch (1 to 2 cm) in length, but range from 0.2 to 1.6 inches (0.5 to 4 cm) long, with finely serrate or crenate-serrate edges (fig. 9). Blades are bright green, thick and leathery, glandular on both surfaces, glabrous above, and paler and puberulent beneath. Staminate catkins are elongate and pendulous in clusters of one to four. They develop in summer and flower with or before leaf development the following spring. Staminate flowers are three per cluster, each with three perianth segments and two stamens subtended by three bracts. Pistillate catkins appear with the leaves. They are conelike, erect, and solitary with two or three flowers per bract. Fruits are narrow-winged, single-seeded samaras. Flowering occurs from April to September. Samaras ripen from July to October (Brinkman 1974c; Hitchcock and others 1964;

Figure 9—Stems of bog birch have reddish to purplish bark and thick, serrate leaves.

Viereck and Little 1972; Welsh and others 1987); they are dispersed by wind, gravity, and sometimes water. They may also be blown for some distance across crusted snow. Throughout much of the species range, reproduction is primarily by seed. In the northernmost limits of its range, seedlings are rare and plants spread primarily by layering (Hermanutz and others 1989; Weis and Hermanutz 1988).

Ecological Relationships and Distribution— Bog birch is widely distributed from the interior of Alaska across northern Canada to Labrador and Greenland. In the West, it is found in mountainous areas from coastal British Columbia to California and Colorado at elevations from 4,000 to 11,000 ft (1,200 to 3,400 m) (Dittberner and Olsen 1983; Harrington 1964; Welsh and others 1987). Bog birch occurs in wet meadows, fens, swamps, bogs (sphagnum and nonsphagnum), muskegs, moist-to-wet tundra, wet meadows, and along low gradient streams and lakes. It is also found on sites where the water table remains high from runoff in nearby uplands. Bog birch maintains itself in these moist habitats and appears to be a climax species under such conditions (Marr 1961; Pojar and others 1984). In alpine areas it may also be found in dry rocky habitats (Brayshaw 1976; Komarkova 1986). Bog birch is highly frost tolerant and is widely distributed in permafrost areas (Krajina and others 1982). Its shade tolerance is moderate to high.

Bog birch most often occurs on wetland sites in lodgepole pine, Engelmann spruce, or subalpine fir forest types (Hansen and others 1988b; Kovalchik 1987; Olson and Gerhart 1982; Pierce and Johnson 1986). It is frequently associated with alder, willows, Woods rose, Douglas spiraea, blueberry, mountain huckleberry, and redosier dogwood. Herbaceous species associated with bog birch include rushes, horsetails, soft-leaved sedge, beaked sedge, bluejoint reedgrass, and tufted hairgrass (Hitchcock and others 1964; Kovalchik 1987; Patterson and others 1985; Welsh and others 1987; Youngblood and others 1985).

Bog birch commonly grows in fens, swamps, or bogs having large accumulations of organic matter derived from sphagnum or nonsphagnum plant materials. On flood plains it often grows in soils with textures ranging from silty to fine sandy loams to organic loam textures (Kovalchik 1987). Mineral requirements of bog birch may vary with population. Krajina and others (1982) and Moss and Wellner (1953) reported the species occurs in acidic or humic soils that are low in nutrients, particularly calcium and magnesium. They noted the absence of bog birch from swamps and fens with high nutrient contents derived from adjacent uplands. However, Pojar and others (1984) noted the reverse to be true.

Plant Culture—Most samaras are wind dispersed in fall. Smaller quantities are released through the winter and early spring as the catkins disintegrate on the shrub. Many of these may be consumed by birds. Samaras are sometimes collected from the surface of crusted snow. Fruits are harvested, processed, and stored as described for water birch. There are between 3 and 5 million cleaned seeds per lb (6,600,000 and 11,000,000 per kg) (Brinkman 1974c). Culture is as described for water birch (Brinkman 1974c; Lotan 1981). Kelly (1970) reported that bog birch's value in rehabilitation is limited; it does not transplant easily. In the northern portion of the species range, few viable seeds are produced, and bog birch spreads primarily by stem layering (Hermanutz and others 1989; Weis and Hermanutz 1988).

Uses and Management—Bog birch is consumed by many wildlife species. Moose, elk, and mule deer make moderate to heavy use of the shrub in summer and winter (Dorn 1970; Kufeld 1973; Kufeld and others 1973; Zach and others 1982). Pine siskin, chickadees, kinglets, and many other birds use the catkins, buds, and seeds (Brayshaw 1976; Komarkova 1986; Pojar and others 1984; Stephens 1973). Livestock make only light to moderate use of bog birch except in late summer when the boggy soils dry out (Dayton 1931; Hansen and others 1988b; Kovalchik 1987). Energy and protein value of the species are low.

Wetland areas supporting bog birch burn only infrequently due to the normally high water content of the vegetation and soil (Crane 1982; Kovalchik 1987). Such sites frequently act as firebreaks, but sometimes burn during dry summers or in late fall. Shoot systems may be destroyed but the plants resprout rapidly, particularly if the organic layer of soil around the base is not removed. Germination of wind-dispersed seeds from surviving plants, or seeds arriving from offsite, might be facilitated or enhanced by the presence of exposed mineral soils.

Varieties and Ecotypes—None.

Family Betulaceae

Betula occidentalis
Water birch

Description—Water birch, also known as spring or red birch, ranges from shrublike to treelike in growth habit (fig. 10). Plants grow rapidly and are short lived. They may attain heights of 36 ft (11 m), with clump diameters of up to 20 ft (6 m), and major trunk diameters of 1 ft (0.3 m). New stems develop from the root crown, eventually forming dense, multistemmed clumps with ascending branches and open crowns (Hansen and others 1988a; Youngblood and others 1985). The thin, smooth bark is dark brown to black on young trunks; it becomes lustrous coppery to brownish red on older trunks. Lenticels are light colored and vertical. The alternate, deciduous leaves are petiolate with bright green stipules. They are glabrous to pubescent, glandular, ovate to suborbicular or slightly obovate, and 1 to 2 inches (2.5 to 5 cm) long. The blade apex is rounded to acute, the base usually rounded, veins prominent, and the margins sharply once or twice serrate.

Male and female flowers develop in separate inflorescences on a single plant. Staminate catkins are formed during the summer or fall and rapidly elongate into tassel-like catkins 1 to 4 inches (2.5 to 10 cm) long the next spring. Staminate flowers grow in clusters of three; each consists of three perianth segments and two stamens, all subtended by three bracts. Blooming occurs as the leaves expand. Female flowers develop in conelike catkins 1 to 1.5 inches (2.5 to 4 cm) long. Water birch flowers in April and May. Fruits turn brownish tan as they ripen in fall. Samaras are shed from the catkins in fall and winter and are dispersed by wind, gravity, and sometimes water. They may be blown for considerable distances across crusted snow. Weather conditions and foraging by seed-eating birds contribute to overwinter disintegration of the catkins (Brinkman 1974c; Lanner 1983).

Figure 10—Water birch forms attractive foliage and flowers as it grows along valley bottoms and riparian sites.

Ecological Relationships and Distribution—There are more than 40 species of *Betula* in the North Temperate and Arctic Zones. Some taxa hybridize, producing intermediate populations in zones of distribution overlap (Dugle 1966; Hitchcock and Cronquist 1973). Water birch is distributed from Alaska to California and east to Saskatchewan and New Mexico. It forms dense thickets in riparian woodland communities and in moist areas of drier habitats (Arno and Hammerly 1977; Hansen and others 1988a; Padgett and Youngblood 1986; Welsh 1974). It is common along streams, on steep slopes, or on alluvial terraces from Engelmann spruce, ponderosa pine, and Douglas-fir zones to sagebrush communities (Hansen and others 1988a,b; Padgett and Youngblood 1986; Youngblood and others 1985). Communities tend to remain rather stable in spite of annual flooding (Padgett and others 1989; Youngblood and others 1985). However, the plants are susceptible to windthrow because they grow on sites with high water tables and are usually shallow rooted (Lanner 1983). In eastern Washington, Oregon, western Idaho, and southern British Columbia, water birch hybridizes with paper birch, producing many localized intermediate forms (Dugle 1966; Hitchcock and others 1973). It is closely related to bog birch (*Betula glandulosa*), and in western Canada hybridizes with this species (Dugle 1966).

Water birch is listed as a dominant species in a number of communities or habitat types of the Intermountain region (Hansen and others 1988a,b; Olson and Gerhart 1982; Padgett and others 1989; Youngblood and others 1985). It occurs with many woody riparian tree and shrub species including cottonwoods, maples, aspen, thinleaf alder, willows, alder, and redosier dogwood (Lanner 1983; Olson and Gerhart 1982; Padgett and others 1989). It is also associated with many shrubs that are facultative riparian species such as Woods rose, Nutka rose, chokecherry, Saskatoon serviceberry, currant, and skunkbush sumac (Hansen and others 1988a,b; Kelly 1970; Olson and Gerhart 1982; Padgett and others 1989; Youngblood and others 1985).

Water birch is adapted to soils ranging in texture from silty to sandy to coarse-textured types that contain at least 35 percent rock fragments. These often have thin profiles and overlie river cobbles or other rocky substrates (Hansen and others 1988b; Padgett and others 1989). Nutritional requirements for magnesium and calcium are relatively high (Krajina and others 1982).

Plant Culture—Seeds should be collected from selected young, accessible, highly productive trees by hand stripping the catkins into bags before they begin to disintegrate. Fruits are sometimes shed on snow and may be hand collected.

Catkins should be thoroughly dried prior to extraction. The tiny samaras are separated from the catkins by screening them through a round-holed screen and fanning to remove the remaining bracts (Brinkman 1974c). Samaras should be dried prior to storage at 36 to 38 °F (2.2 to 3.3 °C).

Seed fill and quality vary greatly among years. Fill should be estimated prior to harvest by observing seeds under transmitted light (Patterson and Bruce 1931). Wet prechilling for 4 to 8 weeks releases embryo dormancy. Dormancy may also be overcome by germinating seeds in light (Brinkman 1974c; Yelenosky 1961).

Plantings are generally established from bareroot or container stock rather than from seed. Emergence of seedlings from direct seedings on wildlands is erratic. Only 15 to 20 percent of the planted seeds of these species usually produce usable seedlings. Seeds planted in nursery beds or containers must be covered as lightly as possible (Hartmann and others 1990). Covering may not be necessary if the soil surface is kept moist. Newly emerged seedlings are susceptible to damping off at low temperatures (Marchant and Sherlock 1984). They benefit from shade for the first 2 or 3 months (Brinkman 1974c). Seedlings develop rapidly, producing dense root systems, and may be transplanted after one or two growing seasons (Brinkman 1974c). Cuttings are difficult to root, but leafy cuttings will root in summer if planted under glass and treated with IBA (Doran 1957; Hartmann and others 1990). Low-growing forms are easily propagated by layering.

Seed or cuttings used to produce planting stock should be harvested from areas near the planting site. Seedlings should be planted early in spring while native birch near the planting site is still dormant. Seedlings planted on adapted sites with good soil water establish well and grow rapidly if protected from browsing and competition.

Uses and Management—Water birch provides food and cover for many wildlife species (Kufeld 1973; Gullion 1964; Rue 1964; Stark 1966). It is useful for streambank stabilization in adapted areas. It grows rapidly, producing a dense, fibrous, but shallow root system. It is useful in shelterbelts if adequate water is available (Cook 1981), and has some potential as an ornamental. The hard wood is used locally for firewood and fenceposts (Lanner 1983).

Dense thickets or corridors of water birch provide thermal, hiding, and travel cover for a wide array of wildlife species (Hansen and others 1988a). Palatability of water birch to big game is usually low. It may be used when other browse is limited (Hansen and others 1988b; Kufeld 1973; Kufeld and others 1973). Its presence in many riparian woodland communities contributes to their structural diversity and provides habitats for many bird species (Lanner 1983; Youngblood and others 1985). Seeds, catkins, buds, and sap of water birch are used by many birds including grouse, redpolls, pine siskin, chickadees, kinglets, red-napped sapsucker, and broad tailed hummingbirds (Brinkman 1974c; Gullion 1964; Platts and others 1987).

Water birch is not highly palatable to livestock, although it is used to some extent by sheep and goats (Youngblood and others 1985). Dittberner and Olsen (1983) rated energy and protein values as fair. Productivity is often reduced by flooding and sedimentation, and the nearly impenetrable monotypic stands reduce livestock access (Hansen and others 1988a).

Water birch is usually associated with riparian communities that act as firebreaks and burn only during late summers or dry years. Shoots will burn in intense fires. Burned plants generally resprout from the root crown, which is often protected to some extent if the soil is wet. New plants may also develop from seed delivered by wind or water from areas outside the burn. Germination is favored by exposure of mineral soils and reduced competition following fires (Crane 1982; Hansen and others 1988a,b).

In Utah, water birch is recommended for landscape plantings in residential areas developed on historic mule deer winter range. Many traditionally used landscape plants in these areas have been heavily browsed and damaged by mule deer. Water birch is normally browsed only moderately by mule deer and recovers quickly (Austin and Hash 1988).

The root systems of water birch stabilize banks; overhanging branches shade the water and supply organic matter, which improve fish habitat (Youngblood and others 1985). Soils on steep streambanks may be susceptible to erosion, especially along trails used by livestock and wildlife. Heavy recreational use associated with fishing may also increase sloughing rates (Hansen and others 1988a). Stands should, therefore, be maintained for their streambank stabilization value (Hansen and others 1989; Youngblood and others 1985).

Varieties and Ecotypes—None.

Family Betulaceae

Betula papyrifera
Paper birch

Description—Paper birch is a treelike species growing from 60 to 130 ft (18.3 to 39.6 m) tall and 2 to 3 ft (60 to 90 cm) in diameter from a deep root system (fig. 11). Alternative names are canoe, white, and silvery birch. Trees are distinguished by their grayish white to coppery bark with long brown horizontal lines. The outer bark often peels in long strips; the inner bark is orange. The leaves are ovate to acuminate and doubly serrate, usually with tufts of hairs in the vein axils on the lower surface. Leaves are 2 to 5 inches (5 to 13 cm) long and 1 to 2 inches (2.5 to 6 cm) wide. Male flowers develop in early spring on long, yellowish, pendulous catkins. Female cones are 1 to 2 inches (2.5 to 6 cm) long, hanging from slender stalks. Fruits are translucent samaras with the wings slightly broader than the nutlet. Paper birch and water birch hybridize widely in areas where their ranges overlap (Hitchcock and others 1961; Marchant and Sherlock 1984; Welsh and others 1987).

Figure 11—White-barked, multiple-stemmed paper birch is often found growing in a forest openings.

Ecological Relationships and Distribution—Paper birch is distributed from Alaska east to Newfoundland and south across the northern tier of States including Washington, northern Idaho, and Montana. It occurs in riparian habitats, dry bogs, swamps, and poorly drained acidic soils with pH as low as four (Marchant and Sherlock 1984). It also grows on open slopes, rock slides, forest openings, and disturbances. It occupies soils with silty loam, sandy, and gravely textures. It is an aggressive pioneer species on logged or otherwise disturbed areas, and rapidly invades areas where mineral soils are exposed.

Plant Culture—Culture and management are largely as described for water birch (Brinkman 1974c). Cones are more accessible, abundant, and easily harvested from young trees. Minimum seed-bearing age is about 15 years (Brinkman 1974c). Catkins may open during dry, cold periods from late fall well into winter; when large numbers of samaras are deposited on the surface of crusted snow.

Seeds are cleaned using, a number seven sieve to separate fruits from chaff (Marchant and Sherlock 1984). There are 610,000 to 4,120,000 cleaned seeds per lb (1,344,800 to 9,083,000 per kg); the average is 1,380,000 seeds per lb (3,042,000 per kg). Longevity of seeds dried to a water content of 1 to 5 percent and stored at room temperature is about 1.5 to 2 years. Viability tends to decrease rapidly at greater water contents, even if seeds are kept in cold storage (Brinkman 1974c).

Seeds require a wet prechilling treatment of at least 30 days or fall sowing to produce nursery stock. Surface-sown seeds exposed to light will germinate without cold wet prechilling. Seedlings are subject to damping off if crowded or if temperatures are cool. They are resistant to frost but not shading (Krajina and others 1982). Propagation from cuttings is not recommended (Marchant and Sherlock 1984).

Uses and Management—Seedlings have been used for revegetating riparian sites and forest disturbances, improving wildlife cover, landscaping recreational sites, and in ornamental plantings. Plants have established and survived well, but have not been extensively used in wildland plantings. Young plants grow quite rapidly and compete well with understory competition. Paper birch resprouts following fire and is capable of withstanding both periodic flooding and drought (Marchant and Sherlock 1984). It is browsed to some extent by wildlife, horses, and cattle. Fruits are eaten by many birds.

Varieties and Ecotypes—None.

Family Caprifoliaceae

Lonicera ciliosa, Orange honeysuckle
Lonicera involucrata, Bearberry honeysuckle
Lonicera utahensis, Utah honeysuckle

Introduction—There are about 180 honeysuckle species distributed across the Northern Hemisphere, Africa, Java, and the Philippines (Brinkman 1974f), although only about 20 species occur in North America (Hitchcock and others 1959). All are widely planted for their fragrant flowers and ornamental fruits. Some species provide food and cover for wildlife and are valuable for erosion control and shelterbelt plantings (Adkins 1980; Brinkman 1974f; Plummer 1977; Plummer and others 1968; USDA Forest Service 1985a).

Different species of honeysuckle possess important traits that are useful for range and wildland enhancement. Some of the more important characteristics include consistent and abundant fruit production, low stature, cover for birds and small mammals, excellent establishment traits from direct seeding and transplanting, rapid growth, and excellent windbreak attributes and conservation features.

Plant Culture—All three species described in this chapter produce small berries and seeds. Berries are usually dislodged by stripping or beating the stems when fruits are mature. Seeds are extracted from the berries by macerating the pulp and flushing with water. Once seeds are cleaned, they are easily seeded with conventional seeders. Seedlings develop quite successfully, but most plantings have been completed using bareroot or container transplants.

Family Caprifoliaceae

Lonicera ciliosa
Orange honeysuckle

Description—Orange honeysuckle is a native trailing or twining vine. Stems are branched and may become 20 ft (6.1 m) long (Hitchcock and others 1959). Although plants normally grow in wet sites in aspen and conifer forests, they are also encountered in open areas on rocky and shallow soils. This vine naturally occurs in southwestern Canada, from Oregon to California, and east to Idaho and Montana (Hitchcock and others 1959). Individual plants can spread over large areas on fertile or disturbed soils. They root at the junction of each node if the stem remains in contact with a wet soil surface (Monsen 1975). This species is easily transplanted from stem cuttings.

Uses and Management—The orange yellow to orange red flowers and foliage are very attractive and could be used in roadside, summer home, and recreational landscaping. In northern Idaho this species has survived serious air pollution created by smeltering operations, while a number of other native shrubs have succumbed (Monsen 1975).

Varieties and Ecotypes—None.

Family Caprifoliaceae

Lonicera involucrata
Bearberry honeysuckle

Description—Bearberry honeysuckle is a native shrub that is found throughout the Intermountain West from Alaska to Quebec and south to California, New Mexico, and Mexico (Viereck and Little 1972; Welsh and others 1987). It has yellow to purplish tinged flowers (fig. 12) and black fruit. There are about 326,000 seeds per lb (718,700 per kg) at 100 percent purity. This shrub grows to 2 to 6 ft (0.6 to 1.8 m) tall. It occurs on fertile soils along streambanks and in riparian sites in the aspen, Douglas-fir, and spruce-fir communities.

Uses and Management—Bearberry honeysuckle has been planted with some success in conservation and wildlife projects. It has not done well when planted on disturbed sites. This species is used by large and small game and livestock during spring and summer

Figure 12—Bearberry honeysuckle, widespread in Western North America, is used in conservation plantings because of its attractive flowers.

months. It has potential for restoring disturbances within its natural range, but its seeds are not easily harvested, thus seed availability is limited.

Varieties and Ecotypes—None.

Family Caprifoliaceae ____________

Lonicera utahensis
Utah honeysuckle

Description and Distribution—Utah honeysuckle is a native shrub that grows 3 to 6 ft (0.9 to 1.8 m) tall (Welsh and others 1987) (fig. 13). It has pale yellow to yellowish-white flowers and red fruit. It occurs from British Columbia and Alberta, south to California and Wyoming. It is fairly common in the Intermountain West within mountain brush, ponderosa pine, aspen, and spruce-fir communities.

Uses and Management—This shrub has good fire tolerance, and is used extensively by livestock and game during the summer and fall seasons. Utah honeysuckle does well under heavy grazing and survives heavy trampling. It has excellent ornamental characteristics including showy flowers and fruit. The plant establishes well from transplanting and can withstand considerable traffic and other abuses. It should be considered for use in restoration projects, recreational areas, summer homes, and administrative sites.

Varieties and Ecotypes—None.

Family Caprifoliaceae ____________

Sambucus cerulea
Blue elderberry

Description—Blue elderberry (fig. 14) is a large spreading shrub or small tree growing to 10 ft (3.0 m) tall. It has distinctive opposite branches and leaves, pithy young stems, and older grayish stems with irregularly furrowed and ridged bark. Flowers are white and borne in large flat-topped clusters (compound cymes). Fruits are black to blue (Hitchcock and others 1959; Welsh and others 1987). The root system is generally fibrous and spreading, but a thick taproot may be present (Haeussler and Coates 1986; Welsh and others 1987).

Ecological Relationships and Distribution—Blue elderberry is most common on moist, well-drained sunny sites, but it is also somewhat shade tolerant (Dayton 1931; Plummer and others 1968; Van Dersal 1938) and occurs at elevations between 4,250 and 8,200 ft (1,300 and 2,500 m) (USDA Forest Service 1937). It ranges from British Columbia and western Alaska south to California, Arizona, New Mexico, Texas, and northern Mexico (Dayton 1931; Harrington 1964; Hitchcock and others 1959; Little 1979; Powell 1988). It may be found on a wide range of soil types, growing from the sagebrush grass zone to well above the mountain brush and ponderosa pine communities. It also grows in openings in aspen and spruce-fir communities (Welsh and others 1987). Blue elderberry is found in canyon bottoms, along streams, and on sites that are wet during the spring. In riparian areas, blue elderberry can occur in dense stands; in other areas individual plants are generally widely spaced. Plants are often abundant in burned areas.

Figure 13—Distinctive flowers and leaves of Utah honeysuckle, an understory shrub that grows with mountain brush, ponderosa pine, aspen, and conifer forests.

Figure 14—Blue elderberry growing at the base of a rocky slope in eastern Idaho.

Plant Culture—Blue elderberry generally produces a good seed crop every year. Berrylike fruits are produced in large clusters. Each fruit contains three to five seeds (Hitchcock and others 1959). Fruit clusters are easily collected by cutting them from the stem. Seeds are extracted from the fruit by using a Dybvig macerator. The resulting pulp and seeds are dried, then lightly chopped and separated using an air screen fanning machine. Unfilled seeds can be removed by flotation. At 100 percent purity there are about 217,000 seeds per lb (478,500 per kg). Acceptable purity is 95 percent and germination 50 percent. Good viability is retained for up to 16 years (Haeussler and Coats 1986).

Germination of blue elderberry is inhibited by a hard seedcoat and embryo dormancy (Plummer and others 1968). Without artificial treatment, germination of planted seeds may occur sporadically over one to three growing seasons. Scarification in acid or a 2-month warm pretreatment followed by a wet prechilling of up to 5 months improve germination (Brinkman 1974j). Fall seeding is recommended to permit overwinter wet prechilling (Plummer and others 1968). Seeds in the soil seedbank often germinate readily following fire (Heit 1967a).

Elderberries can be established by direct seeding in favorable spots (Plummer and others 1968). Seed may be hand planted in pits on burns, chained areas, or disturbed riparian sites. Elderberry seed may also be planted alone or with other shrubs using Hanson or thimble seeders. Elderberries should be planted separately from grasses to protect the shrub seedlings from competition. Seeds should be covered 0.25 inch (6 mm) deep on a firm seedbed.

Blue elderberry is easily propagated, planted, and established using container or bareroot stock (Plummer and others 1968). Plants grow quickly in nursery beds, and often develop a thick taproot and spreading root system. Root pruning can eliminate or reduce this problem. Blue elderberry can also be established from cuttings (Plummer and others 1968).

Blue elderberry shrubs begin growth slowly in early spring, although rapid vegetative development occurs in June or July. The number of stems and buds, as well as total productivity, fluctuate greatly from year to year. Older branches die back during the winter. New growth develops from large vegetative buds on the rhizomes.

Uses and Management—Blue elderberry has been used successfully in soil stabilization (Plummer and others 1968), riparian plantings (Carson and Edgerton 1989; Goldner 1984), streambank stabilization planting (Lines and others 1979), and for revegetation of mined areas (Ferguson and Frischknecht 1985; Hungerford 1984; Monsen 1984). Fruits of blue elderberry are gathered and used for making wine, jellies, candy, pies, and sauces (Mozingo 1987; Powell 1988).

Blue elderberry is grazed by livestock and wildlife species throughout the year (Dittberner and Olsen 1983; Kufeld 1973; Kufeld and others 1973; Martin and others 1951; Robinette 1972). However, use varies by season (Kufeld 1973; Sampson and Jesperson 1963; Smith and Hubbard 1954; Steele and Geier-Hayes 1987). Spring and summer use are light. Many mature plants grow so tall that by late summer much of the foliage is out of reach of grazing animals. Palatability and use increase dramatically after the fruit ripens and the foliage is frosted (Dayton 1931). Plants are heavily used by cattle, deer, and elk in fall; they are especially palatable to sheep. Use decreases in the winter after leaf fall, but plants provide important herbage. The berries and dried fruit, which often remain on the shrubs through the winter, are consumed and dispersed by birds and many other animals. Buds are used by grouse, rodents, and big game animals in winter. The shrub provides cover for big game and nongame species, and perching and nesting sites for birds (Brown and others 1977; Dittberner and Olsen 1983; Gray and Greaves 1984). Blue elderberry is persistent and recovers well from moderate grazing and trampling (Monsen 1984; Plummer and others 1968; Van Dyne and Payne 1964). Continual, heavy grazing can be detrimental. Seeded areas should not be grazed for two or three growing seasons following seeding. Buds and branches may be defoliated by grasshoppers during mid or late summer during years when population densities are high. Plants generally recover the following year.

Blue elderberry exhibits good fire tolerance (Aro 1971) and is able to resprout from the root following fire (Little 1979; Preston 1948; Steen 1965; Van Dersal 1938). Germination of seed buried in the soil is enhanced by fire (Heit 1967a; Morgan and Neuenschwander 1988).

Varieties and Ecotypes—None. There are many ecotypes within the species. Drought-tolerant, shrubby populations associated with sagebrush types do well with only 12 inches (30 cm) of annual precipitation. Tall, almost treelike populations also occur. Some populations are consistently good seed producers, while others produce erratic seed crops.

Family Caprifoliaceae

Sambucus racemosa
Red elderberry

Description—Red elderberry is a native circumboreal shrub (Hitchcock and others 1959). Two natural varieties occur in the Western United States: *S. r.* var. *microbotrys* has red fruits and is widely distributed, ranging from Wyoming and northern California south to Mexico. *S. r.* var. *melanocarpa* produces black fruits, and occurs primarily in the Rocky Mountains from Canada south to the Pacific Northwest and Wyoming (Welch and others 1987).

Red elderberry has distinctive opposite branches and leaves. Leaves are pinnately compound, leaflets are five to seven serrate, pointed, 1.2 to 5.9 inches (3 to 15 cm) long, and 0.4 to 2.4 inches (1 to 6 cm) broad. Plants are fairly short, usually about 3 to 6 ft (0.9 to 1.8 m) in height. Stems have warty bark with brown pith; they have a rank odor if bruised and crushed (Kelly 1970; Viereck and Little 1972). The numerous white to cream-colored flowers are borne in terminal pyramidal clusters (cymes) less than 3 inches (8 cm) wide. The fruit is a red drupe that ripens in September. Each drupe contains two to four seeds (Hitchcock and others 1959; USDA Forest Servcie 1985; Welsh and others 1987).

Ecological Relationships and Distributions—Red elderberry occurs in subalpine, spruce-fir, lodgepole pine, and aspen communities (fig. 15). It is distributed across North America from Alaska to Newfoundland and south to New Mexico and Georgia (Great Basin Flora Association 1986; Viereck and Little 1972; Worley and Nixon 1974). It prefers full to intermediate sunlight, and is not found in full shade (Haeussler and Coats 1986). Greatest areas of abundance are in openings where winter snow accumulates and remains late in the spring, riparian areas, meadows, parks, and other wet areas. Red elderberry grows in association with tall and intermediate forbs and grass communities. It occurs singly and in patches of various sizes.

Figure 15—Red elderberry frequently occurs in forested openings and subalpine communities.

Plant Culture—Red elderberry flowers in midsummer. Fruits ripen in mid to late September. Good seed crops are produced most years. Fruit clusters are harvested by cutting them from the stems. Seeds are extracted with a Dybvig macerator. Seeds and pulp are dried, lightly chopped, and processed through an air screen fanning machine to separate seeds and debris. At 100 percent purity there are about 286,000 seeds per lb (630,500 per kg). Acceptable seed purity is 95 percent and germination is 50 percent. Success from direct seeding can be erratic (Plummer and others 1968). Germination requires wet prechilling; therefore, fall seeding is recommended. Seed should be covered lightly and planted in areas where competition will be light for a few years. Red elderberry can be propagated by cuttings, either hardwood cuttings started in winter or softwood cuttings taken during spring and summer (Doran 1957; Ritter and McKee 1964).

Most natural reproduction occurs vegetatively from buds on stems, rhizomes, and root crowns following fire or mechanical damage (Conrad and McDonough 1972; Van Dersal 1938). Some reproduction also occurs from seed. Seeds are dispersed by birds and rodents and can remain dormant in the soil for long periods. Seeds scarified by fire often germinate in large numbers during the first season following burning (Heit 1967a; Hungerford 1984; Kramer 1984).

Uses and Management—Red elderberry is used seasonally by sheep, cattle, deer, bear, porcupine, and elk (Conrad and McDonough 1972; Dayton 1931; Kufeld 1973; Kufeld and others 1973; Martin and others 1951; Ritter and McKee 1964; Smith 1953; Steele and Geier-Hayes 1987; Zager 1980). It is one of the most palatable browse species for elk in Idaho and Montana (Gaffney 1941; Young and Robinette 1939; Zager 1980). Palatability is excellent for sheep following frost.

All top growth is consumed or dies to ground level each fall. Fruits mature in late August and September. They are consumed by birds, rodents, livestock, and big game. Seed is cached and used by rodents. During winter porcupines and mice feed on the buds and bark (Conrad and McDonough 1972). Red elderberry provides valuable nesting and perching habitat and food in the form of berries and buds for a large number of birds (Denslow 1987; Gullion 1964; Martin and others 1951; Van Dersal 1938).

Red elderberry is used to stabilize disturbed and erosion-prone areas, especially on aspen and upper spruce-fir sites, riparian areas, seeps, and other moist sites (Platts and others 1987; Worley and Nixon 1974). Bareroot stock and container-grown stock have been used successfully for planting disturbed riparian areas in aspen and ponderosa pine forests (Platt and others 1987). Red elderberry is used as a colorful ornamental (Kelly 1970; Ritter and McKee 1964), and should be considered when planting recreational sites, summer homes, and ski areas.

Varieties and Ecotypes—None. There is, however, considerable variation within the species.

Family Caprifoliaceae ____________

Symphoricarpos albus
Common or white snowberry

Description—Common snowberry is an erect, multi-branched shrub usually 3.3 to 6.6 ft (1 to 2 m) tall, but ranging from 1.6 to 9.8 ft (0.5 to 3 m) in height (fig. 16). Plants are fibrous rooted with the densely branched root system concentrated near the soil surface. The species is slightly rhizomatous with sprouts from the thick, spreading rhizomes forming dense thickets. The slender upright stems are hollow, smooth, and brownish. Twigs are glabrous and obscurely puberulent. Leaves are opposite, thin, pale green, elliptic to elliptic ovate, and entire or with a few coarse, irregular teeth. They are 0.6 to 2 inches (1.5 to 5 cm) long and 0.4 to 1.4 inches (1 to 3.5 cm) wide with petioles 0.1 to 0.2 inch (2 to 4 mm) long. Leaves on sterile shoots may be somewhat larger. Racemes are terminal or sometimes in the upper leaf axils. They are dense, subsessile and few flowered. The perfect flowers are small, pinkish, and bell shaped. The five-parted corolla is 0.2 to 0.3 inch (5 to 7 mm) long and nearly as wide. The interior is densely hairy. Corolla lobes range in length from one-half to nearly equaling the tube length. Anthers alternate with the petals and nearly equal the filaments in length. There is a single style. The ovary is four locular. Generally two locules produce a single mature seed each. The white pulpy fruits are subglobose or ellipsoid and 0.3 and 0.6 inch (8 to 15 mm) in diameter. Seeds are elliptical, flattened, creamy white, smooth, and 0.16 to 0.2 inch (4 to 5 mm) in length with fleshy endosperm and a tiny, poorly developed embryo (Evans 1974; Hitchcock and others 1959; Hopkins and Rawlings 1985; Kovalchik and others 1988; Marchant and Sherlock 1984; Viereck and Little 1972; Welsh and others 1987).

Figure 16—Open, branching, scattered, pale-green leaves, and shedding bark are distinctive characteristics of common snowberry.

Ecological Relationships and Distribution—Common snowberry occur across the United States and Canada except in the far north of Alaska and Canada and the Southern States. It naturally occurs associated with conifer species, in shade and in openings with full sunlight.

Plant Culture—Common snowberry seeds are white and average 76,000 per lb (167,500/kg). One hundred lb (45 kg) of fresh fruit will yield 3 to 5 lb (1.4 to 2.3 kg) of cleaned seed. Good seed crops are produced in 4 out of 5 years. Flowering occurs from June through July. Fruits remain on the plant into winter or until eaten. Fruits are processed through a Dybvig macerator, dried, and run across an air screen separator. Unfilled seeds are removed by flotation. Germination is delayed by dormancy, which can be overcome with wet prechilling or scarification with sulfuric acid. Germination will occur over a number of years. Young plants grow slowly; however, they can mature and flower in 3 or 4 years.

Uses and Management—Common snowberry is an important forage plant in the West, especially for sheep and deer, which make considerable use of it year around. Elk strip the leaves in the fall. Plants can be lost as a result of excessive use.

This species has been used extensively as an ornamental. It can be directly seeded or transplanted in restoration projects. It does not do well on disturbed sites such as mines and road fills and cuts.

Varieties and Ecotypes—There are a number of ornamental varieties and selections, but none are available for use on rangelands and disturbed sites.

Family Caprifoliaceae ____________

Symphoricarpos longiflorus
Desert snowberry

Description—Desert snowberry is a native, long-lived, deciduous shrub. Plants are low growing, erect to arching, and range in height from 1.6 to 5 ft (0.5 to 1.5 m). The ability of the species to spread by rhizomes is poorly known. Plants exhibit wide variation in leaf and twig pubescence. Young stems are persistent, glabrous to pubescent, and tend to spread at right angles, giving the plant a thorny appearance. The firm leaves are simple and opposite, 0.2 to 0.6 inch (6 to 15 mm) long and 0.1 to 0.3 inch (2 to 7 mm) wide, oval to lanceolate or oblanceolate, and entire or with one or two teeth. The fragrant flowers are solitary, paired in the leaf axils, or in small, few-flowered, terminal racemes. The calyx and corolla are five lobed and regular. The slender corolla tubes are 0.4 to 0.7 inch (1.0 to 1.8 cm) long, salverform, glabrous, and pale to deep pink. Lobes are much shorter than the tube and rather abruptly spreading. Anthers are sessile, alternating with the corolla lobes. The single style is stiff and hairy above the center. The ovary is four loculed; the two functional locules each contain a single seed. The fruit is a white, waxy, two-seeded berry about 0.3 to 0.4 inch (8 to 10 mm) in diameter. Seeds are 0.2 inch (5 mm) long and acute at the base (Cronquist and others 1984; Davis 1952; Evans 1974; Welsh and others 1987).

Ecological Relationships and Distribution—Desert snowberry occurs on deep, well-drained soils in desert-shrub, pinyon-juniper, sagebrush, mountain bush and ponderosa pine communities from Oregon to Colorado, and south from southern California to Texas. It is the most drought tolerant of the snowberries. It grows intermixed with other species, but not in closed stands.

Plant Culture—Desert snowberry produces white, two-seeded berries. There are an average of 70,000 seeds per lb (154,000/kg). One hundred lb (45 kg) of fresh fruit will yield 5 to 7 lb (2.3 to 3.2 kg) of cleaned seed. Good seed crops are produced in about 2 out of 5 years, depending on spring and summer storms. Flowering occurs in June to mid July. Berries are harvested by hand stripping or beating. Fruits are extracted by maceration through a Dybvig cleaner. Unfilled seeds are removed by flotation. Germination can be erratic. Dormancy can be overcome with wet prechilling and scarification with sulfuric acid. Fall seeding will permit prechilling to occur. Young plants can mature and produce seed in 3 to 4 years and reach full stature in 5 to 6 years.

Uses and Management—Desert snowberry can be an important browse plant for sheep and deer, and to a lesser extent for cattle. It is fairly resistant to grazing. On many overgrazed sagebrush ranges in which the understory species have been eliminated, desert snowberry and sagebrush will remain. Excessive use will result in death of plants.

This species can be seeded or transplanted. It does not do well on severely disturbed sites. It does best on soils with well-developed, undisturbed horizons.

Varieties and Ecotypes—None.

Family Caprifoliaceae

Symphoricarpos occidentalis
Western snowberry, wolfberry

Description—Western snowberry is an erect shrub, branching weakly from a woody base and short main branches. Plants are 1 to 3.3 ft (0.3 to 1 m) tall, spreading freely from rhizomes, and often forming dense thickets that exclude other vegetation. Roots are densely branched, shallow, and intermixed with stout creeping rhizomes. Young twigs are puberulent to glabrous. Petioles are 0.1 to 0.4 inch (3 to 10 mm) long. The opposite leaves (fig. 17) are thick, elliptic to ovate, entire or with a few, coarse, blunt, irregular teeth. Most are 0.8 to 3.1 inches (2 to 8 cm) long and 0.4 to 2 inches (1 to 5 cm) wide with somewhat revolute margins. Leaves on sterile shoots are often larger, frequently more lobed, glabrous above, and usually hirsute puberulent beneath, at least along the main veins. Few to many-flowered spikelike racemes are produced at the ends of the twigs and in the upper leaf axils. The five-merous corollas are often wider than long, pink to rose colored, and densely hairy within. Lobes are arcuate spreading. Anthers alternate with the petals and are shorter than the filaments. The style may be hairy near the middle, but is occasionally glabrous. The ovary is four loculed; two locules usually produce one mature seed each. Fruits are subglobose and greenish white, turning black after frost. The two seeds are white, somewhat ellipsoid, and flat on one side with a poorly developed embryo (Cronquist and others 1984; Davis 1952; Hansen and others 1988b; Hitchcock and others 1959; Wasser 1982; Welsh and others 1987).

Figure 17—Western snowberry with ovate leaves and small white flowers is widespread in aspen and conifer forests where it often occurs in dense thickets.

Ecological Relationships and Distribution—Western snowberry is widespread from British Columbia to Manitoba, south to Washington, Idaho, and Colorado. In Utah it is most often associated with riparian communities, mainly with cottonwood and willow species (Welsh and others 1987). It does especially well on sites with high water tables. It is also found in the mountain brush, open conifer sites, and upper pinyon-Rocky Mountain juniper communities, especially on east- and north-facing slopes. It competes well with understory herbivore species.

Plant Culture—Fruits of western snowberry are collected by hand stripping. Seeds are extracted by maceration through a Dybvig cleaner. There are about 74,000 seeds per lb (163,000 seed/kg). One hundred lb (45 kg) of fresh fruits will normally yield 8 to 10 lb (3.6 to 4.5 kg) of seed. Good seed crops can be expected 3 out of 5 years. Flowering occurs from the first of June through late July. Fruits ripen from mid-September to mid-October. Considerable seed dormancy can exist. This can be overcome with moist prechilling and scarification with sulfuric acid. Fall seeding will help to overcome dormancy. Seedling emergence, however, can be erratic over a few years. Plants can be established from nursery-grown container and bareroot stock. Wilding stock can be obtained early in spring while the ground is still moist and before plants break dormancy.

Uses and Management—Western snowberry can be used extensively by sheep and deer, and a little less by cattle. Elk prefer it in the fall after it has been frozen. It can receive heavy browsing and trampling in riparian areas. Excessive use can result in plant death. This species has been used fairly extensively in restoration projects, especially as transplants.

Varieties and Ecotypes—None.

Family Caprifoliaceae

Symphoricarpos oreophilus
Mountain snowberry

Description—Mountain snowberry is a spreading to erect branching shrub 4.9 to 6.6 ft (1.5 to 2 m) tall (fig. 18). Leaves and twigs are densely puberulent to glabrous and sometimes glaucous. The thin opposite leaves are elliptic to ovate, entire, or with a few teeth or lobes. They range from 0.4 to 2 inches (1 to 5 cm) in length and 0.1 to 1 inch (0.3 to 2.5 cm) in width. Leaves on sterile shoots may be larger (Mozingo 1987). The cream-colored to pinkish flowers have an unpleasant odor. They are solitary or paired on short, drooping pedicels in the upper leaf axils, or borne on short, few-flowered terminal racemes. The corolla and calyx are five- or occasionally four-lobed. The corolla is longer than wide, elongate campanulate to tubular funnelform. The corolla lobes are one-fourth to one-half as long as the tubular portion of the corolla. The interior of the tube is sometimes hairy below the level of filament insertion, but may be glabrous. The filaments are equal to or shorter than the anthers. The ovary is four-locular. Two locules normally contain several abortive ovules each; the remaining two locules each contain one normal pendulous ovule. Fruits are waxy, white ellipsoid, and about 0.3 to 0.4 inch (7 to 10 mm) long. The hard nutlets or seeds are 0.2 to 0.3 inch (4 to 6.5 mm) long (Cronquist and others 1984; Hitchcock and others 1959; Welsh and others 1987).

Ecological Relationships and Distribution—Mountain snowberry is common in midelevation sagebrush, ponderosa pine, Gambel oak, aspen, Douglas-fir, lodgepole pine, and spruce fir communities in the Intermountain region. It can be found growing from British Columbia to Montana, and south to California, Arizona, and New Mexico (Welsh and others 1987). Plants may be locally abundant, and in some cases form nearly pure stands. Mountain snowberry will dominate aspen stands. This shrub does well in full sunlight and shade.

Plant Culture—Mountain snowberry seeds are collected by hand stripping the two-seeded fruits from the stems. Good seed crops are produced 3 out of 5 years. Seeds are cleaned in a Dybvig macerator. Unfilled seeds are removed by floatation. Germination is delayed by the impermeable endocarp and an immature embryo. Pretreatments include a 3- to 4-month wet prechilling retreatment. Scarification with sulfuric acid is also used to break the dormancy imposed by the endocarp (Evans 1974). The embryo develops to

Figure 18—Mountain snowberry is commonly encountered in open parks and conifer forests.

maturity during an extended period of wet prechilling. There are about 75,000 seeds per lb (165,000/kg). One hundred lb (45 kg) of fresh fruits will yield 6 to 10 lb (2.7 to 4.5 kg) of seed. Flowering occurs through June and July. Fruits mature from mid-September through October.

Successful establishment may be achieved by fall planting. Seeds may be hand planted or drilled. Seeds should not be directly planted with grasses because snowberry seedlings develop very slowly. Mature plants will, however, develop in 3 to 4 years. Mountain snowberry is easily established using nursery-grown bareroot or container stock. Seedlings propagated in the nursery or greenhouse grow relatively rapidly, producing extensively branched root systems. Softwood cuttings taken during the period of flowering or vegetative growth are easily rooted and transplanted (Everett and others 1978a; Mirov and Kraebel 1939).

Uses and Management—This species does not grow well on disturbed roadways, mine sites, or similar disturbances unless areas are top soiled. It has been seeded and transplanted fairly extensively on such sites with good success.

Mountain snowberry is low growing, and is accessible to all classes of livestock and wildlife. This shrub is an important source of forage in the early spring, as it is one of the first shrub species to leaf out. In areas where snowberry is a dominant species, it often provides important forage throughout the spring and fall. The persistent, fleshy fruits of all snowberry species are taken by a variety of birds. Field mice scatter the seeds, and plants are widely established from mice caches.

Varieties and Ecotypes—None.

Family Cornaceae

Cornus stolonifera
Redosier dogwood

Description—There are about 30 species of dogwood; most occur in the Temperate Zone of the Northern Hemisphere. Three species occur in the Rocky Mountain region. Redosier dogwood, named for its red to purplish bark is also known as creek dogwood. It is a deciduous, short-lived, rapidly growing, thicket-forming shrub common to moist places (fig. 19). Its spreading clumps of slender stems rise to 15 ft (4.6 m) in height and 20 ft (6 m) in width from a central crown and spreading root system. Stem layers form on decumbent to prostrate stems that simulate stolons. The degree of vegetative spread varies widely. Bark of young branches is bright red to purplish, later turning gray green. Lenticels are diamond shaped. Leaves are petiolate, opposite, entire, elliptic-ovate to obovate and usually acuminate, 1 to 4 inches (2.5 to 10 cm) long and about two-thirds as wide. They are distinctively pinnately veined and sometimes wrinkled, sparsely strigillose and greenish on the upper surface, and paler with pubescence along the veins and sometimes covering the lower surface. Flowers are clustered in flat-topped, ebracteate cymes. Penduncles and branches are strigose to conspicuously spreading pubescent. Flowers consist of four very small sepals, four white petals, 0.1 to 0.2 inches (2 to 4 mm) in length, four stamens, and a two-carpellate pistil. The white to bluish drupes are berrylike, glabrous to pubescent, and 0.28 to 0.35 inches (7 to 9 mm) in diameter. Flesh is thin and succulent or mealy. There are usually one or sometimes two bony stones. A smooth rather than grooved stone is a major feature separating *C. s.* var. *stolonifera* from *C. s.* var. *occidentalis*, although they are widely hybridized (Hitchcock and others 1961). Redosier dogwood flowers from May to July, depending on location. There may be a second period of flowering later in the summer. Fruits ripen from July to September and remain on the plant for 8 or 10 weeks (Olsen and Nagle 1965; Orme and Leege 1980; Stark 1966).

Ecological Relationships and Distribution—Redosier dogwood is widely distributed across North America, occurring from Alaska to Newfoundland and south from California to the Northeastern States. The species also occurs in central Mexico. It grows at elevations from 1,500 to 10,000 ft (460 to 3,030 m) (Harrington 1964; Thornburg 1982) on moist sites, usually along streams, swamps, low meadows, river and creek banks, fields, and woods in areas receiving more than 19 inches (48 cm) of annual precipitation.

Figure 19—Redosier dogwood with its distinctive red bark, opposite leaves, and stoloniferous habit grows in riparian areas and on other moist sites.

It is one of the earliest shrubby plants to invade bogs and swamps due to the ability of its roots to live immersed in water (Conway 1949). It is frequently associated with stands of alder, birch, and willow, and in moderately moist areas, with mountain maple, blackberries, or wild roses. Large plants grow singly in grasslands, incapable of spreading by layering due to the dense ground cover. Redosier dogwood, highly adaptable to a range of soil types, is found on sphagnum mats with a pH of 3.2 (Jewel and Brown 1929) and alkaline soils of pH 8 (Van Dersal 1938). It grows on soils with textures ranging from silty to clayey. In Wisconsin it is recommended for planting on soils with a pH of 5.0 to 6.0, base exchange capacity of 6.0 me per 100 g, and total nitrogen of at least 0.7 percent (Wilde 1946). Roots of redosier dogwood may be associated with vesicular arbuscular mycorrhiza (Barnhill 1981).

Redosier dogwood will grow in full sun or in shaded areas. In full sun, the plants are dense and compact with many lateral branches. In shade, the growth habit is more open and sprawling with few axillary branches, larger leaves, thinner and less curled blades, and lower leaf/total weight ratios. Shrubs growing in full sun tend to develop richer purple coloring in the fall (Sheppard and Pellitt 1976).

Use of redosier dogwood in landscaping, along highways, and on mine spoils has led to a number of physiological studies to determine the effects of short days, water stress, defoliation, and low temperature in initiating and maintaining various degrees of frost hardiness (Chen and Li 1978).

Lumis and others (1973) found that of 20 deciduous shrubs selected from those growing along highways in Ontario, redosier dogwood exhibited the greatest sensitivity to aerial drift of deicing salt because its buds are exposed in winter. Affected trees exhibited twig dieback, a tufted growth pattern, and a greater susceptibility of flowering buds than vegetative buds.

Heale and Ormrod (1982) evaluated plants used for revegetation of toxic wastes high in nickel and copper at primary base metal smelters and found redosier dogwood exhibited typical symptoms. It was sensitive to both levels of nickel tested (2 and 10 mg per 1), but was sensitive only to the highest copper level tested (20 mg per 1, but not 4 mg per 1).

Uses and Management—Redosier dogwood seedlings establish and grow rapidly on wet sites, making it a useful species for streambank, erosion control, and windbreak plantings. It can withstand moderate browsing, but repeated heavy browsing leads to plant loss (Swihart and Yahner 1983). New plantings begin producing fruit in 3 to 5 years.

Berries of redosier dogwood provide nutrients for pheasants, grouse, and many other birds in early winter (Stokes 1977). In New England redosier dogwood seeds were found in the diets of 95 bird species (McKenny 1939). Beaver, bears, and mountain goats use the fruit, wood, and foliage (Murie 1951; Rue 1964). Rabbits, moose, deer, and elk take twigs and exposed winter buds. Plants on winter ranges sometimes suffer from excessive browsing. Kufeld (1973) rated the forage value of redosier dogwood as valuable in winter and fall and highly valuable in summer. It receives moderate fall and winter use and heavy summer use from mule deer (Kufeld and others 1973). The species provides dense summer cover and partial winter cover for birds and other small animals.

Redosier dogwood is recommended for streambank plantings to stabilize eroding banks and provide shade. It may be used to provide an attractive row in windbreak and conservation plantings in areas with adequate water availability (Cook 1981; Olson and Nagle 1965; Stokes 1977). Varieties selected for ornamental use generally have a more compact growth form. In landscapes it provides obvious color and a graceful growth form during all seasons (Stokes 1977; Sutton and Johnson 1974).

Plant Culture—Fruits are collected as soon as they are ripe to reduce losses to birds. Seeds should be fully mature when harvested; some planting failures have been attributed to use of immature seeds (Smithberg 1974). Embryo dormancy is overcome by a 60- to 90-day wet prechilling at 35 to 41 °F (2 to 5 °C). A tetrazolium chloride or embryo excision test is normally used to indicate seed quality and preclude the lengthy wet prechilling requirement (Heit 1955; Brinkmann 1974d). The double-celled fruits sometimes contain two viable embryos, which may contribute to high germination percentages.

Field seeding is best accomplished by spot seeding untreated seed in fall or wet prechilled seed in spring on favorable microsites. Seedlings must be protected from competition and browsing. Peterson (1953) found that laboratory wet prechilling produced better greenhouse germination than wet prechilling through exposure to winter conditions, or combinations of each type of wet prechilling with scarification. Laboratory wet prechilling also provided the greatest resistance to damping off.

Nursery seeding is accomplished by seeding freshly collected fruits. Dry stored fruits should be soaked in water prior to planting (Heit 1968a). Seeds may also be wet prechilled in the laboratory for spring planting. Seed should be drilled at a density of 40 viable seeds per ft^2 (430 per m^2). Seedlings grow rapidly under favorable conditions. One- or two-year-old bareroot stock may be used for outplantings (Shaw 1984). Plants may also be grown as containerized seedlings (Landis and Simonich 1984).

Redosier dogwood reproduces vegetatively from stolons or layering (Peterson 1953; Smithberg 1974). Layering may be induced by pressing branches to the ground with hooks and covering them with loose soil. Rooted shoots are later severed, dug, and transplanted. Layers, as well as hardwood or softwood cuttings, may be used for vegetative propagation. Dormant cuttings may be rooted immediately in the field in moist areas, or rooted in a nursery or greenhouse prior to field planting (Doran 1957). Planting stock is generally available commercially, but origin should be matched as closely as possible to the planting site.

Varieties and Ecotypes—None.

Family Cupressaceae

Cupressus arizonica
Arizona cypress

Description—Arizona cypress is an erect, somewhat pyramidal, evergreen tree with fragrant, resinous foliage (Johnson 1974c; Welsh and others 1987). Five different varieties were described by Johnson (1974c); these differ somewhat in erectness and crown spread (Sudworth 1915; Wolf and Wagener 1948). Trees are mainly 15 to 70 ft (5 to 21 m) in height (Johnson 1974c; Welsh and others 1987). Trunks are 5 to 20 inches (13 to 51 cm) thick; twigs are stout, branching at nearly right angles; the bark is scaly or furrowed and usually grayish. Leaves are scalelike, sharply pointed, blue green, and 0.1 inch (2 mm) long. Cones are globose, 0.6 to 1 inch (1.5 to 2.5 cm) thick, short-stalked, hard and woody, with six to eight flattened scales bearing a hard point in the center. Seeds are 0.1 inch (2 mm) long and purplish brown (Welsh and others 1987). Plants are monecious. Staminate and ovulate strobili are produced on the ends of the branches. Staminate strobili are long and cylindrical, turning yellow as pollen ripens (Johnson 1974c). Ovulate strobili are small, usually less than 0.3 inch (6 mm) long, and green, with six to 12 distinctly arranged scales (Johnson 1974c).

Ecological Relationships and Distribution— Arizona cypress is distributed from Texas to Arizona and Mexico (Welsh and others 1987). The varieties described by Johnson (1974c) occur in somewhat different locations, mostly in north-central Arizona, southern California, and Mexico. This plant has commonly been grown as an ornamental and Christmas tree throughout much of the West. It has proven adaptable to areas outside its native range, and has been planted on numerous sites including many range and wildland communities (fig. 20). It is best adapted to sites receiving at least 14 to 16 inches (36 to 41 cm) of annual precipitation. Normal occurrence is on north slopes, coves, benches, and canyon bottoms (Sudworth 1915), particularly moist, sheltered canyon bottoms.

Plant Culture—Throughout its natural range, cones develop in late fall and pollen is shed in October and November (Johnson 1974c); seeds mature 15 to 18 months later. At the time of maturity cones are about 1.2 inches (3 cm) diameter. Because cones require approximately 2 years to mature, numerous cones of different ages are borne on a single tree. Some trees produce abundant female cones; other trees are much less productive. Trees less than 10 years of age normally do not produce many cones. Insects often damage the cones; consequently, seeds should be carefully inspected to assure healthy cones and viable seeds are collected. Ripe cones are dark brown or deep purplish brown (Sudworth 1915; Wolf and Wagener 1948).

Seeds are harvested by handpicking or beating the tree to dislodge the hard woody cones onto canvas tarps. Trees can be damaged from excessive flailing. Cones are normally harvested in early to late fall. The cones are serotinous; they open when mature to shed the seeds. The scales surrounding the cones form a tight cluster that can be difficult to open unless quite dry. Drying the seeds normally causes natural shattering in 1 to 2 months. Johnson (1974c) suggested storing the cones for several days in a refrigerator to aid in drying and to prevent cone hardening. Seeds normally separate freely from the cones. Approximately 55,050 cleaned seeds per lb (121,400 per kg) were reported by Johnson (1974c) for collections of *C. a.* variety *glabra*. Between 90 and 100 seeds are produced per cone. Considerably larger numbers are reported for other varieties (Goggans and Posey 1968; Johnson 1974c; Wolf and Wagener 1948). Seeds are flattened or lens shaped with short wings (Johnson 1974c).

Seeds wet prechilled for 30 days at 34 °F (1.1 °C) will germinate readily at incubation temperatures near

Figure 20—A 10-year-old planting of Arizona cypress provides wildlife cover in south-central Idaho.

70 °F (21.1 °C) (Johnson 1974c), but most authors recommend incubation at alternating temperatures of 86 °F (30.0 °C) day, and 68 °F (20.0 °C) night (International Seed Testing Association 1966; Stein 1966; USDA Forest Service 1948). Seeds may be infested with mold or bacteria that reduce germination. Treatment with Captan (N-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarborimide) or other fungicides will retard fungal development (Johnson 1974c). Because young seedlings are also susceptible to damping off fungi, seedbeds or nursery-grown containers can also be pretreated with a fungicide.

Arizona cypress has been established by fall seeding in a well-prepared seedbed. Seedlings are sensitive to herbaceous competition, and require a weed-free seedbed for 1 to 2 years. Established seedlings are vigorous and grow rapidly when well protected. Plants may attain heights of 2.5 to 4 ft (0.8 to 1.2 m) in 2 to 3 years. They continue to grow rapidly, but may not reach mature stature for 40 years.

Seedlings and transplant stock are easily grown, and the plant is sold by many commercial nurseries. Small stock 6 to 10 inches (15 to 25 cm) high and large ball and burlap trees are usually available.

Uses and Management—Arizona cypress is an important resource in its native range. It provides lumber, wildlife habitat, and watershed protection (Johnson 1974c). This tree has been particularly useful for landscape and erosion control plantings in southern California on a range of soil types at elevations below 6,000 ft (1,800 m) (Horton 1949). It is well suited as a ground cover or landscape plant because it grows rapidly, is long-lived, and has an attractive pyramidal growth form (Horton 1949).

Within the Intermountain States, this tree has been used for conservation and wildlife habitat improvement projects. It has been successfully used as a windbreak or cover plant to protect structures and shelter range and farmlands. It has been used to provide cover in mixed plantings with other trees and shrubs. Being evergreen, it is particularly important as winter cover. It provides a dense amount of foliage from the base to the top of the plant. It has survived wind and heavy snowstorms, but some individuals and populations lack cold tolerance to harsh conditions in mountainous regions in the West.

This tree species has been useful for wildlife habitat improvement in Utah (Plummer and others 1968). It establishes and grows well, particularly from transplanting in mountain brush, pinyon-juniper, and big sagebrush communities. Seed germination is somewhat erratic, and irregular stands have established from direct seedings. Natural spread by seedling recruitment is poor from all plantings within the Intermountain area.

This species has received considerable browsing by big game at all planting sites in the Intermountain area. Game animals use the plant heavily in summer, and in lesser amounts in the spring, fall, and winter. The foliage is quite palatable, and heavy browsing and highlining of the trees normally occurs. Heavy browsing can prune or eliminate leaf and small stem growth from the lower portion of the plant.

Arizona cypress has demonstrated mixed success on mine sites and other disturbances. It is not adapted to infertile mine wastes unless top soiled. It does not serve well as a pioneer species on barren disturbances. Young plants succumb quickly if planted on marginally adapted sites.

Varieties and Ecotypes—None.

Family Cupressaceae

Juniperus horizontalis
Creeping juniper

Description—Creeping juniper is a native, decumbent to procumbent or prostrate shrub that normally attains heights of 8 to 12 inches (20 to 31 cm) (Bifoss 1947; Great Plains Flora Association 1986; Welsh and others 1987) (fig. 21). Plants develop in clumps or mats that may exceed 23 ft (7.0 m) in diameter (Hitchcock and others 1969; Stephens 1973). The decumbent or prostrate stems root at the nodes forming well-rooted clumps. Leaves are mostly 0.04 to 0.16 inch (1 to 4 mm) long, decurrent, opposite, scalelike or awl shaped, and acute to spinulose tipped. Cones mature the first season; they are green when immature and ripen to blue purple or blue black. They are glaucous, 0.2 to

Figure 21—Creeping juniper growing as an understory with aspen.

0.4 inch (5 to 10 mm) thick, and mostly three- to five-seeded (Welsh and others 1987). Seeds are reddish brown and ovoid to spherical (Hitchcock and others 1969). Plants are dioecious, and although mature cones may be produced in one season (Welsh and others 1987), 2 years are normally required (Great Plains Flora Association 1986; Miller 1978).

Ecological Relationships and Distribution— Creeping juniper is widely distributed in North America (Little 1979). It occurs from Montana to northern Colorado and Utah, and east to northeastern Iowa, Nebraska, Illinois, and New York (Little 1979). It is abundant throughout Canada (Couchman and Von Rudloff 1965), and occurs from Alaska and the Yukon, east to the Atlantic, and south to British Columbia (Welsh and others 1987). The shrub is widely distributed over a number of different plant communities. It grows in association with grass and broadleaf forbs at low elevations in the northern Great Plains (Girard 1985; Hansen and others 1984; Johnston 1987). It is also associated with conifer forests, aspen, and limber pine (Girard 1985) at high elevations and on more moist sites (fig. 21).

Plant Culture—Staminate cones are produced at the tips of the branches in early spring. Pollination of pistillate cones normally occurs in April and May (Miller 1978). Pistillate cones form globose, berrylike fruits (Great Plains Flora Association 1986; Hitchcock and others 1969; Miller 1978). As they ripen they change in color from green to blue black or bluish purple (Stephens 1973). Cones normally remain on the plant until the late fall or early winter of the second year. When fully mature they drop from the plant.

Seeds are harvested by stripping or picking the ripened cones. Cones can also be dislodged by flailing the branches and dislodging them onto canvases spread on the ground. It is advisable to collect the cones as soon as they ripen. Collecting green cones or immature seeds is not advised, as they are difficult to separate from fully ripened seeds during cleaning. Freshly collected cones should be spread to dry, but can be stored and seeded as dry cones or as cleaned seeds (Johnsen and Alexander 1974). Seeds are normally extracted from the cones by maceration using a Dybvig seed cleaner. The debris is floated away in water (Johnsen 1959; Johnsen and Alexander 1974). If cones are completely dry before cleaning, they may require soaking for a few days to aid in separation. The macerated material is dried and then fanned to separate seeds from the trash. Seeds should be stored in sealed containers at 20 to 40 °F (–6.7 to 4.4 °C) with relative humidity at about 10 percent (Johnsen and Alexander 1974; Jones 1962).

Germination of creeping juniper seed is delayed by embryo dormancy and an impermeable seedcoat. Seeds also require a period of dry afterripening (Pack 1921). To enhance germination, seeds of most junipers are subjected to various pretreatments including wet prechilling at 40 °F (4.4 °C) for 30 to 120 days (Barton 1951; Johnsen and Alexander 1974).

When planted in the fall, seed dormancy can usually be broken by overwinter wet prechilling. Seedbeds should be covered with mulch to ensure the soil remains moist during the time of germination (Johnsen and Alexander 1974). Seeds are normally covered to a depth of at least 0.25 inch (6.4 mm) in a firm seedbed (Stoeckeler and Slabaugh 1965). Seedbeds are frequently shaded during the first growing season to protect the soil surface from rapid drying and reduce the chance of damage from early spring frosts (USDA Forest Service 1948).

Creeping juniper can be propagated from stem cuttings. Portions of the stem that contact the soil and form roots can be cut and separated into individual plants. The stem cutting and excised root system can be planted in containers, grown to a suitable size, and field planted. Stem cuttings can also be rooted easily under greenhouse conditions (Zorg 1954). Stem cuttings taken in early winter (November and December) root readily without the use of rooting compounds (Doran 1957; Kiplinger 1938).

Plantings of 2-year-old bareroot stock have established and survived better than younger, smaller stock. Field lifting and transplanting must be completed in early spring when plants are dormant. Although transplanting may be done later in the season, supplemental irrigation is usually required to assure survival.

Uses and Management—Creeping juniper has not been used extensively in large revegetation projects. Although recognized as an important ground cover and a locally useful forage plant for wildlife, it has been difficult to establish on wildland sites. This species has been able to persist following heavy grazing when more palatable shrubs and herbs have been eliminated. Consequently, rehabilitation programs often do not include this shrub. Creeping juniper normally occurs as scattered plants, occupying ridge crests, rocky slopes, ledges, washes, or areas that are difficult to plant with conventional equipment. Although site accessibility limits planting in some areas, this plant is important for ground cover and wildlife habitat and should not be overlooked.

Creeping juniper provides dense cover on harsh sites. Its low evergreen growth habit provides diversity and cover throughout the entire year. Ecotypes that are semierect or upright furnish better habitat for wildlife. This shrub grows on sites where few other plants are adapted. Because creeping juniper grows on isolated wildlife ranges, it is important to maintain its presence. It occurs in most plant communities and big game winter ranges on sites where soil protection and forage diversity are critical for protecting watershed and wildlife values. Consequently, it is important that techniques are developed to better accommodate its propagation and field planting.

Creeping juniper normally receives only limited use by big game, but locally heavy winter browsing has been reported (Frischknecht 1975; Miller 1978). Dusek (1975) found that creeping juniper provided a major portion of mule deer diets during March and April in north-central Montana. This plant provides important fall, winter, and spring forage for big game (Dusek 1971; Kufeld and others 1973; Lovaas 1958; Martinka 1968; McKean 1954; Schallenberger 1966). It is more commonly used by deer, but Dirschl (1963) found that creeping juniper provides about 10 percent of the winter diet of pronghorns, and was the dominant forage from December to March in some parts of Saskatchewan. Some ecotypes in the Intermountain States exhibit considerable differences in use by game animals. Selections that receive moderate or heavy use are consistently browsed at these levels, although climatic, edaphic, or other factors may contribute to selective use by game.

Birds and other wildlife seek sites occupied by this shrub. The cones provide food for many game birds and mammals. They remain on the shrub for 1 or 2 years and provide 20 to 40 percent of the total food consumed by sharptail grouse (Miller 1978). Not all plants produce heavy seed crops. Annual production is often quite low, but fruits that do develop are used during winter and early spring periods when other foods are less available.

Creeping juniper begins growth very early in spring. Game animals are attracted to the shrub in late winter and early spring when other forages are less palatable. The plant grows in areas where game may be forced to concentrate during periods of deep snow and adverse weather conditions. At these critical periods, it provides protection, cover, and forage that are crucial for the survival of game animals.

Creeping juniper has been used to restore disturbed watersheds and mine sites. It is extremely difficult to establish by direct seeding because of germination problems. Transplanting has been the most successful means of establishment; however, costs associated with transplanting limit its usefulness. Transplants are difficult to establish on semiarid sites. Small transplants root slowly and require frequent irrigation to fully establish. Thus, it has been difficult to plant sites that do not remain moist through the year of planting. Once established and well rooted, this species survives very well. New plantings are not able to compete well with broadleaf herbs and grasses, and the shrub should be planted alone.

This shrub occupies areas in Wyoming, Montana, and Colorado where considerable surface mining occurs. Use of this shrub has been encouraged where efforts are made to restore native communities. Creeping juniper has established slowly on mine spoils, and appears sensitive to soil conditions. Although it naturally occurs on infertile sites, it is not well suited to all mine wastes and spoil materials. It does best on sites that have been top soiled or contain soil fines capable of holding soil moisture. It has been less successful on rocky, coarse mine wastes and exposed substrata. To be successful on mine disturbances, a balanced amount of soil nutrients must be provided.

This shrub can be used to restore mine spoils where irregular topography is created. If topsoil or surface soil material is reapplied, the plant can be successfully planted to re-create natural communities and landscapes-disturbed areas to match adjacent native plant associations.

Creeping juniper can also be used to stabilize watersheds and erodible sites. It establishes and grows slowly, a major disadvantage in stabilizing erosive soils and steep slopes. However, once established, it is able to withstand windy conditions, and provides excellent ground cover under very exposed and harsh situations. This shrub is also very useful as a landscape species. It is widely used in horticultural plantings in areas including recreational sites, campgrounds, parks, and associated sites where little maintenance is provided. It is particularly useful in planting parks and recreational sites where use of native species is emphasized. It can withstand heavy traffic, and is used to align walkways, roadways, and trails.

Varieties and Ecotypes—Various selections have been developed for horticultural uses that exhibit different colors, or vary in growth habit, leaf texture, rooting habits, and growth rates. However, none have been released for wildland situations.

Family Cupressaceae

Juniperus osteosperma
Utah juniper

Description—Utah juniper is a small tree normally with a single stem and several short branches that originate near the ground (fig. 22). Individual trees may exceed 21 ft (6.4 m) in height (Goodrich and Neese 1986). They have thin, fibrous bark that shreds from the trunk and branches (Welsh and others 1987). Welsh and others (1987) described the mature leaves as typically opposite, scalelike, 0.04 to 0.12 inch (1 to 3 mm) long, and yellowish green. Juvenile leaves are decurrent, awl-shaped, sharp, and 0.1 to 0.3 inch (2 to 8 mm) long. Plants are monoecious; staminate cones are yellowish brown and 0.1 to 0.2 inch (3 to 4 mm) long; ovulate cones are subglobose, 0.2 to 0.5 inch (6 to

Figure 22—Stands of Utah juniper furnish considerable cover for a variety of wildlife following chaining and seeding with grasses and forbs.

12 mm) thick and brownish or blue to blue purple at maturity. There are one to two seeds per cone (Arnold and others 1964; Johnsen and Alexander 1974; Tueller and Clark 1975; Welsh and others 1987).

Ecological Relationships and Distribution—Utah juniper occurs from Montana and Wyoming, south to California, Arizona, and New Mexico (Griffin and Critchfield 1972; Hitchcock and Cronquist 1973; Welsh and others 1987; Zarn 1977). It grows with singleleaf pinyon to form vast woodlands, typically existing between more xeric cold desert shrub communities at lower elevations and mountain brush or ponderosa pine at higher elevations. It normally occurs between elevations of 6,000 to 7,500 ft (1,800 to 2,300 m) (Goodrich and Neese 1986), although it is not uncommon between elevations of 2,790 to 8,000 ft (850 to 2,400 m) (Welsh and others 1987).

Utah juniper is the dominant species, along with a number of shrubs and grasses, on many sites that have been subjected to heavy domestic grazing (Clary 1975a) and reduction of wildfires. These management practices have resulted in an increase of trees, coupled with a decrease of understory plants. Pinyon-juniper stands have not only increased in density, but have spread to occupy adjacent shrub and grass communities (West and others 1979). The spread of Utah juniper may be regulated by periods of drought and the occurrence of years of favorable precipitation (Blackburn and Tueller 1970).

Utah juniper is more tolerant of arid regions in the Great Basin (Tausch and others 1981) than singleleaf pinyon; it is the only tree species present in many areas. It forms dominant stands throughout much of southern Utah and Nevada. Treshow and Allan (1979) concluded that the distribution of Utah juniper is primarily regulated by precipitation. Tree stands normally occupy sites that receive from 10 to 25 inches (254 to 635 cm) of annual rainfall (Blackburn and Tueller 1970). Utah juniper is more tolerant of fire and spring frost, and performs better with low summer precipitation than singleleaf pinyon pine (Tueller and others 1979; West and others 1979), yet these factors do not fully explain the distribution and composition of the tree species and communities. At higher elevations, singleleaf pinyon may dominate and is generally more abundant.

Utah juniper is widely adapted to a variety of soil types and parent materials. It grows on limestone, sandstone, granite, and mixed materials (Clary and Jameson 1981). Utah juniper is particularly well adapted to rocky, well-drained, coarse-textured soils (Eckert 1957).

Plant Culture—Good seed crops are normally produced annually by most wildland stands, although abundant seed crops may only occur every 2 to 6 years. Seeds require about 2 years to mature. Cones appear from mid-April to mid-May, and normally mature in late fall or early winter the second year after flowering (Johnsen and Alexander 1974). Cones of different ages are normally found on the same plant. Mature cones are darker in color and are obviously drier than immature cones (Zarn 1977).

Most wildland stands produce commercially harvestable crops, although selected individuals or small groups of trees may be the primary producers. Seed collection, cleaning, and storage practices are similar to those described for creeping juniper and discussed by Johnsen and Alexander (1974).

As with other junipers, the seed coats are impermeable and embryos are dormant (Johnsen 1959; Johnsen and Alexander 1974). Seeds are difficult to germinate without pretreatment. Johnsen and Alexander (1974) recommended a 120-day warm pretreatment at 68 to 86 °F (20 to 30 °C) alternating diurnal temperatures followed by wet prechilling for 120 days at 41 °F (5.0 °C). Incubation at alternating day and night temperatures of 68 to 86 °F (20.0 to 30.0 °C) for 70 days resulted in less than 50 percent germination.

Although Utah juniper spreads well by natural seeding, it is a difficult plant to propagate and it establishes poorly by artificial seeding. Field plantings establish erratically and unpredictably. Erratic seed germination is the primary factor affecting poor seeding establishment. Pretreatments to stimulate and regulate seed germination have been somewhat helpful when seeds are germinated under controlled laboratory conditions. However, pretreatment practices have not significantly improved seedling emergence from wildland plantings. Seedling establishment in nurseries has been enhanced by prechilling seeds or by mulching and irrigating the seedbeds, but erratic stands still result (Johnsen and Alexander 1974).

Seedlings of Utah juniper that emerge in early spring and survive spring frosts are most likely to survive their first season. Seedlings that germinate late in spring, as soil moisture is depleted, are less likely to survive. New seedlings grow slowly and normally require 2 to 4 years to attain large stature. During this period of establishment, mortality is very high. Young plants that do survive for 1 to 4 years become hardy, and can persist with considerable herbaceous competition and adverse climatic conditions. Blackburn and Tueller (1970) concluded that spread of juniper is favored by years of good seed production followed by 6 years of average or above-average precipitation. Seedling establishment is difficult to predict. Numerous chaining and burning projects have cleared areas and created openings where new seedlings may establish. Chaining and other activities bury surface-deposited seeds, but new tree seedlings do not always invade the treated sites. New tree seedlings may not appear for many years after treatment, and increases may occur after understory species have established a dense cover.

Tree seedling survival is affected by the presence and density of understory herbs. Monsen and others (1987) found that native understory species, including shrubs, have prevented tree seedling encroachment in central Utah. Seeding introduced grasses and broadleaf herbs on pinyon-juniper sites reduces the establishment of tree seedlings, but the influence of individual herbaceous species is not fully understood. The presence of native herbs also limits tree seedling survival.

Tree recruitment is undoubtedly site influenced. Natural recruitment frequently occurs very rapidly on both treated and untreated sites where mature trees have been removed by burning or chaining. On adjacent treated areas, tree recovery has been delayed for extended periods even though all sites receive similar amounts of precipitation. In addition, at some Utah locations, Utah juniper stands cleared of mature trees at different times, have little tree recruitment, but other sites have experienced considerable tree recovery each year after treatment.

When direct seeded, Utah juniper should be planted at a depth of 0.5 to 1.0 inch (1.3 to 2.5 cm) and sown in late summer or fall (Heit 1967b; Johnsen and Alexander 1974; Stoecker and Slabaugh 1965). Hand seeding in small openings where the soil surface is protected by litter, rock, or other debris tends to improve survival.

Utah juniper is widely used in landscape plantings as 2- to 5-year-old container transplants (Johnsen and Alexander 1974). Bareroot transplants have also been cultivated for field plantings. Survival of larger 2- to 3-year-old stock has exceeded that of smaller transplants. Small transplants grow slowly and do not compete as well as larger stock. Utah juniper transplants do not survive well if the primary root of young plants is damaged. This impact is less evident for larger stock.

Utah juniper can be propagated from stem cuttings taken from November through February, but it is difficult to root (Doran 1957; Snyder 1954). Treatment with root-inducing substances may or may not be beneficial (Doran 1957; Zorg 1954).

Uses and Management—Utah juniper is widely regarded as an important plant for big game winter ranges. The plant provides important cover and forage for wildlife (Frischknecht 1975). Nearly all big game animals utilize pinyon-juniper woodlands. This species is not regarded as highly palatable to big game by most authors (Brotherson and Osayande 1980). Rosenstock and others (1989) found that mule deer depended heavily on juniper during winter months, and it is a principal part of their diet during the midwinter period. The species may be regarded as an emergency winter forage plant (Gullion 1964), with only fair energy and protein values (Dittberner and Olsen 1983), but Kufeld and others (1973) concluded that juniper is moderately to heavily grazed by big game during most seasons. The fruits are widely used by numerous birds (Turkowski and Watkins 1976). Big game and livestock graze the understory of pinyon-juniper sites heavily in spring, fall, and winter.

Utah juniper provides essential cover for big game, particularly during the winter months. Animals seek cover and protection, and current chaining practices are now being carefully evaluated to assure that adequate sized openings, escapeways, and concealment cover are retained.

Game animals, livestock grazing, and recreational uses of pinyon-juniper sites have increased dramatically in many locations. Game animals have been forced to use pinyon-juniper areas in the spring, fall, and winter, as access to and use of natural ranges have been diminished by the construction of homes, roads, farms, ranches, and commercial developments. Many pinyon-juniper sites have been converted to shrub/grass communities and managed to prevent tree recruitment. Pinyon and juniper have also spread to occupy sites that are void of competitive understory species. The encroachment has been facilitated by the reduction or control of wildfires. Consequently, pinyon-juniper sites have become increasingly important to the management of wildlife populations. Chaining, burning, and seeding of pinyon-juniper areas for livestock grazing may not be economically practical in all situations, but restoration and improvement for wildlife habitat improvement is beneficial.

Pinyon and juniper communities are an important component of many watersheds. These sites may not receive great amounts of precipitation each year, but plants grow on steep slopes that are subjected to runoff and erosion from high-intensity storms. Closed stands of pinyon-juniper and communities that lack suitable understory provide poor ground cover and are high sediment producers. These sites should be managed to prevent infrequent, but damaging erosion and runoff from unpredictable storm events. Pinyon-juniper woodlands are also subjected to wildfires and other impacts that can diminish tree cover. If the tree communities lack a suitable understory, the burned or disturbed sites become vulnerable to erosion; this significantly impacts downstream resources. Consequently, it is important to maintain a diverse understory of shrubs and herbs that are capable of recovering following these natural disturbances.

Pinyon and juniper communities have been invaded by cheatgrass, even where closed tree stands exist. As mature trees die from fires, insects, or disease, the annual grass spreads quickly, and once in place prevents the recovery of nearly all native species. Extensive areas of pinyon-juniper woodlands throughout the Intermountain region occur with only remnant amounts of native shrubs and herbs, but with scattered and suppressed amount of cheatgrass. As these sites eventually burn, the sites are converted to annual grass communities. The annual grass ranges burn frequently, resulting in a loss of wildlife habitat. To prevent the conversion of pinyon-juniper sites to annual grass, sites can be artificially seeded with desirable understory natives following burning or other disturbances. In addition, potential problem areas can be treated by controlled burns or chaining followed by seeding. This practice has been extensively employed in Utah and other Intermountain States. This problem has not been fully understood and addressed in land management programs.

Deterioration of pinyon-juniper communities within the Intermountain area has had a significant impact on big game populations. Most pinyon-juniper sites have been heavily impacted by previous grazing by livestock and wildlife. This has resulted in a loss of shrub and herb understory. Trees have increased and once in place prevent the return of the desired understory. Consequently, extensive chaining, clearing, and seeding projects have been employed to reduce tree density and allow seeded species to establish. Numerous native shrubs, broadleaf herbs, and grasses have been developed to convert tree-dominated sites into sites dominated by a more diverse array of species.

Varieties and Ecotypes—None.

Family Cupressaceae

Juniperus scopulorum
Rocky Mountain juniper

Description—Rocky Mountain juniper is typically taller than Utah juniper, normally reaching 10 to 20 ft (3.0 to 6.1 m) in height (Welsh and others 1987), but heights of 20 to 50 ft (6.1 to 15.2 m) are not uncommon (Johnsen and Alexander 1974). Crowns are conical to pyramidal or, less commonly, rounded. The bark is thin, fibrous, and shredded. Leaves are opposite, but sometimes in threes, scalelike, 0.02 to 1.2 inches (0.5 to 30 mm) long, green or blue green, sometimes with dorsal resin glands. Juvenile leaves are needlelike and 0.1 to 0.3 inch (3 to 8 mm) long (Welsh and others 1987). Plants are generally monoecious with staminate cones 0.08 to 0.12 inch (2 to 3 mm) long; female cones develop strobili or berrylike structures that are 0.2 to 0.3 inch (4 to 8 mm) thick at maturity (Johnsen and Alexander 1974; Zarn 1977). Arnow and others (1980) distinguished Rocky Mountain juniper from Utah juniper by leaf shape; Rocky Mountain juniper has entire and opposite leaves rather than minutely toothed and somewhat whorled leaves.

Ecological Relationships and Distribution—Rocky Mountain juniper occurs throughout central British Columbia and Alberta, and much of the Pacific Northwest, Rocky Mountains, and Great Basin. It is found from the northern Great Plains, south to Nevada, Arizona, New Mexico, and Texas (Fowells 1965; Hitchcock and Cronquist 1973; Pieper 1983; Welsh and others 1987; Zarn 1977). It is commonly encountered in canyons and cool exposures at higher elevations than Utah juniper, normally occurring as scattered plants rather than extensive stands (Goodrich and Neese 1986). It usually grows with mountain big sagebrush, mountain brush, ponderosa pine, aspen, and Douglas-fir at elevations between 7,000 and 9,000 ft (2,100 and 2,700 m) (Fowells 1965; Goodrich and Neese 1986). At higher elevations it grows with Engelmann spruce and subalpine fir. Although a typical mountain species, it often occurs at low elevations in valley bottoms with cold air drainage (Welsh and others 1987). It is most common in open woodlands or with big sagebrush-grass communities. Throughout central Utah it is particularly abundant with Gambel oak. The erect columnar variety is more common in Utah on open aspects with mountain big sagebrush. It is also common in northern Wyoming and southern Montana.

Plant Culture—Cones appear from mid-April to mid-June, mature from mid-September to mid-December the second year after pollination, and persist on the plant for 2 to 3 years (Fowells 1965; Johnsen and Alexander 1974). Seeds are harvested, cleaned, and stored as described for other junipers (Johnsen and Alexander 1974). Seed production is erratic, but some seeds are produced every year; abundant crops are produced about every 2 to 5 years. Seeds are collected by hand stripping or beating the limbs to dislodge the cones onto canvas spread on the ground. Seeds are relatively small compared with those of other junipers; the count ranges between 17,850 and 42,100 seeds per lb (39,350 and 92,800/kg) (Johnsen and Alexander 1974).

Germination is delayed because of embryo dormancy and hard impermeable seedcoats; seed pretreatments are recommended to hasten germination. Untreated seeds may require 14 to 16 months to germinate (Afanasiev and Cress 1942). Johnsen and Alexander (1974) reported that Rocky Mountain juniper seeds require a warm pretreatment at 68 °F (20 °C) for 45 to 90 days followed by wet prechilling to initiate germination.

Johnsen and Alexander (1987) suggested different methods of pretreatment and seeding. These include: (1) cleaning the seed followed by warm/cold wet pretreatment and fall seeding; (2) storage of the cones (berries) for 1 year before cleaning, wet prechilling, and fall or spring seeding; and (3) a warm pretreament outdoors from spring to the time of fall sowing.

Seeds should be planted in a firm seedbed at a depth of 0.25 to 0.5 inch (6 to 13 mm). Addition of a surface mulch is helpful. When planting wildland sites, spots should be selected that are somewhat protected and have variable soil conditions. Seedlings do not emerge from bare, open, compacted, or crusted surfaces.

Young Rocky Mountain juniper plants normally grow faster than Utah juniper until they reach mature stature. Fowells (1965) reported fairly uniform growth to an age of 40 years, at which time the growth rate declines. Plants live 250 to 300 years (Tueller and Clark 1975).

This species is easier to rear as bareroot or container stock than Utah juniper. Seeds are somewhat less dormant, and plants usually grow faster when irrigated and fertilized. Commercial growers often produce this species and are able to rear the plant with good success. Transplant stock of various ages is produced and sold as potted container stock or ball-and-burlap plants. Plants are usually 3 to 4 years of age before they are of sufficient size for commercial sales.

Uses and Management—Rocky Mountain juniper (fig. 23) is commonly used for conservation, windbreak, and horticultural purposes. This species has been useful for improving upland game bird habitat on farmlands (Miller and others 1948). Its pyramidal evergreen growth habit provides attractive yearlong protection. The plant is sufficiently drought tolerant to persist on sites receiving 12 to 14 inches (30.5 to 35.6 cm) of precipitation. It is better adapted to alkaline soil conditions than most other junipers (Miller and others 1948). Rocky Mountain juniper is particularly useful when planted in combination with other trees and shrubs as a windbreak or screen. It withstands harsh, cold temperatures, and can be used to protect roadways, buildings, and other facilities.

This species is also of importance as a cover and forage plant for big game. It receives moderate use in winter, spring, and fall (Kufeld and others 1973). However, considerable differences are noted among sites and game animals. Some plants are grazed heavily, but most trees are not grazed extensively. Livestock generally make little use of this plant.

Rocky Mountain juniper furnishes excellent cover for a variety of wildlife. It frequently grows in association with various shrubs that provide winter cover. Big game animals often use stands of Rocky Mountain juniper for cover and protection. Sites that are used for this purpose should be managed to maintain appropriate cover and habitat.

Rocky Mountain juniper frequently grows in canyon bottoms, streams, seeps, and other riparian areas. It provides excellent cover and structural diversity. Plants also normally support a herbaceous understory if sites are properly managed. Small pockets of Rocky Mountain juniper, intermixed with mountain big sagebrush, are important areas for wildlife. The diversity provided by this plant is important for many upland sites where lower growing shrubs occur.

Few other tree species are able to grow where this native normally exists. Because it is relatively slow to establish and mature, removal of this species should be avoided. Restoration projects should be designed to

Figure 23—Young Rocky Mountain juniper trees grow in association with mountain big sagebrush.

leave this species in areas of high importance. Rocky Mountain juniper normally grows on sites that are moist enough to support understory herbs. Herb and shrub seedlings are better able to establish with this overstory tree than with Utah juniper. Direct seeding of herbs can be recommended on areas where scattered plants exist. Complete removal of the trees is not required to accomplish seedling establishment of desired native understory species.

Rocky Mountain juniper has been planted on mine disturbances with mixed success. Small 1- to 2-year-old container stock has not established or persisted well on mine wastes in southeastern Idaho and southern Montana. Larger stock, 2- to 6-year-old potted plants, survive better than smaller stock. Supplemental irrigation for 2 to 3 years significantly improves establishment on harsh sites. Once plants are well rooted, they persist well.

Varieties and Ecotypes—None.

Family Elaeagnaceae

Elaeagnus commutata
Silverberry

Description—Silverberry is a native, deciduous shrub, mostly 3 to 6.5 ft (0.9 to 2.0 m) tall, with peltate scales. Plants vary in growth habit, often occurring as thicket-forming shrubs up to 12 ft (3.7 m) tall or frequently as small trees (Johnson and Anderson 1980). Stems are stoloniferous and unarmed. Leaves are 0.5 to 2.8 inches (1.3 to 7.1 cm long), 0.2 to 1.2 inches (6 to 31 mm) wide, elliptic to oblanceolate, acute to obtuse or rounded and silvery on both sides with brown scales. Flowers are one to four per axil, 0.4 to 0.6 inch (1.0 to 1.5 cm) long, and yellowish. The fruit is drupelike, consisting of a dry indehiscent achene enveloped by a fleshy persistent hypanthium. Fruits are 0.2 to 0.4 inch (6 to 10 mm) long, mealy, and silvery (Welsh and others 1987).

Ecological Relationships and Distribution—Silverberry occurs from Quebec to the Yukon, and south to Minnesota, Wyoming, Utah, and northern Colorado (Harrington 1964). In Utah, it is usually restricted to riparian zones at elevations between 6,000 and 8,000 ft (1,800 and 2,400 m) (Welsh and others 1987). Plants occur in areas receiving 18 to 20 inches (45.7 to 50.8 cm) of annual precipitation, but usually require supplemental water even on moist sites (fig. 24). Silverberry is very winter hardy and drought tolerant. In eastern Utah, silverberry grows along streams and dry hillsides (Goodrich and Neese 1986). In the interior of Alaska it grows on rocky, south-facing slopes and sandbars (Viereck and Little 1972), often forming thickets along major streams.

Figure 24—Silverberry grows along stream bottoms with willows and other riparian species in eastern Utah.

Plant Culture—Silverberry plants flower in early summer. The large, silver-green drupelike fruits ripen in late fall and early winter. This shrub produces abundant seed crops at intervals of 1 to 2 years. Ripe fruits can be picked by hand, or the bushes can be beaten to dislodge the fruits onto canvas spread on the ground (Olson 1974). The fruits are easier to clean before they dry. Seeds are extracted from the fruit by maceration in a Dybvig separator, and water is used to grind and float the pulp away (Heit 1968a; Olson 1974). Between 2,700 and 4,600 cleaned seeds are reported per lb (5,950 to 10,140 per kg) of pure seed (Olson 1974).

Silverberry has not been widely used in range and wildlife projects. Seeds should be planted 0.5 to 1 inch (1.3 to 2.5 cm) deep in a firm seedbed. Seedling growth rate is fairly rapid, and young plants persist quite well if planted in adapted areas. Plants also establish well from bareroot or container-grown stock. Silverberry is reported to have stoloniferous stems (Johnson and Anderson 1980), and can spread from underground rootstocks (Viereck and Little 1972). Vegetative spread has not occurred in wildlife plantings in Utah.

Uses and Management—Silverberry has been selectively used throughout the Western United States. It was propagated as early as 1813 (Olson 1974) for windbreaks and shrub row plantings, but has not been used extensively in recent programs. The species has been recommended for windbreak and wildlife plantings in Wyoming (Johnson and Anderson 1980). Plants are grown as ornamentals and windbreaks in the interior of Alaska (Viereck and Little 1972). Plants produce leaves having an unusual silver-green cast. Leaves persist on the shrub until early winter, thus furnishing an attractive background screen.

In Utah, big game have made moderate use of the shrub during the spring and fall months, but they seem to prefer the plant much more as summer browse. Reports by Kufeld and others (1973) and Dusek (1971) described limited fall grazing but increased summer browsing by big game. The shrub has been transplanted with good success on mine disturbances in southeastern Idaho, and has received only limited use by mule deer.

Silverberry appears to have particular value for riparian habitat improvement within its native range. It transplants very well and grows rapidly even with some understory competition. It is able to establish and grow on moist and well-drained soils, typical of disturbed riparian sites. It provides considerable cover for animals and soil protection. It is a well-rooted plant that can provide excellent soil stability, but it does not spread as does Russian-olive to become a serious weed.

Silverberry has considerable value as an ornamental plant for residential and recreational sites. It can be used to enhance parkways, campgrounds, and recreational sites, particularly near streams and semiwet areas. It can be used to screen and protect structures, roadways, trails, and campgrounds. It does not attract heavy use by wildlife and can be used where animal concentration is to be avoided.

Varieties and Ecotypes—None.

Family Elaeagnaceae

Shepherdia argenta
Silver buffaloberry

Description—Silver buffaloberry is a deciduous, thorny shrub with a spreading to ascending growth habitat that attains heights of 6 to 10 ft (1.8 to 3.0 m) (Thilenius and others 1974a; Welsh and others 1987). Goodrich and Neese (1986) reported that plants may reach heights exceeding 22 ft (6.7 m). Branchlets are covered with silvery peltate scales and terminate in sharp thorns. Leaves are opposite, petiolate, 0.2 to 2.4 inches (0.5 to 6 cm) long, and 0.12 to 0.55 inch (3 to 14 mm) wide. They are oblong, elliptic or lanceolate, and silver gray on both sides. Plants are dioecious, with axillary flowers that can be perfect or imperfect. Flowers are 0.1 to 0.16 inch (2.5 to 4 mm) long with yellowish perianths. The red fruit is drupelike, 0.16 to 0.28 inch (4 to 7 mm) long, and edible, though tart (Goodrich and Neese 1986; Sampson and Jespersen 1963; Welsh and others 1987). Staminate flowers have eight stamens alternating with glandular thickenings at the base of the perianth lobes (Welsh and others 1987). The perianth of pistillate flowers is short and tubular, investing the ovary.

Ecological Relationships and Distribution—Silver buffaloberry is distributed from British Columbia to Saskatchewan, and south to California, Nevada, New Mexico, and North Dakota. It occurs along streams in sagebrush and pinyon-juniper woodlands (Sampson and Jesperson 1963). It is widely scattered throughout Utah at elevations between 4,590 and 7,510 ft (1,400 and 2,290 m) along streambanks, terraces, and on moist or wet sites (Welsh and others 1987). It occupies ditch banks, abandoned fields, disturbed fence lines and powerlines (Goodrich and Neese 1986). In Wyoming it grows in bottomlands, on moist hillsides, and on streambanks at elevations up to 7,000 ft (2,100 m) (Johnson and Anderson 1980).

Plant Culture—Plants flower in spring, beginning in early April and continuing into June. Fruits ripen from June to August, and they remain on the bush until December (Plummer and others 1968; Thilenius and others 1974a; Van Dersal 1938). Ripe fruits are most easily collected by flailing the plant, causing the fruits to drop onto canvas spread on the ground. Fruits may be handpicked, but the thorny branches hinder this approach.

Stems, twigs, and leaves must be separated from the fruits before they are macerated and the pulp floated away with water. The seeds (cleaned achenes) are processed with a fanning mill to separate them from small debris. Seedlots can be cleaned to a high purity. There are between 18,000 and 67,000 seeds per lb (39,700 and 147,700 per kg); the average is 41,000 seeds per lb (90,390 per kg) (Thilenius and others 1974a). Mirov and Kraebel 1939 and Plummer and others (1968) reported the average number of cleaned seeds per lb is between 10,800 and 18,000 (23,810 and 39,680 per kg). Cleaned seeds can be stored in open warehouses for at least 5 years without appreciable loss of viability (Plummer and others 1968).

Both embryo dormancy and hard seedcoats restrict or delay germination. Thilenius and others (1974a) found that wet prechilling for 60 to 90 days, followed by exposure to alternating day and night temperatures from 86 to 69 °F (30.0 to 20.0 °C) for 30 to 60 days, resulted in 26 to 93 percent germination.

Seeds sown in fall will germinate in spring. Seeds should be planted at a depth of 0.5 to 1 inch (1.3 to 2.5 cm). Seedlings and young plants have established moderately well on range or conservation plantings. Seedling growth is only fair, but as plants reach 1 or 2 years of age, they become well established and are very persistent. Seeds are easily handled and planted with most conventional planters. Bareroot or container-grown transplants establish better than direct seedings. The shrub is not browsed very heavily, nor adversely affected by insects, consequently it is able to establish without serious delays (Plummer and others

1968). Silver buffaloberry grows moderately well with herbaceous understory species. If 1-year-old transplant stock is planted, very good survival and excellent growth can be attained. The shrub is produced by many commercial nurseries. Root sprouts can be propagated with good success.

Uses and Management—Silver buffaloberry has been widely planted for shelterbelts, game habitat, cover, and watershed protection (Thilenius and others 1974a). It has been used in ornamental plantings because of its gray, willowlike foliage (Sampson and Jespersen 1963). The thorny nature of this plant limits its use in heavily populated areas. However, it can be planted in recreation sites to screen areas, direct foot traffic, and control or restrict use of campgrounds and parks. It is used as the outer row in multirow shelterbelt plantings, but it is often planted alone where a low, dense cover is required (Johnson and Anderson 1980). The shrub is highly susceptible to heart rot, and breakage by wind and snow results as the wood becomes brittle (George 1953). In the Midwest, high winds have uprooted cultivated trees; consequently, this species is not recommended for windbreak plantings, particularly near buildings and walkways. (George 1953).

Silver buffaloberry is recommended for use in pinyon-juniper, big sagebrush, inland saltgrass, and wet meadow communities of Utah for wildlife habitat improvement (Plummer and others 1968). It is especially useful on sandy soils and in moist sites (Thornburg 1982). The thorny thickets created by this shrub provide cover and nesting sites for birds and other animals; quail (Martin and others 1951) and some small mammals take the drupelike berries (Hall 1946). Big game animals make considerable use of the shrub during the summer but only moderate use in the winter (Compton 1966; Dusek 1971; Kufeld and others 1973; Lamb 1968; McKean 1954; Plummer and others 1968).

Although silver buffaloberry is normally recommended for moist site plantings, it has performed well on mine disturbances in southeastern Idaho, Montana, and Wyoming (fig. 25). It has established and grown well on sites receiving 16 to 24 inches (40.6 to 61.0 cm) of annual precipitation. The species has established from transplant stock on mixed, infertile mine wastes and exposed substrata. It has exhibited adaptability to coarse-textured spoils, rocky substrata, and mixed heavy-textured soils. It fixes nitrogen (USDA Forest Service 1948), which explains its excellent vigor and growth on infertile mine spoils. Thornburg (1982) reported that a number of collections are being evaluated for use on mined lands in the northern Great Plains.

This species is used to restore riparian disturbances; it is well suited to both mesic and dry sites. It provides overstory cover, thickets, and low ground cover. It is adapted to streambanks, sandbars, unstable soils, and moist sites in pinyon-juniper and sagebrush communities where few upright species grow. It transplants very well and can be used to populate open, exposed sites.

Figure 25—Silver buffaloberry has been successfully established on mine disturbances in southeastern Idaho.

Varieties and Ecotypes—None.

Family Elaeagnaceae

Shepherdia canadensis
Russet buffaloberry, soapberry

Description—Russet buffaloberry is a native, thornless, small to medium, spreading shrub 3 to 9 ft (0.9 to 2.7 m) tall (Thilenius and others 1974a). Branches are covered with brown peltate scales. Leaves vary in length from slightly less than 0.25 to 3 inches (0.5 to 8 cm). They are ovate to lanceolate, rounded apically and basally, green above and slightly pale beneath. Flowers vary from 1 to several per axil, and 0.08 to 0.12 inch (2 to 3 mm) long. Fruits are 0.16 to 0.28 inch (4 to 7 mm) long, red, and quite succulent (fig. 26). When mixed with water the fruits produce a soapy solution (Welsh and others 1987).

Ecological Relationships and Distribution—Russet buffaloberry occurs as an understory in aspen, fir, lodgepole pine, spruce, open woodlands, and old burns (Goodrich and Neese 1982; Viereck and Little 1972). It often forms dense thickets on gravel bars bordering streams. It is distributed from east-central Alaska to Newfoundland, and south to Maine, New York, Michigan, New Mexico, and Oregon (Viereck and Little 1972). It is widespread throughout Utah at elevations between 6,690 and 10,500 ft (2,000 and

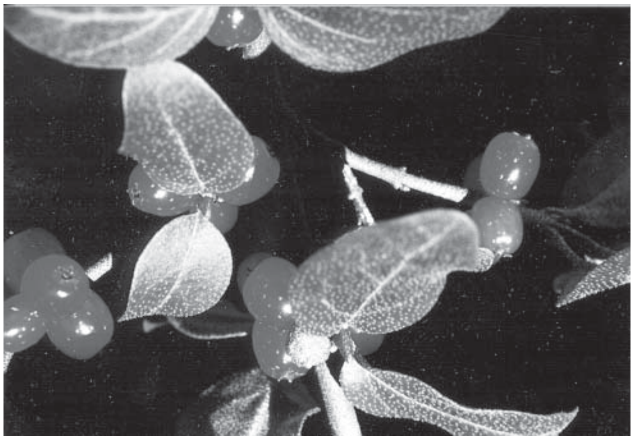

Figure 26—Fruits of russet buffaloberry are brilliant red and highly attractive. Seedlings establish well on mine sites and other disturbances.

3,200 m) (Welsh and others 1987), and it occupies similar elevations in Colorado (Harrington 1964).

Plant Culture—Thilenius and others (1974a) reported that this shrub is well suited for dry, rocky banks, but experimental plantings in central Idaho on mine and roadway disturbances have not been successful. Transplant stock propagated from native stands has not established well when planted on adjacent disturbances. The species appears sensitive to shade, soil disturbances, and competition from understory herbs. It has not established well on mine spoils or on streambanks that have been subjected to soil loss from flooding. Planting success may be significantly improved with the use of better quality stock, but this species has been less widely used and has not been as successful in revegetation plantings as silver buffaloberry.

Uses and Management—Russet buffaloberry occurs at rather high elevations and on sites where logging, road construction, and mining have created considerable disturbances; consequently, it has been used for revegetation of these sites. It provides useful ground cover and improves diversity in lodgepole pine forests where other understory and shrubs are lacking.

Varieties and Ecotypes—None.

Family Elaeagnaceae

Shepherdia rotundifolia
Roundleaf buffaloberry

Description—Roundleaf buffaloberry is a short statured plant growing 3 to 6.5 ft (0.9 to 2.0 m) in height. The twigs are stellate hairy with white or yellowish trichomes. Leaves are ovate to oval, rounded apically, silvery green above, pale beneath, and clothed with trichomes that provide a silvery appearance. Flowers are yellowish and very attractive. Fruits are 0.2 to 0.31 inch (5 to 8 mm) long, drupelike, and orange to red (Welsh and others 1987). This is an attractive shrub with distinct silver-green foliage, thick leaves, and colorful fruits and flowers.

Ecological Relationships and Distribution—Roundleaf buffaloberry is native to the blackbrush, ephedra, shadscale, pinyon-juniper, and ponderosa pine communities of southeastern Utah and Arizona (Welsh and others 1987). It is not reported from Colorado. This shrub is endemic to the Colorado Plateau (Welsh and others 1987), and occupies important areas where restoration of native shrubs is desirable (fig. 27). Investigative studies have been conducted to develop methods to culture and establish this species by artificial plantings.

Plant Culture—Seeds of roundleaf buffaloberry are relatively large compared to those of other buffaloberry species. There are about 6,855 cleaned seeds per lb (15,110 per kg) (Plummer and others 1968). Abundant seedcrops are produced infrequently, usually once every 3 to 10 years, although some fruits may be produced on individual plants more often. Plants flower early in spring, and fruits usually ripen in early to late July (Plummer and others 1968). The plants are very attractive because of the color contrast between the fruit and leaves. Berries are processed by maceration to release and separate the seeds. Seeds germinate erratically following extended periods of wet prechilling. Young plants grow slowly, even if protected from competition. Nursery and greenhouse-grown stock also grow slowly, although older plants grow somewhat faster.

Figure 27—Roundleaf buffaloberry is a unique, attractive shrub common to arid regions of the Colorado River drainage.

Uses and Management—This species is most important in the unique desert shrublands of southern Utah and Arizona. It provides useful ground cover, aesthetics, and limited, but seasonal forage for big game (Plummer and others 1968). Attempts to culture this species have only resulted in fair success; but with further research, this species may be of more use for restoration of recreational sites and native shrub communities. It has been successfully used in landscape plantings. It grows well with limited irrigation, and once established produces considerable foliage. It demonstrates utility in recreation plantings for screening campgrounds and related sites. It also provides a useful and attractive native shrub that can be used to restore native communities in highly used recreation sites.

Some collections of roundleaf buffaloberry have not survived when transferred to more northern climates in central Utah. This species normally grows with a limited understory and cannot compete well if planted with a dense cover of herbs. Plants are difficult to establish from transplanting or direct seeding.

Varieties and Ecotypes—None.

Family Ephedraceae

Ephedra nevadensis
Nevada ephedra

Description—Nevada ephedra or jointfir is a member of the gymnosperm family Ephedraceae. This dioecious shrub grows to 5 ft (1.5 m) tall and has evergreen stems with paired scalelike leaves 0.08 to 0.2 inch (2 to 5 mm) long (Welsh and others 1987). One to several male cones are borne at the nodes. Female cones are borne solitary at nodes and produce a pair of pale-brown to yellowish-green seeds (Welsh and others 1987). The stems of Nevada ephedra are divergent, coarse, bluish-green to gray, and produced on older wood. In contrast, green ephedra produces erect, parallel, broomlike stems that are green to yellow green in color (Cronquist and others 1972; Dayton 1931).

Ecological Relationships and Distribution—Nevada ephedra is a native perennial shrub that occurs throughout the Intermountain West in juniper-pinyon, big sagebrush, Indian ricegrass, rabbitbrush, black sagebrush, blackbrush, salt desert, and cresotebush types in central and southern Utah, Nevada, Arizona, California, and Mexico (Cronquist and others 1972). It frequently grows with green ephedra; however, it is usually more abundant on drier sites and in salt desert, black sagebrush, and blackbrush types. This species is generally found growing in areas with 7 to 14 inches (18 to 36 cm) of annual precipitation. Nevada ephedra has good tolerance to soil salinity and can be found growing in well-drained to fairly poorly drained soils ranging from rocky, sandy loams to fairly heavy clays (Dayton 1931; Plummer 1977). Nevada ephedra occurs in open stands of scattered plants, but commonly forms dense, slowly spreading colonies. Individual plants may be connected by underground stolons that develop when branches are covered with windblown sand or silt (Wallace and Romney 1972).

Plant Culture—Seed crops are produced erratically (Cronquist and others 1972; Wallace and Romney 1972). Generally, one good seed crop is produced every 5 to 6 years (fig. 28). Consequently, seed must be harvested and stored for anticipated planting needs. Within the Great Basin, cones appear in April to early May, and seeds ripen in July (Dayton 1931; Turner and Randall 1987). Farther south, cones appear in March and seed matures in June. Seeds are easily collected, cleaned, and seeded. Mature seeds must be collected quickly before they drop from the shrub or are gathered by rodents. They are collected by beating the cones into a container. Establishment and maintenance of seed orchards on adapted sites might alleviate seed supply problems. Four to 6 years should be allowed for stand establishment before significant seed crops are produced. Seeds can be easily separated from debris with an air screen cleaner, providing seeds with better than 99 percent purity. There are about 20,000 Nevada ephedra seeds per lb (44,100 per kg) at 100 percent purity.

Seed remains viable for long periods when stored air dry at room temperature. Seedlots of Nevada ephedra

Figure 28—Nevada ephedra generally grows on dry sites in pinyon juniper, big sagebrush, Indian ricegrass, rabbitbrush, black sagebrush, blackbrush, salt desert, and creosote communities.

exhibited 89 percent germination following 15 years of storage (Stevens and others 1981a). With 25 years of storage, germination was 77 percent (Stevens and Jorgensen 1994). Seeds germinate under a wide range of temperatures without wet prechilling or other pretreatments (Young and others 1977). Seeds of Nevada ephedra will germinate somewhat faster than seeds of green ephedra. Nevada ephedra can be seeded separately or in conjunction with other shrubs, grasses, and forbs within its native range. When drill seeded, Nevada ephedra and most other shrubs do best if planted in separate rows from competitive perennial grasses. Seeding Nevada ephedra through a seed dribbler or thimble seeder provides good results. Nevada ephedra does best when seeded on a firm seedbed and covered to 0.5 inch (1.3 cm) depth.

In most of the Intermountain West, Nevada ephedra should be seeded in fall to allow for effective use of spring soil moisture and precipitation (Plummer and others 1968). In the more southerly regions, good results have been obtained with midsummer seeding, just prior to the summer storm period. Plants often require 5 to 10 years to attain a height of more than 2 ft (61 cm) (Plummer and others 1968), yet seedlings emerge and establish quickly. Seedlings withstand extreme drought once established.

Nevada ephedra can be transplanted with moderate success (Plummer and others 1977). Roots of bareroot stock are generally weakly developed and are very fragile and easily damaged. The root systems of containerized stock are sometimes too small to bind the root plug together. The plug must be carefully removed from the container to avoid breaking the roots. Low root-to-shoot ratios are common for both types of stock, and survival rates are frequently less than 40 percent. Wieland and others (1971) found that *Ephedra* species could be propagated from rooted cuttings. Everett and others (1978a), however, reported little success in rooting cuttings of either Nevada ephedra or green ephedra.

Uses and Management—Nevada ephedra provides forage and cover for cattle, sheep, deer, and antelope (Dayton 1931; Dittberner and Olsen 1983; Kufeld and others 1973; Smith and Beale 1980; Stevens 1983b; Welsh and others 1987). It is reported to be the most important forage plant of the ephedra species (USDA Forest Service 1937). Use is often difficult to detect or measure because browsing causes the young stems to break off at the joints. Nevada ephedra can be an important source of browse during drought and winter periods. Quail and cottontail rabbits use the species for food and cover (Stanton 1974). Seeds are readily gathered and eaten by rodents and birds. Rodents cache seeds, which can then emerge in clusters of new seedlings.

Nevada ephedra has been used to stabilize rocky and sandy areas (Plummer 1977). It is well adapted for use as a low-maintenance, low-water-requiring ornamental for home sites, parks, recreational areas, and administrative areas. It establishes slowly and has not done well on exposed substrata at mine sites or on road disturbances. Plants should not be grazed for two to three growing seasons following seeding. Grazing and trampling should be avoided until shrubs become firmly established and are 5 to 8 inches (13 to 20 cm) tall.

Varieties and Ecotypes—None.

Family Ephedraceae

Ephedra viridis
Green ephedra

Description—Green ephedra is also called Brigham tea, Mormon tea, or jointfir. This dioecious shrub has evergreen stems, can grow to 4 ft (1.2 m) tall, and produces a deep fibrous root system (Cronquist and others 1972; Wasser 1982). Green ephedra produces erect, parallel, jointed, broomlike stems that are green to yellow green (Cronquist and others 1972). Leaves are small ligulelike scales, and are opposite at stem nodes. Plants are dioecous; male cones are compound, borne at the nodes or terminal points on the stems. Female cones are solitary or whorled, and sessile or peduncled (Wasser 1932; Welsh and others 1987). Cones are formed in pairs and are slightly boat shaped.

There are two varieties of green ephedra. *E. v.* var. *viridis* has sessile female cones, nonviscid stems, and grows to 6 ft (1.8 m) tall. *E. v.* var. *viscida* has pedunculate female cones and viscid stems. It occurs on sandy soils where it may be grasslike in appearance; it is often covered with sand with only small stems protruding (Kartesz and Kartesz 1980; Welsh and others 1987).

Ecological Relationships and Distribution—Green ephedra is a native, perennial shrub that occurs on shallow to medium depth soils, on sandy or rocky slopes and in valleys (Plummer and others 1968; Wasser 1982) throughout the Intermountain West (Cronquist and others 1972). It occurs in juniper-pinyon-sagebrush, rabbitbrush, black sagebrush, blackbrush, salt desert shrub, ponderosa pine, and mountain brush types (Plummer and others 1968; Stevens 1983b) (fig. 29). Green ephedra frequently grows with Nevada ephedra; however, it is usually more abundant on mesic sites with 9 to 14 inches (23 to 36 cm) of annual precipitation. Green ephedra occurs as dense, individual bushes and in large stands.

Figure 29—Green ephedra exists as an important component of many shrub communities in the foothill regions of central Utah.

It sprouts readily from the root or crown following fire (Young and Evans 1974, 1978b).

Plant Culture—Cones develop in April and May; seeds ripen in July and early August. The large seeds are easily collected, cleaned, and planted. Mature seeds must be collected quickly because they are dislodged from the plant by wind. Seeds are also quickly gathered by rodents and birds. Heavy seed crops are produced erratically (Plummer and others 1968). Generally, one good seed crop is produced every 5 years. Consequently, seed must be harvested and stored for later use. Seeds are harvested by dislodging them into a container. They can be easily separated from debris with an air screen cleaner. Seed lots usually are 99 percent pure. There are about 25,000 green ephedra seeds per lb (55,100 per kg) at l00 percent purity.

Seed remains viable for long periods when stored air dry at room temperatures. Stevens and others (1981a) found that seedlots of green ephedra exhibited 87 percent germination following 15 years of storage. With 25 years of storage, germination declined to 2 percent (Stevens and Jorgensen 1994). Seeds will germinate under a wide temperature range without wet prechilling or other pretreatments (Young and others 1977).

Green ephedra can be successfully seeded with other shrubs, grasses, and forbs within its native range. If drill seeded, it should be planted in separate rows to reduce competition with perennial grasses. Seeding green ephedra with a seed dribbler or thimble seeder has resulted in good success. Seeds establish best when planted at a depth of 0.5 inch (1.3 cm) on a firm seedbed. Rodents often gather planted seeds, and can limit the success of direct seedings.

In the Intermountain region, green ephedra should be seeded in the fall. (Plummer and others 1968; Vories 1981). Seedlings that emerge early and quickly can best withstand extreme drought. Both green ephedra and Nevada ephedra can be transplanted with only moderate success (Luke and Monsen 1984). The roots of bareroot stock and container stock develop slowly and are easily damaged. Survival rates are frequently less than 40 percent.

Uses and Management—Green ephedra provides forage and cover for cattle, sheep, deer, and antelope (Dayton 1931; Dittberner and Olsen 1983; Kufeld and others 1973; Smith and Beale 1980; Stevens 1983a; Welsh and others 1987). It is also grazed by bighorn sheep, rabbits, and quail (Stanton 1974). Green ephedra is heavily hedged by sheep, particularly during winter periods. Because of its evergreen growth habit and abundant herbage that protrudes above the snow, green ephedra is an important species on winter game and livestock ranges. Seeds are gathered and eaten by rodents and birds, which tend to spread the species.

Both green ephedra and Nevada ephedra can be used to stabilize rocky, sandy, and disturbed areas (Plummer 1977; USDA Forest Service 1976; Wasser 1982; Young and others 1979a). However, green ephedra persists much better on disturbances and exhibits adaptation to a wider range of soil conditions.

Although both green ephedra and Nevada ephedra have been used in ornamental and landscape plantings (USDA Forest Service 1976; Wasser 1982), green ephedra has survived much better, and is less sensitive to supplemental irrigation and cultivation.

Varieties and Ecotypes—None.

Family Ericaceae

Arctostaphylos uva-ursi
Bearberry manzanita

Description—Bearberry manzanita is a prostrate, mat-forming, evergreen shrub with stoloniferous stems (Hitchcock and Cronquist 1973; Morris and others 1962; Noste and Bushey 1987; Welsh and others 1987). The branches are ascending; the internodes are usually apparent, puberulent, and sometimes glandular. The exfoliating bark has a dull brown to red color. (fig. 30). Leaves are 0.2 to 1.1 inches (0.6 to 2.7 cm) long, 0.1 to 0.5 inch (3 to 12 mm) wide, oblanceolate to spatulate, and glabrous or puberulent, especially on the margins. The inflorescence is racemose. The axis and bracts are glandular. Flowers are pink to white, and 0.16 to 0.2 inch (4 to 5.2 mm) long. Fruits are 0.2 to 0.4 inch (6 to 11 mm) thick, globose, bright red, and

Figure 30—Bearberry manzanita is a mat-forming, evergreen shrub that provides excellent ground cover.

berrylike with separable nutlets. The four to 10 nutlets are fused or partially fused, 0.12 inch (3 mm) long, 0.08 inch (2 mm) wide, and light brown with a very thick seedcoat (Belcher 1985; Welsh and others 1987).

Many roots appear near the soil surface to form a dense, fibrous system (Berndt and Gibbons 1958). Numerous runners extend laterally from the crown to a distance in excess of 3 ft (0.9 m) (McLean 1967). Bearberry manzanita is able to regenerate by resprouting from stolons (Berndt and Gibbons 1958). Rowe (1983) reported that sprouting also occurs from large lignotubers.

Ecological Relationships and Distribution—Bearberry manzanita is circumpolar in distribution, occurring in North America from Labrador to Alaska, and south to northern California, and the mountains of New Mexico, Virginia, Illinois, and Nebraska (Berg 1974; Sampson and Jespersen 1963). It is common in ponderosa pine and Douglas-fir forests in mountainous regions, and it also occurs in oak woodlands and chaparral types in Arizona and California. Cooper and others (1987), Mueggler and Campbell (1986), and Youngblood and Mauk (1985) reported bearberry manzanita was present in many of the conifer forest and aspen types in Utah and northern Idaho. In Utah it is encountered in conifer forests at 7,000 to 11,500 ft (2,140 to 3,510 m) in the north and north-central portions of the State (Welsh and others 1987).

Bearberry manzanita exists on a variety of soil types including weakly developed soils and coarse-textured materials (Carmichael and others 1978). It is usually regarded as a late seral species. However, it does not form an abundant understory in forest communities in Utah and northern Idaho (Cooper and others 1987; Mueggler and Campbell 1986; Youngblood and Mauk 1985). It persists in open and shaded areas for extended periods, and thus remains as a component of various successional stages of community development.

Bearberry manzanita is generally not considered fire tolerant (McKell and others 1972), but some plants are able to survive burning. Following fire, new shoots develop from portions of the plant that did not burn. Seeds stored in the soil are stimulated to germinate by the heat treatment provided from burning (Carmichael and others 1978), and numerous seedlings may appear 1 to 5 years after a burn (Pase and Pond 1964).

Plant Culture—Flowers appear from March to May; fruits ripen from June to August and are dispersed from August to March (Berg 1974; Everett 1957; McMinn 1951; Munz and Keck 1959).

Fruits are collected by hand stripping, but some can be dislodged by beating the bush with a paddle. Seeds are easier to clean when the fruit is still green. If the fruit is allowed to dry, the fruit coat and fleshy material are difficult to remove. Cleaning is accomplished using a macerater to grind and remove the fleshy material from the seeds. Grinding is frequently conducted using water to flush away the fleshy material. After grinding, the material is dried and screened with a fanning mill to separate the seeds from other materials. Certain seedlots have a large number of empty seeds; these can be removed by flotation or use of a gravity table separator. Seeds can be stored for long periods at room or warehouse temperatures (Glazebrook 1941). Bearberry manzanita produces between 26,800 to 58,000 clean seeds per lb (59,080 to 127,870 per kg) (Berg 1974; Glazebrook 1941; McKeever 1938; Plummer and others 1968).

Seedcoats are thick, hard, and impermeable to water; however, a small opening extends from the surface of the seedcoat to the embryo. This is plugged with a waxlike substance that may be removed by soaking the seeds in sulfuric acid. Wet prechilling treatments are required to overcome the embryo dormancy. In addition, the embryo requires afterrippening (Glazebrook 1941). Most authors recommend various periods of acid scarification, followed by a warm pretreatment and a period of wet prechilling. Berg (1974) and Milstein and Milstein (1976) recommended 2 to 5 hours of acid scarification and planting in summer, or a warm pretreatment at 25 °C (77.0 °F) for 60 to 120 days, then a wet prechill for 60 to 90 days. McLean (1967) suggested an acid soak for 7 hours, followed by a warm, wet pretreatment at 68 °F (20.0 °C) for 90 days, and a wet prechill at 34 °F (1.1 °C) for 90 days. Giersbach (1937) recommended an acid soak for 3 to 5 hours, then overwinter storage outdoors in mulch flats.

Following treatment, seeds are usually incubated at high temperatures. Milstein and Milstein (1976) recommended incubating pretreated seeds at a constant temperature of 78 to 80 °F (25.6 to 26.7 °C). Berg (1974) suggested either constant temperature incubation at 77 °F (25.0 °C), or alternating 86 °F (30.0 °C) day, and 68 °F (20.0 °C) night. These treatments produced 30 to 61 percent germination in 15 to 30 days. Germination exceeding 90 percent has been reported by Glazebrook (1941).

Early summer planting, following acid soaking, is recommended by Berg (1974), Milstein and Milstein (1976), and Swingle (1939), but early fall seeding of treated seeds is also employed. Seeds are small and should be planted approximately 0.5 inch (1.3 cm) deep. Seed germination will normally occur in 20 to 40 days (Milstein and Milstein 1976). On wildland sites, seedling emergence has been observed to occur in 5 to 10 days. Seedlings are slow developing and can be suppressed by competitive vegetation. Also, seedbeds often dry rapidly and some seedlings fail to survive.

Plants can be easily propagated by stem tip cuttings (Berg 1974). Doran (1957) reported that cuttings taken in late fall or winter (October to February) root well. Eighty-eight percent of cuttings taken in October rooted in 22 weeks, but if treated with IBA, 3 mg per g of talc, 96 percent rooting occurred in 15 weeks. Stem cuttings taken in February rooted best, 90 percent in 11 weeks. Cuttings are rooted under greenhouse conditions using bottom heat at 76 °F (24.4 °C). Once stem cuttings are rooted, they survive field planting very well.

Bearberry manzanita is widely used for horticultural plantings. Considerable information is available related to vegetative propagation and culture (Darbyshire 1971; Dehgan 1972; Dehgan and others 1975; Hildreth 1969; Leopold and Kriedeman 1975). Dehgan and others (1977) recommended stem cuttings be taken in winter or early spring and treated with low IBA concentrations. Rooted cuttings survive better if hardened off gradually, starting with complete shade and progressing to an open situation. Potting material and pots should be well drained to avoid overwatering.

Uses and Management—Various authors consider the genus, *Arctostaphylos*, to provide quality browse (Conrad 1987), but reports by Cada (1971), Cooperrider (1969), Cowan (1947), Gullion (1964), Hill and Harris (1943), Kamps (1969), Kufeld and others (1973), and Lovaas (1958) indicated that the plant receives moderate use by wildlife. In general, it is one of the earliest shrubs to initiate growth in spring. Leaves are also maintained on the shrub during winter, and game animals are attracted to the plant during the winter and spring periods. It often grows on open sites, not heavily covered by snow, that are important winter grazing locations. Game animals frequently utilize the shrub, although it may not be a major portion of their diet.

Bearberry manzanita is widely used for landscape plantings, and numerous selections are available. Because it grows as a low-spreading plant, it has been used in erosion control and watershed plantings. It requires special care to assure establishment by transplanting as container or bareroot stock. Transplants must be dormant when field planted or they are susceptible to damage by frost or drought. Dormant stock that is field planted early in the spring survives well.

Small rooted transplants usually grow slowly, and often fail to survive if planted on unstable slopes or surfaces. Larger transplants (2-year-old stock) survive harsh conditions much better and grow faster. However, growth is usually slow and plants fail to provide immediate ground cover. Normally 3 to 5 years are required before plants spread and occupy a large area. If this species is used to control erosion, transplants should be spaced 1.5 to 2.5 ft (46 to 76 cm) apart, depending on surface conditions.

Collections acquired from wildland sites can be propagated for field plantings, but have demonstrated adaptability to specific site conditions. Materials growing in shaded areas beneath ponderosa pine perform erratically when transplanted in open areas at similar elevations. Transplants also grow poorly on road and mine disturbances, although poor performance may be due to poor planting stock. However, this species appears to be sensitive to soil conditions and has not survived on mine disturbances.

Bearberry manzanita slowly invades road and logging disturbances, but only in areas where some topsoil has accumulated. Although use is questionable on harsh disturbances, its growth habit is an important feature. Topsoiling and use of soil amendments significantly enhance survival and growth rates.

This plant has adapted well when used for recreational sites, landscaping summer homes, and other low-maintenance landscape areas. Considerable differences in ecotypes and growth forms are available to provide diversity in landscape plantings. It could be more widely used within the Intermountain area for this purpose.

Varieties and Ecotypes—Various horticultural selections are available, but materials have not been selected for wildland uses.

Family Fagacae

Quercus gambelii
Gambel oak

Description—Gambel oak (fig. 31) is a member of the white oak subgenus *Lepidobalanus*. Most taxonomists consider Gambel oak part of the *Quercus undulata* complex, which hybridize readily (Welsh

1986). Gambel oak is a native, broadleaf, deciduous shrub that typically forms dense stands (Neilson and Wullstein 1983). It generally grows from 3 to 20 ft (0.9 to 6 m) in height, forming spreading thickets connected by underground rhizomes (Christensen 1949). In the southern end of its range it can be treelike and as much as 20 to 25 ft (6 to 7.6 m) tall (Wagstaff 1985). Leaves are alternate and broadly obovate to oblong lanceolate, with considerable variation among clones. Leaves are somewhat leathery, yellow green to dark green above and pale yellowish and densely hairy below. They turn a deep-reddish color in fall.

This monoecious, wind-pollinated shrub bears red pistillate flowers in the upper leaf axils. Male flowers grow in pendent catkins that are borne singly or in groups at the base of new shoots (Harper and others 1985). Fruits are brown acorns enclosed in a cap. Acorns form and mature in 1 year (Harper and others 1985). Reproduction is primarily vegetative from an extensive, freely branching, underground network of lignotubers (enlarged, stemlike structures covered by numerous adventitious buds), roots, and rhizomes (Tiedemann and others 1987). Lignotubers account for up to 72 percent of the total belowground biomass (Tiedemann and others 1987).

Ecological Relationships and Distribution—Gambel oak is widely distributed throughout the Southern and Central Rockies. In the Intermountain West, Gambel oak occurs in valleys, foothills, on alluvial fans, and on lower mountain slopes between sagebrush, pinyon-juniper, aspen, and spruce-fir types. When it is not the dominant species, it can be found growing as a codominant with big sagebrush, pinyon, juniper, ponderosa pine, mountain mahogany, bitterbrush, cliffrose, aspen, snowberry, spruce, and fir.

Gambel oak occurs between 4,000 and 9,000 ft (1,200 and 2,700 m). Pure stands occur along the Wasatch Mountains, Wasatch Plateau, and west slope of the Rocky Mountians in western Colorado in nearly continuous belts (oakbelt) between 5,500 and 7,000 ft (1,700 and 2,100 m) (Cottam and others 1959). Gambel oak generally requires annual precipitation between 15 and 22 inches (38.1 and 55.9 cm) (Harper and others 1985). However, it does occur in some areas where annual precipitation is as low as 12 inches (30.5 cm). The most common soils in which Gambel oak occurs are calcarcous, heavy, and fine-grained loams. It can also be found on sandy, gravelly, and clay loams, and alluvial sands (Christensen 1955; Tucker and Muller 1958).

Figure 31—Clumps of Gambel oak provide soil protection and habitat for wildlife and livestock.

Gambel oak occurs as a climax species on many sites, and as a mid or early seral species on others (Harper and others 1985). In some areas Gambel oak is considered the ecological equivalent of ponderosa pine (Harper and others 1985).

Plant Culture—Gambel oak reproduces both vegetatively and sexually. Clones expand through both radial and lateral growth (Christensen 1955). Rate of vegetative spread ranges from 1.5 to 12 inches (381 to 360 mm) annually; the average is 4 inches (10 cm) per year (Christensen 1955). Gambel oak sprouts quickly after burning, wood harvesting, chaining, cabling, or other disturbances. Sprouts may appear 10 days after removal of top growth (Harrington 1985). Rate and degree of sprouting are greatest from clones with smaller stems. Clones with stems greater than 12 inches (31 cm) in diameter are poor sprouters (Reynolds and others 1970).

Sexual reproduction is by acorns. Acorns develop and mature in 1 year (Harper and others 1985). They usually ripen in late September and October, and can be collected by beating them into a container. Acorns must be stored in a cool, moist environment or they will dry and die. Storage should not extend beyond the first winter following collection because of rapid loss of viability. Seeding should occur in late fall or early spring. High pregermination mortality can result from predation by birds, mammals, insects, and parasitism. Acorns can germinate in fall after dispersal; they may be killed by frost if not covered by litter and snow (Christensen 1949). Seedlings are susceptible to damage by early fall or late spring frosts, grazing, and summer drought (Neilson and Wullstein 1983). Gambel oak seedlings are rare in many areas, particularly in the northern part of its range (Christensen 1955; Reynolds and others 1970).

Plants can be established from properly planted container stock. Establishment success has also resulted from moving partial clones with front-end loaders. This involves moving and placing 2 to 3 ft (61 to 90 cm) of soil, roots, rhizomes, and lignotubers. Gambel oak wildings do not transplant well.

Uses and Management—Gambel oak and associated species provide valuable food and cover for livestock and many wildlife species. This species is generally not highly palatable, but its abundance and availability, particularly on fall, winter, and spring ranges, make it an important browse species. Gambel oak is regarded as fair forage for all classes of livestock (Harrington 1985). Summer cattle use has been identified in northern Utah (Julander and Robinette 1950). Sheep use can be light (Dayton 1931). Gambel oak is used extensively by mule deer throughout the year (Bowns 1985; Harper and others 1985; Kufeld and others 1973). Elk browse oak during winter and spring (Kufeld 1973; Reynolds and others 1970). Bighorn sheep make use of the plant during summer months (Rominger and others 1988).

Young shoots and new growth are the most preferred portions of this shrub. Preference of most browsing animals for Gambel oak varies with availability of other species. Use increases as other species become less available. Gambel oak can be poisonous to livestock when used exclusively, but when consumed in combinations with other species, it is generally harmless (James and others 1980).

Quantity and quality of associated forage production can be very high in Gambel oak communities. Understory production may reach 3,000 lb per acre (3,360 kg per ha). Understory production within oak clones can be twice as high as between clones. Understory species within clones also green up 2 to 3 weeks earlier in the spring and stay green later in the season than do the same species between clones (Bowns 1985; Stevens and Davis 1985).

In most areas the Gambel oak type has the highest forage productivity potential of any vegetative type in the Intermountain West. It has been severely abused by livestock at many locations. Productive understory species have been grazed out and replaced by less productive plants. In most areas the understory is almost nonexistent. As a result oak density and clone size have increased substantially.

The Gambel oak type is important for livestock, wildlife, and watershed protection. These areas can be critical spring and fall ranges for cattle, sheep, deer, and elk, and winter range for elk. Floods produced by high-intensity July and August rainstorms are common on depleted Gambel oak stands. Heavy snow pack and spring snowmelt have the potential for producing destructive spring runoff from these depleated communities. It is important that the Gambel oak type be well managed and restored to its productive potential.

Gambel oak also provides valuable escape, thermal, and travel cover for deer, elk, livestock, and small mammals. A large number of birds use Gambel oak for nesting, hiding, and resting (Marti 1977). Acorns are highly preferred by deer, elk, hogs, javelina, turkey, band tailed pigeons, squirrels, and numerous small mammals and birds (Christensen 1949; Harper and others 1985; Reynolds and others 1970; Steinhoff 1980). Many small birds and mammals cache acorns for later use.

Gambel oak is a valuable browse and cover plant in many areas, but it can grow too dense and exclude understory vegetation, big game, and livestock. A mosaic of clones or stands interspersed with open areas provides the best habitat for big game and livestock (Stevens and Davis 1985). Management objectives should be directed toward maintaining a mosaic of clones and interspaces. Fire, herbicides, and mechanical treatment can be used successfully to open stands and increase accessibility to clones (Bowns 1985; Stevens and Davis 1985). When Gambel oak is disturbed, understory species should be seeded to improve composition and production and to retard oak suckering and regrowth (Stevens and Davis 1985).

Wood value of Gambel oak can be high (Clary and Tiedemann 1986). Average energy content is estimated at 340,000 Btu per ft^2 (4.77 kcal per g) (Harper and others 1985); it can be an economically important fuel wood with high heat-yielding qualities. Gambel oak has been used successfully for long-term rehabilitation of disturbed sites (Dittberner and Olsen 1983).

Gambel oak resprouts rapidly following fire. Rate of recovery varies with fire severity, climatic factors, and site characteristics (Harper and others 1985). Fire generally does not harm or kill Gambel oak. Spring and fall burns have little detrimental effect. However, summer burns can inhibit regrowth and may even kill Gambel oak (Harrington 1985). Following fire, the rate and amount of resprouting can be reduced by seeding competitive herbs (Stevens and Davis 1985). Gambel oak generally sprouts as early as 10 days after being burned (Harrington 1987). When Gambel oak is burned, chained, cabled, or otherwise disturbed, deer and elk browsing increase (Stevens and Davis 1985). Deer, elk, and livestock seem to prefer burned over oak communities (Harper and others 1983).

Improved Varieties—None. Considerable variation exists with this species throughout its geographical range.

Family Oleaceae

Fraxinus anomala
Singleleaf ash

Description—Singleleaf ash is one of only a few native ashes to occur in the Intermountain region. It is a small, deciduous shrub or tree, commonly 8 to 13 ft (2.4 to 4 m) tall (Welsh and others 1987), but sometimes attaining heights of 26 ft (8 m) (Goodrich and Neese 1986; Harrington 1964). It usually develops multiple stems, and branchlets that are characteristically four angled. Leaves are simple to two or three foliate, ovate, crenate-serrate to subentire, glabrous, 0.6 to 2.6 inches (1.5 to 6.5 cm) long, and 0.4 to 2.4 inches (1 to 6 cm) wide. Flowers are polygamous and occur in panicles with a minute calyx and no corolla. Fruit is a one-seeded samara, 0.5 to 1 inch (12 to 25 mm) long, 0.31 to 0.4 inch (8 to 10 mm) wide, and winged almost to the base (Goodrich and Neese 1986; Harrington 1964; Kearney and Peebles 1942; Munz and Keck 1959; Welsh and others 1987).

Ecological Relationships and Distribution— Singleleaf ash occurs from Colorado west to California and south to New Mexico and Arizona (Harrington 1964). It is common in west-central and southwestern Colorado at 4,500 to 6,000 ft (1,400 to 1,800 m) (Harrington 1964). It occurs on rocky, sandy canyons along the Green River in Utah (Goodrich and Neese 1986), but is more widespread throughout eastern and southern Utah. It exists in pinyon-juniper woodlands and mixed desert shrub communities mainly on rimrock or along drainages at elevations between 2,900 and 8,500 ft (890 and 2,600 m) (Welsh and others 1987). It occupies dry canyons and gulches between 3,000 and 11,000 ft (910 and 3,400 m) in California (Munz and Keck 1959).

The plant is important on upland sites where it grows intermixed with salt desert shrubs, pinyon-juniper, and basin big sagebrush. It is particularly abundant in the Four Corners region and throughout much of the Colorado River drainage where it occurs on sandstone outcrops and shallow soils (fig. 32). It does not form dense stands, but is normally found scattered among rocky bluffs and ledges. It also occurs on limestone soils, but usually on well-drained sites (Stark 1966).

Figure 32—Singleleaf ash occurs on shallow soils and sandstone outcrops in the Four Corners area.

Plant Culture—Small, rather inconspicuous flowers appear from April to May at about the same time the leaves develop. Flowers are grouped in terminal or axillary clusters. Fruits are long, single-seeded samaras with distinct wings that are borne in clusters. They ripen from mid-July to mid-August (Plummer and others 1968). As fruits mature they change from green to yellow or light brown. Fruits often remain on the bush for a number of weeks before dispersing. Ripened fruits can easily be collected by hand picking or dislodging them onto canvas spread on the ground.

Fruits are dried before cleaning. They are separated from stems and leaves by fanning or with air screen cleaners. The wings can be removed from the fruit by grinding or maceration. Removing the wings aids in planting, but does not affect germination. Seeds of most ash species must be stored in sealed containers at 4l °F (5.0 °C) and 7 to 10 percent moisture content.

Singleleaf ash produces good seed crops infrequently. Abundant crops may be produced once every 3 to 5 years. Insects damage a number of seeds as they ripen. Usually, less than 50 percent of the seeds from wildland collections are viable. A number of freshly collected seeds will germinate, but most are dormant and require wet prechilling. Seeds sown in fall usually receive an adequate wet prechilling treatment and germinate uniformly in spring. Artificial wet prechilling of ash seeds is accomplished by diurnal alternating temperatures of 86 and 68 °F (30 and 20 °C) (Bonner 1974b).

Uncleaned or dewinged fruits are difficult to seed with conventional drills. The fruits are large and irregular in shape and do not flow through seedboxes and seeding equipment. Fruits should be planted in the soil at a depth of about 0.5 inch (1.3 cm).

Trial seedings, primarily in central Utah, have produced irregular stands. This has been attributed to seeding poor quality seed. Seedlings and young plants grow quite slowly. Even under irrigation, nursery-grown plants develop slowly. Wildland planted seedlings often increase only 6 inches (15.2 cm) in height during a single season. As plants reach 3 to 5 years of age, the growth rate increases. A dense, well-branched root system is formed the first year; once established the plants are very persistent.

Singleleaf ash can be grown as transplant stock for field plantings, although transplanting success has been quite erratic. One-year-old transplants are not very large, usually less than 5 to 6 inches (12.7 to 15.2 cm) tall, but with healthy root systems. Survival of transplanted stock has often been 25 to 40 percent, but losses are often attributed to extreme conditions of the planting sites. Growth response of singleleaf ash has varied among collections. Plant materials obtained from eastern Utah have grown quite slowly, but plants establish and persist very well.

Uses and Management—Singleleaf ash is one of only a few shrubs or trees adapted to rocky and arid sites in the sagebrush, salt desert shrub, and pinyon-juniper communities. It develops an upright growth form that provides food and cover for wild animals and domestic stock. The plants are very persistent, and are not eliminated by extended periods of drought or heavy browsing. Singleleaf ash is also well adapted to infertile soils, and performs well in such situations. The plant serves as an overstory species with sagebrush and fourwing saltbush, providing cover and protection for wildlife in barren areas. When intermixed with pinyon and juniper, it provides forage diversity for game and livestock.

Singleleaf ash competes well with pinyon and juniper, and if not heavily grazed, it is able to remain vigorous and healthy amid dense stands of these trees. The species is an important plant for watershed protection; it grows in areas where high-intensity rains occur infrequently, but can cause considerable erosion. This species is also able to persist and provide cover on sites where few other species may occur.

Singleleaf ash has been used to a limited extent on mine sites, roadways, and recreational disturbances. A slow growth rate, however, limits its value in areas where rapid development of cover is desired. It is suited to rocky soils, but is not well adapted to mine disturbances if planted on mine wastes or substrates. It has considerable potential for landscape plantings, particularly in highly scenic areas of eastern and southern Utah. It can be used to restore disturbances near recreational areas, parks, and roadways. Additional information is needed to improve the culture of this important species.

Varieties and Ecotypes—None.

Family Polygconaceae

Eriogonum heracleoides, Wyeth or whorled eriogonum, buckwheat
Eriogonum umbellatum, Sulfur eriogonum, buckwheat
Eriogonum wrightii, Wright eriogonum, buckwheat

Introduction—Eriogonum or buckwheat, as most species are commonly called, occurs only in North America. There are a considerable number of *Eriogonum* species in the Western United States (Dayton 1931, 1960; Harrington 1964; Hitchcock and others 1964; Judd 1962; Welsh and others 1987). The genus includes annual and perennial herbs, subshrubs, and woody shrubs. Most species have taproots; some of the subshrubs have spreading or prostrate stems that root at the joints (Dayton 1960). The shrubby species generally produce semierect stems. Flowering stocks are herbaceous, erect, and leafless. Flowers are small and arranged in umbels, cymes, or racemes. The fruit is a three-angled or three-winged achene (Dayton 1931, 1960; Hitchcock and others 1964; Welsh and others 1987). Sulfur eriogonum, Wyeth eriogonum, and Wright erigonum have been the most successful species used in restoration projects. They are easily cultured and establish well without extensive seedbed preparation or protection of young seedlings. They exist on dry situations, and prefer rocky, sandy, well-drained soils in areas of moderate to low rainfall. Consequently, they are useful shrubs in restoration of harsh sites.

Varieties and Ecotypes—None.

Family Polygconaceae

Eriogonum heracleoides
Wyeth or whorled eriogonum, buckwheat

Description—Wyeth eriogonum is a native perennial, mat-forming subshrub with woody branches and persistent vegetative stems. Stems arise from rosettelike bases and produce distinctive whorled leaves. Flowering stems are densely branched and grow to 2.5 ft (76 cm) in height. Cream-colored to yellow flowers develop on umbellate inflorescences (fig. 33) (Hitchcock and others 1964; Welsh and others 1987). Abundant seeds are generally produced each year. There are about 141,000 seeds per lb (310,800 per kg) at 100 percent purity.

Ecological Relationships and Distribution—Wyeth eriogonum is widely distributed in British Columbia, Montana, Utah, Wyoming, Nevada, and California (Dayton 1960). It is most prevalent in mountain brush and pinyon-juniper communities, but it also occurs in sagebrush-grass, aspen, and spruce-fir types. It invades disturbed sites but is less competitive with annual weeds, particularly cheatgrass, than sulfur buckwheat. This species does well on disturbed sites and openings in various communities and will spread naturally if not heavily used (Plummer 1970). It does increase following burns.

Plant Culture—Wyeth eriogonum, sulfur erigonum, and Wright eriogonum produce good seed crops most years. Even during dry years, some seeds develop. Seeds are quite easily collected by beating them into a container. Seeds are not difficult to clean; they are simply separated from the debris with a fan and screen separator.

Seeds of all three species can be drilled or broadcast seeded, but they should not be planted more than 0.1 inch (3 mm) deep. Fall and winter seeding are preferred. Seeds of all three species germinate readily,

Figure 33—Wyeth eriogonum flowers in early summer and generally produces a reliable seed crop.

reduced. Birds and small mammals seek out and consume the seeds. This species has considerable ornamental potential, especially on low-maintenance areas.

Improved Varieties—None.

Family Polygonaceae ____________

Eriogonum umbellatum
Sulfur eriogonum

Description—Sulfur eriogonum or buckwheat is a perennial subshrub with a strong taproot and freely branching crown. The branches can be prostrate and mat forming, but are usually upright, growing to a height of 1 ft (30.5 cm). Leaves are oval to oblanceolate, green above and grayish beneath, arising from rosettelike stem tips. The inflorescence is a freely branching umbel on a stem about 1 ft (30.5 cm) long. Leaflike bracts develop near the middle of the flowering stem. Flowers are cream colored to deep yellow or greenish yellow. Flowering stems and floral tissue often persist throughout the winter (Dayton 1931, 1960; Hitchcock and others 1964; Welsh and others 1987).

Ecological Relationships and Distribution—Sulfur eriogonum occurs widely throughout Western North America in big sagebrush, pinyon-juniper, mountain brush, ponderosa pine, spruce-fir, aspen, and subalpine communities (Dayton 1960). It is especially well adapted to rocky and exposed sites, and quickly invades and occupies disturbed areas (fig. 34). Seedlings are persistent and competitive. They grow rapidly and

resulting in fairly uniform emergence over a 2-week period in early spring. Seedlings are fairly frost and drought tolerant. All three species establish fairly well when planted in combination with grasses, shrubs, and forbs. Aggressive perennial grasses can, however, become dominant.

Sulfur, Wyeth, and Wright eriogonum establish well from direct seeding and spread naturally on severely disturbed sites such as mines, road cuts and fills, construction sites, and gravel and sand pits. These species are generally able to persist and increase in density following wildfires. Buckwheats most often increase in importance.

Uses and Management—Livestock and big game graze Wyeth eriogonum (Dayton 1960). Most use occurs in late fall and winter when other species are dormant, but some use occurs during summer. This species recovers well from heavy use and will increase in density and productivity when grazing pressure is

Figure 34—Sulfur eriogonum directly seeded on shallow soils persists with competitive annual grasses.

will spread into cheatgrass and perennial bunchgrass communities.

Plant Culture—Seeds of sulfur eriogonum can be harvested, processed, and seeded as described for Wyeth eriogonum.

Uses and Management—Sulfur buckwheat can be an important browse species for sheep, goats, cattle, mule deer, elk, and antelope (Dayton 1931, 1960; Kufeld 1973; Kufeld and others 1973; Monsen 1975; Smith and Beale 1980). This shrub is semievergreen and produces useful forage. Plants receive some summer use, but most use occurs in late fall and winter. Even when heavily grazed, sulfur eriogonum survives and spreads on sites where other important forage plants have succumbed (Monson 1975). Birds and small mammals consume the seeds.

The species has been seeded successfully on severely disturbed sites. It provides rapid soil stabilization and will spread fairly aggressively from seeds to fill openings in the community. It is able to survive on unstable soils, but is not able to persist if buried by soil sloughing. Like other species of eriogonum, sulfur eriogonum has considerable ornamental value, especially in low-maintenance, low-precipitation situations.

Varieties and Ecotypes—"Sierra" sulfur flower buckwheat (*E. umbellatum* var. *polyanthum*) was released for use in California.

Family Polygconaceae

Eriogonum wrightii
Wright eriogonum

Description—Wright eriogonum is a low, white, woolly, perennial shrub usually less than 2 ft (61.0 cm) tall. It commonly forms a basal crown from which many branched stems emerge. The leaves are oblanceolate, sharp pointed at the tips, and covered with fine, white, woolly hairs. The white or pinkish flowers are borne in umbels at the apex of rather short leafless flower stalks (Judd 1962; Welsh and others 1987).

Ecological Relationships and Distribution—Wright eriogonum is found primarily in pinyon-juniper, oak woodlands, and chaparral types in southern Utah, California, Arizona, New Mexico, and Texas (Welsh and others 1987).

Plant Culture—This species is easily established by direct seeding. Seedlings are vigorous, drought tolerant, and persistent. Seeds are usually hand harvested and processed with an air separator.

Uses and Management—Wright eriogonum is considered fairly good forage for sheep and goats and fair for cattle (Judd 1962; USDA Forest Service 1937). Under heavy grazing, this species can be replaced by burroweed and snakeweed (Judd 1962). Birds and small mammals seek out and consume the seeds. Wright eriogonum persists well during drought periods and will increase following burns. This species has been seeded successfully on disturbed sites. It can provide rapid soil stabilization and will spread fairly aggressively from seed.

Varieties and Ecotypes—None.

Family Ranunculaceae

Clematis ligusticifolia
Western virginsbower

Description—Western virginsbower is a woody, climbing vine. The vigorous, glabrous to densely strigose, or villous stems grow to 33 ft (10 m) in length, forming masses of vegetative growth that clamber over neighboring trees and shrubs. Root systems are shallow and fibrous. The opposite deciduous leaves are pinnately compound with 3, 5, or 7 lanceolate to broadly ovate to chordate leaflets. Each leaflet is 0.8 to 3.0 inches (2 to 7.6 cm) long and coarsely few toothed, or sometimes lobed or nearly entire. The twisting petioles develop from enlarged stem nodes and curl around supporting vegetation (USDA Forest Service 1937). The sweet-smelling dioecious flowers are clustered in few-to-many-flowered bracteate cymes. The four oblong-lanceolate sepals are white to cream colored, 0.2 to 0.6 inch (5 to 15 mm) long. There are no petals. Male flowers have numerous stamens and no pistils. Stamens of the female flowers are numerous, but sterile. Pistils are numerous in a capitate cluster. The plumose styles of the villous achenes elongate to 1.0 to 2 inches (2.5 to 5.1 cm) at maturity (Clebsch 1979; Harrington 1964; Hitchcock and others 1961; Welsh and others 1987). Chromosome number is 2n = 16. Geographic races are sometimes recognized (Vines 1960).

Ecological Relationships and Distribution—There are more than 200 species of *Clematis*, occurring primarily in the Temperate Zone of the Northern Hemisphere (Hitchcock and others 1964; Rudolf 1974). Western virginsbower is distributed from British Columbia west of the Cascades to the Columbia River, south on both sides of the Cascades to southern California, and east from Saskatchewan to New Mexico (Hitchcock and others 1961; Rudolf 1974; Welsh and others 1987). It commonly occurs along drainages, in riparian communities, and on steep talus slopes and canyon walls where it trails over boulders, banks, and vegetation.

Western virginsbower is common on roadsides and other disturbed sites. It frequently occurs with other woody species such as cottonwood, willow, common chokecherry, Rocky Mountain maple, bigtooth maple, rubber rabbitbrush, ponderosa pine, and Douglas-fir. It grows on well-drained sandy to rocky soils, ranging from weakly acidic to moderately basic, and may occur on somewhat saline soils (Wasser 1982). It usually grows in areas receiving 12 to 20 inches (30.5 to 50.8 cm) of annual precipitation, but it is most abundant in areas receiving supplementary water. Drought tolerance of established plants varies among populations. Most are weakly to moderately drought tolerant (Wasser 1982). Seeds and vegetative production are markedly reduced in dry years.

Plant Culture—Flowering occurs from March to August and achenes ripen from May to December, depending on geographic location (Mirov and Kraebel 1939; Plummer and others 1968; Swingle 1939). Moderate to heavy seed crops are produced almost every year. Mature fruits are dry and brown with feathery white styles. They are dispersed by wind and gravity; rate of dispersal depends on weather conditions. Fruits are gathered by hand or with a vacuum seed harvester (Plummer and others 1968). Dried fruits are hammermilled with a 3⁄16-inch (0.5-cm) screen operated at 1,120 rpm to detach the styles from the achenes (Wasser 1982). Debris is removed by fanning. Seeds are not removed from the achenes.

Estimates of the number of seeds per lb range from 93,000 to 328,000 (205,000 to 723,000 per kg) (Mirov and Kraebel 1939; Rudolf 1974; Swingle 1939). A purity of 20 to 50 percent and germination of 70 percent are recommended for seed purchases. Greater purities are difficult and expensive to achieve. Viability has been maintained for 2 years in dry storage (Plummer and others 1968).

Wet prechilling at 33 to 40 °F (0.6 to 4.4 °C) for 2 to 180 days is required to release embryo dormancy (Heit 1968a; Rudolf 1974; Young and Young 1986). Germination of wet prechilled seeds after 40 to 60 days at 68 to 86 °F (20 to 30 °C) ranged from 11 to 84 percent (Mirov and Kraebel 1939; Plummer and others 1968; Swingle 1939).

Western virginsbower may be direct seeded in mixtures with other shrubs by drilling or broadcasting. Untreated seeds may be fall planted (Rudolf 1974). Seed should be wet prechilled prior to spring planting (Swingle 1939). Seeds should be covered with about 0.3 to 0.5 inch (7 to 13 mm) of soil. Seedlings are vigorous, but growth is reduced by herbaceous competition. Consequently, no more than 50 percent of the mixture should consist of grass seeds. Western virginsbower normally should be seeded in mixtures at a rate of 1 lb per acre (1.1 kg per ha) or less (Wasser 1982). Holmgren (1954) reported good growth rates, but low survival of seedlings emerging from seedings on southern Idaho big game winter range. Seedlings were quite sensitive to competition from cheatgrass and broadleaf herbs.

Bareroot and container stock establish readily and grow rapidly. Seeds should be cleaned carefully to improve stand uniformity in nursery plantings. Container seedlings may be established from seeds or from cuttings of partially matured wood harvested from late spring to late summer. Young wood with short internodes gives less satisfactory results. Leaf bud cuttings taken in summer may be rooted under mist (Hartmann and others 1990). Layering is useful if only a few plants are needed.

Uses and Management—Western virginsbower is used in seeding or transplanting projects to improve cover and forage for many birds and small mammals. Smith (1953) found that captive mule deer preference for western virginsbower was greatest in early summer and decreased considerably by late summer relative to other native shrub forages provided. The plant receives little use by big game on mule deer winter ranges in southern Idaho (Holmgren 1954). Dixon (1934) reported that its palatability to mule deer in California was low. It receives little use by livestock.

Because of its rapid growth rate, generally low palatability, and ability to naturally invade disturbed sites, western virginsbower is a potentially valuable species for restoring disturbed sites with native vegetation (Bailey 1947; Plummer and others 1968; Rehder 1940; Van Dersal 1938). It has been used for soil stabilization on riparian areas and mined lands (Thornburg 1982), and is particularly useful on steep slopes that would otherwise be revegetated only slowly by herbaceous species (fig. 35). Wider use of the species

Figure 35—Western virginsbower growing on a road fill provides excellent soil stabilization.

is precluded by the difficulty of harvesting and processing large quantities of seed. Seedlings established from seeds or transplant stock develop rapidly, often flowering the first year, and provide cover while other planted species develop more slowly. Seeds and seedlings are sometimes consumed or damaged by small mammals. Leaf spots and rusts are often noted on the foliage, and downy mildew is occasionally a problem (Holmgren 1954).

Plants are moderately shade and frost tolerant, but thermal tolerance varies among ecotypes (Wasser 1982). Shoots may be destroyed by wildfires. Some plants survive by resprouting from rootstocks. The species also reestablishes burned areas by wind dispersal of seeds produced offsite (Plummer and others 1968; Thornburg 1982).

Western virginsbowers' cascade of yellowish foliage and clusters of feathery styles make it a unique and attractive ornamental for use in dry areas (Plummer and others 1968). The plant requires a large shrub or small tree for support. It may be trained to grow over a fence or trellis. Late winter pruning confines the plant to smaller areas (Clebsch 1979). Plants are most productive if planted well away from the supporting plant in slightly acid to moderately alkaline soil. Rich, moist soil and mulching provide needed thermal protection for the root system.

Varieties and Ecotypes—None. Selection trials are being conducted by the USDA Soil Conservation Service, Pullman Plant Materials Center, Pullman, WA, for a cultivar adapted to the northern Intermountain region.

Family Rhamnaceae

Ceanothus species

Introduction—Numerous species of Ceanothus occur in the Western United States. Munz (1974) described over 75 species in California. Considerably fewer species occur in the Intermountain region (Harrington 1964; Welsh and others 1987). However, many species common to the Southwest, northern California, Oregon, and southern Washington have been tested in the Intermountain area. Species that have been entered into adaptation trials were selected from sites with somewhat similar climatic and edaphic conditions.

Different species of Ceanothus possess important traits and have been planted in an attempt to enhance wildlife, range, watershed, or horticultural resources in areas outside their natural range. Although a number of species have been initially screened for adaptability to the Intermountain region, the species discussed in this chapter have been the most promising.

In general, species of Ceanothus have a number of attributes that are important for revegetation. Seeds are easily cleaned and planted. Small seedlings are vigorous and young plants grow rapidly; only a few other shrubs grow as quickly as Ceanothus. Species of Ceanothus are capable of nitrogen fixation and most are well adapted to infertile soils. Most are excellent forage plants, yet recover well from grazing.

Family Rhamnaceae

Ceanothus cuneatus
Wedgeleaf ceanothus

Description—Wedgeleaf ceanothus (fig. 36) is an evergreen shrub (Munz 1974) distributed from Mexico to California, Nevada, Oregon, and southern Washington (Munz 1974; Peck 1941). It is a highly palatable evergreen species, and is heavily browsed as a winter forage (Conard and others 1985; Gibbens and Pieper 1962; Gibbens and Schultz 1963). It is an upright shrub ranging in height from 3 to 23 ft (0.9 to 7 m) (Munz 1974) and forming dense thickets (Stubbendieck and others 1986).

Ecological Relationships and Distribution—Collections from Butte, Shasta, and Siskiyou Counties in California, and Jackson County, OR, have been planted throughout the Intermountain area. Selections from approximately 2,000 ft (610 m) elevation, growing on granitic and basalt soils, have been planted in Utah, Idaho, Nevada, Wyoming, and Colorado. This species occurs as an understory in a number of ponderosa pine communities; outplantings have primarily been confined to ponderosa pine or mountain brush sites in the Intermountain area. Various collections have also been used to treat disturbed sites in southern California (Fessenden 1979).

Figure 36—Capsules of wedgeleaf ceanothus must be harvested when green as they dehisce explosively when dry.

Plant Culture—Seeds of the approximately 12 collections tested in the Intermountain area express similar features. They are small with 49,000 to 54,000 cleaned seeds per lb (108,000 to 119,000 per kg) (Reed 1974; Van Dersal 1938). Plants established in the Intermountain area usually produce good seed crops annually from healthy bushes. Few seedlings have appeared from natural spread in any study site, although some sites are frequently cultivated, which would result in seed burial.

Seeds germinate and establish well from late fall and early winter seedings. Rodents gather ripened seeds from trial plantings and native stands (Conard and others 1985). Consequently, late fall plantings are advised to reduce rodent damage to new plantings. Wedgeleaf ceanothus seeds germinate abundantly after fires (Reed 1974; Sampson and Jespersen 1963); seeds also benefit after being treated with boiling water (Grisez and Hardin 1967). Seeds placed in boiling water for 1 to 3 minutes germinated rapidly and more uniformly than untreated seeds. This response has been recorded for numerous collections. Seeds that are fall seeded following hot water treatment are generally adequately wet prechilled and germinate well in the spring.

New seedlings are quite vigorous and grow rapidly. Growth exceeds that of big sagebrush, antelope bitterbrush, and other commonly seeded shrubs. Young plants are able to recover following some browsing, but Medin and Ferguson (1980) reported that developing stands established by seeding and transplanting on winter game ranges in Idaho ultimately succumb to continued heavy grazing by big game, small mammals, grasshoppers, and to winter injury. Plants are very palatable (Gibbens and Schultz 1963; Scrivner and others 1988) and are heavily used by game and livestock.

Plantings conducted within the Intermountain area exhibit adaptation to a wide array of sites. The species does express broad amplitude (Detling 1961). Of the selections being tested, few exhibit adaptation to calcareous soils common in Utah and Nevada. Plants have established on these basic soils, but normally succumb in 4 to 6 years. Plantings established in central Idaho on granitic neutral or slightly acidic soils have survived quite well. However, collections from central California and Oregon have suffered winter damage. Normally portions of the crown are killed in a single season; however, some plants have persisted for over 30 years. This species cannot be recommended for use on wildlands outside its natural range. However, within its natural range it could be used for watershed protection and wildlife. It can be used for low-maintainance landscaping in areas within its natural range and on similar sites elsewhere.

Uses and Management—The species demonstrates usefulness for seeding disturbed watersheds; it grows rapidly and furnishes excellent ground cover. It also provides cover on open, wind-blown game ranges. This species' ability to fix nitrogen also contributes to its usefulness in range, watershed, and disturbed land plantings.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus greggii
Desert ceanothus

Description—Desert ceanothus is a low-growing to erect shrub 1 to 6.5 ft (0.3 to 2 m) tall, with thick, persistent, entire leaves (Welsh and others 1987). Desert ceanothus grows in mixed desert shrub communities including pinyon-juniper, ponderosa pine, chaparral, and mountain brush sites in Nevada, California, Arizona, New Mexico, Texas, and Mexico (Kearney and Peebles 1960; Thornburg 1982; Welsh and others 1987). It occurs at elevations between 4,000 and 9,400 ft (1,220 to 2,870 m) in southern Utah (Welsh and others 1987).

Ecological Relationships and Distribution—Only a limited number of collections, primarily from southern Utah, have been used in wildland seedings. Collections acquired from scattered stands growing on rocky slopes, and from nearby pure stands, have been tested. Although this species grows on a variety of soil types (Carmichael and others 1978; Plummer 1977; Stark 1966; Thornburg 1982), collections obtained from basic to coarse-textured soils have been the only ones tested. This species is well suited to arid sites and provides an opportunity to enhance plantings where few shrubs are adapted and most species are difficult to establish. Desert ceanothus has been incorporated into a few range and wildlife improvement projects in central and southern Utah.

Plant Culture—Seedlings establish best from late fall and winter seedings. Seeds are small, yet larger than most other species of Ceanothus. There are approximately 23,000 cleaned seeds per lb (50,700 per kg) (Reed 1974). Seeds are borne in capsules that split and disperse the seeds from the bush. Hot water treatments effectively improve germination. Untreated seeds require approximately 42 days of wet prechilling to initiate germination (Stark 1966).

Good seed crops are not produced each year, even from bushes grown under cultivation. Generally, commercially harvestable crops are produced once every 3 to 4 years. Only about one-half the seeds acquired from arid native stands and wildlife plantings in Utah are viable. Keeley (1977) reported similar numbers of viable seeds from wildland collections at other locations. Plants flower in April and May; seeds ripen in July (Reed 1974; Van Dersal 1938) and can be hand collected by stripping the capsules. Like other species of Ceanothus, desert ceanothus seeds disseminate as they ripen. Seeds must be collected when slightly green and stored to allow drying.

Uses and Management—Desert ceanothus is a valuable browse species for big game (Bradley 1965; Gullion 1964; Leach 1956; Pase and Pond 1964; Powell 1988), and is a particularly important winter forage (Conard 1987; Van Dersal 1938) and summer browse for livestock (Boles 1987).

This shrub establishes quickly and is well adapted to fresh disturbances. Horton (1949) reported that plants survive well on road disturbances on coarse-textured soils at elevations near 5,350 ft (1,630 m) in California, and recommended planting container stock or direct seeding in spots to control erosion. Desert ceanothus recovers following fire because seeds stored in the soil are fire activated. Resprouting from root crowns does occur, but only infrequently.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus integerrimus
Deerbrush ceanothus

Description—Deerbrush ceanothus is a spreading, erect, deciduous shrub that grows rapidly (Cronemiller 1959; Hitchcock and Cronquist 1973; Munz 1974; Van Dersal 1938). Leaves are large and oblong-ovate in shape (Cronemiller 1959); some remain on the bush throughout the winter (Cronemiller 1959; Munz 1974; Van Dersal 1938). Like other species of Ceanothus, it is able to fix nitrogen (Biswell 1960; Harvey and others 1980).

Plant Culture—Seeds ripen in midsummer and are dispersed as the capsule dries and dehisces (Keeley 1987). The seeds are smaller than those of most other Ceanothus species with about 70,000 cleaned seeds per lb (154,300 per kg) (Reed 1974). Seeds are long-lived and may persist in the soil for decades (Cronemiller 1959; Pase and Brown 1982; Quick and Quick 1961). Seedcoats are impermeable to water, and embryo dormancy also exists (Heit 1967a). Seed germination can be enhanced by heat pretreaments (Shmida and Barbour 1982), and is best induced by boiling the seeds for 1 to 3 minutes followed by wet prechilling (Quick and Quick 1961). Viability of deerbrush ceanothus seed lots usually is higher than for seed lots of other species of this genus. Over 85 percent of cleaned seeds are often viable (Van Dersal 1938). Empty or immature seeds are difficult to separate from filled seeds using a gravity table or by flotation.

Ecological Relationships and Distribution—Deerbrush ceanothus is widely distributed in the Cascade Mountains of Oregon and Washington southward to southern California, Arizona, and New Mexico (Conard and others 1985; Kearney and Peebles 1960; Munz 1974; Peck 1941). It grows as the dominant understory in a number of tree and shrub communities (Conard 1987; Conard and others 1985; Gratkowski 1961a; Hartesveldt and others 1975). It is also well suited to open, dry slopes with and without shade (USDA Forest Service 1937). Based on its range of adaptation and rapid growth, this species has been evaluated for watershed and wildlife habitat improvement projects in central Idaho (fig. 37). Plantings have established well from fall and winter seeding or transplantings of bareroot stock. Young plants grow rapidly; yearly growth rates have exceeded 30 inches (76 cm). In addition, the shrub exhibits an ability to persist with understory grasses and herbs. The species sprouts aggressively following clipping. Although stem layering was reported by Biswell and Gilman (1961), this attribute has not been observed from plantings in Idaho. Deerbrush ceanothus grows well on fertile soils, but collections currently under study are not especially drought tolerant.

Uses and Management—Collections from California and Oregon have been evaluated for their ability to control erosion and restore wildlife habitat on logging roads and related disturbances where ground cover is essential. The plants form extensive, fibrous root systems when nursery grown. The root system provides excellent soil stability, and plants effectively stabilize erodible slopes and unstable banks. Plantings established at numerous sites in Idaho have been

Figure 37—Deerbrush ceanothus in south-central Idaho plantings provide excellent wildlife habitat and watershed protection.

seriously weakened and thinned by cold winter temperatures. The plants are not cold tolerant and serious dieback occurs each year. Less than 20 percent have survived on these plantings. Winter losses have also been noted from 1-year-old stock growing in nursery beds. The shrub has failed when planted on mine disturbances and infertile sites in Idaho, Utah, Nevada, and Wyoming, although Biswell (1960) and Harvey and others (1980) reported the plant is able to fix nitrogen and has been successfully planted on disturbed sites in the Southwest. It has not done well throughout the Intermountain region on disturbances lacking topsoil. It does well on road fills created in the Idaho Batholith, but not on mine wastes.

Although game animals utilize the shrub on research plantings and the plant provides considerable cover, it is not native to the Intermountain region, and replacement of other shrubs with this species is not advisable. It is not sufficiently winter tolerant to persist within the Intermountain region.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus lemmonii
Lemmon ceanothus

Description—Lemmon ceanothus is a low, evergreen, spreading shrub that attains a height of 1.5 to 3 ft (46 to 91 cm); leaves are alternate, elliptical, 0.5 to 1.2 inches (13 to 30 mm) long, bright green and waxy above. Flowers are pale blue and abundant; seeds form within capsules (Munz and Keck 1959; Sampson and Jespersen 1963).

Ecological Relationships and Distribution—Lemmon ceanothus is a less widely distributed shrub than other species of Ceanothus. It is primarily confined to ponderosa pine communities from the base of the Sierra Nevada Mountains from Tuolumne and Eldorado Counties northward, and in the inner Coast Ranges from Lake and Yuba Counties north to Humboldt and Shasta Counties, California (Munz and Keck 1959). Although regionally adapted, it is an important deciduous shrub for wildlife (Sampson and Jespersen 1963).

Plant Culture—Seeds of lemmon ceanothus have an impermeable seedcoat and embryo dormancy. Heat scarification reduces seedcoat impermeability and hastens germination. Following heat treatment, wet prechilling for approximately 2 months is required to relieve embryo dormancy. Young seedlings are vigorous and can survive some herbaceous competition.

Uses and Management—Research with this species for revegetation plantings in the Intermountain region has been limited. Plantings have been established on wildlife and watershed sites in the Interior Western States. Plant materials acquired from northern California have been the primary source for most plantings.

The species is best adapted to sites receiving 15 to 25 inches (380 to 640 mm) of annual precipitation. It has not proven adapted to basic soils, and it is not winter hardy. Less than 10 percent of all plants have survived for more than 5 years in plantings in the Intermountain region.

This species has received considerable use by big game. Its rapid rate of growth is an impressive feature. It is an attractive shrub, particularly when in bloom (fig. 38). The flowers are abundant and cover the bush with a dark blue blanket. Seed production is erratic. Plants are easily cultivated and have considerable potential for horticultural uses. They can also be used in low maintenance plantings and on recreational sites. This species cannot be recommended for use outside its natural range. However, within its area of adaptation the shrub can and should be used to restore disturbed communities and provide wildlife forage and watershed protection.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus prostratus
Prostrate ceanothus

Description—Prostrate ceanothus is a low decumbent or prostrate, evergreen, layering shrub most prevalent in California (fig. 39). It grows 2 to 6 inches (5.1 to 15.2 cm) in height; stems root at the nodes,

Figure 38—Lemmon ceanothus is covered by masses of tiny blue flowers in spring.

Figure 39—Plants of prostrate ceanothus form a dense, low ground cover on an unstable granitic slope in central Idaho.

spreading to form dense mats 2 to 8 ft (0.6 to 2.4 m) across. Leaves are opposite, dark green, smooth above and sometimes gray green beneath. The margins usually have coarse teeth near the tip. Flowers are blue and borne in umbels. Fruits are roundish capsules (Sampson and Jespersen 1963).

Ecological Relationships and Distribution—Prostrate ceanothus occur in California on open flats and in pine forests at elevations from 3,000 to 6,500 ft (910 to 2,000 m) from Calaveras and Alpine Counties northward to Modoc County, and west to Siskiyou and Trinity Counties. It also occurs in Washington, Oregon, and western Nevada (Hitchcock and Cronquist 1973). It grows in mountain shrub, ponderosa pine, and red fir forests of higher mountain regions, usually forming carpets (Sampson and Jespersen 1963). A disjunct population occurs near Council, ID.

Plant Culture—Seeds are large, ranging from 37,500 to 44,500 per lb (82,700 to 98,100 per kg). However, they are difficult to collect from the low-growing plants. Seeds must be hand collected by picking small groups of fruits before the capsules are fully ripe. When dry, the capsules dehisce and scatter the seeds.

Seeds persist for many years in the soil, and can be stored under warehouse conditions for long periods without loss of viability. Seed germination is fire dependent. Treatment of the seeds with boiling water for 0.5 to 3 minutes hastens germination (Reed 1974). Seedlings develop well from fall and late winter seeding.

Nursery-grown bareroot stock establishes well as do rooted cuttings. Container stock can be propagated from seed or from stem cuttings (USDA Forest Service 1976). However, transplants must be dormant when field planted. If plants begin growth before field planting, they are susceptible to frost and drought. Seedlings and young plants are vigorous but grow slower than most other ceanothus species. New seedlings and transplants survive well on disturbed soils (Brown and others 1971; Tiedemann and others 1976).

Uses and Management—Prostrate ceanothus has been widely used for soil stabilization (Brown and others 1971; Tiedemann and others 1976; USDA Forest Service 1976), conservation (Plummer 1977), and horticultural plantings (Van Rensselaer and McMinn 1942), particularly in central California. Extensive transplanting projects have been employed to treat harsh, erodible sites. Prostrate ceanothus has attractive evergreen leaves and has been used to provide ground cover and serve as background plants to complement floral plantings and mixed shrub beds.

Prostrate ceanothus has been successfully used to control erosion and stabilize roadways, and logging and mine disturbances in the Intermountain area. Its ability to fix nitrogen (Delwiche and others 1965; Stewart 1967) possibly contributes to its success on infertile soils. Collections from Oregon and California have been widely used and are well adapted to mountainous areas dominated by forested communities. Most of these collections are tolerant of both shaded and open planting sites. The planting stock is widely adapted to infertile soils, exposed substrata, and mine wastes. Townsend (1966) reported this species recovers quickly following fires, and is one of the first species to reoccupy disturbances.

Prostrate ceanothus does not persist well with other plants. It spreads to provide a dense ground cover intermixed with few other plants. Prostrate ceanothus grows very slowly, and it spreads by stem layering. Numerous shallow roots are formed along the spreading stems. Prostrate ceanothus is able to persist and spread when buried by unstable soil. It is particularly useful for stabilizing steep banks, roadcuts, and unstable surfaces; however, it does grow slowly. Wildlife have made little use of the shrub on roadway plantings in Idaho, which allows it to be used on steep sites where animals may cause damage. However, Sampson and Jespersen (1963) reported that the shrub is browsed heavily by deer in California. Kufeld and others (1973) reported, from a summarization of studies in California, that the species is moderately used in all seasons.

This species provides attractive cover and has been used to landscape recreational sites and wildland areas where low maintenance is provided.

Varieties and Ecotypes—Various ecotypes and collections of prostrate ceanothus have been developed for horticultural uses. Stock can be purchased from wildland nurseries. A collection acquired near Council, ID, is particularly adapted to more arid sites, surviving in areas receiving 15 to 20 inches (38 to 51 cm) of annual precipitation. It does well in open areas, and is better adapted to sites supporting other shrubs and some herbs than most other collections.

Family Rhamnaceae

Ceanothus martinii
Martin ceanothus

Description—Martin ceanothus is a low, rounded to spreading, unarmed shrub, between 8 and 32 inches (20 to 81cm) tall (Welsh and others 1987). The leaves are alternate and deciduous with short petioles. Blades are green on both sides, 0.3 to 1.2 inches (7.6 to 30.5 mm) long, 0.2 to 0.8 inch (5.1 to 20.3 mm) wide, elliptic to oval, ovate, or obovate, and entire or serrulate except at the base. The inflorescence is corymbose with numerous white flowers (fig. 40). The fruit is a three-lobed capsule 0.16 to 0.2 inch (4 to 5 mm) thick. Seeds are shiny brown and 0.1 inch (3 mm) long. Sutton and Johnson (1974) reported the plant is evergreen, although plants may retain their leaves until late into winter when most are shed.

Ecological Relationships and Distribution—Martin ceanothus is much more limited in distribution than most other species of ceanothus in the Intermountain region. It occurs in Utah, Nevada, Colorado, and Wyoming, at elevations between 6,000 and 9,500 ft (1,800 and 2,900 m) (Welsh and others 1987). Kearney and Peebles (1942) reported the plant grows in the Kaibab Plateau and Grand Canyon areas at about 7,500 ft (2,300 m).

Martin ceanothus grows in small patches or as scattered plants in pinyon-juniper, mountain brush, big sagebrush, ponderosa pine, Douglas-fir, aspen, and bristlecone pine communities in Utah. Youngblood and Mauk (1985) reported that Martin ceanothus occurs in limited areas within the conifer forest types of central and southern Utah. The plant is not highly shade tolerant, but is able to persist beneath Gambel oak, mountain maple thickets, and ponderosa pine overstories, and it responds quickly to burning or other methods of clearing. It is noticeably absent from the aspen communities in Utah described by Mueggler and Campbell (1986), possibly due to the dense overstory provided by this tree species. Where it grows with other shrubs, particularly Gambel oak, it is most prevalent in small, open areas where overstory species do not occur.

Figure 40—Martin ceanothus receives extensive use by wildlife and livestock.

At lower elevations Martin ceanothus normally grows as scattered plants with big sagebrush, skunkbush sumac, antelope bitterbrush, and rubber rabbitbrush. Populations occur as somewhat isolated stands on very harsh sites that also support green ephedra, Wyeth eriogonum, mountain ash, and bristlecone pine. It exists as a minor component in Gambel oak, creeping barberry, and gray horsebrush communities. It seldom forms thickets. It often occupies ridgetops and exposed south and west slopes where few other species exist. It is well adapted to rocky, well-drained soils (Van Dersal 1938), and frequently occurs as the dominant plant in these situations.

This shrub is fire tolerant, but would not be considered a seral species in most situations. Although it recovers quickly following fire, it does not spread rapidly to occupy extensive areas. Other mountain brush species also recover well and are able to maintain their postfire position in these communities following burning.

Plant Culture—Plants begin growth early in spring, and leaves normally appear by early April. Flowers are formed in clusters on short stalks that often overtop the leaves and foliage. Under wildland conditions not all plants flower profusely each year. Good seed crops normally occur about once every 3 years, but even during periods of low production, some bushes produce considerable seed. Grazing by big game and livestock normally restricts seed production on many wildland sites. Plants established at protected nursery sites in Utah and Idaho have developed good seed crops nearly every year. Plants reach seed-bearing age in about 4 years if protected from grazing. Thereafter, annual seed production increases for about 3 years or until plants attain full stature.

When plants are in full bloom, the bushes are very attractive and colorful. Flowering occurs in May and June, and seeds mature from mid-July to mid-August (Plummer and others 1968). Flowering generally occurs late enough in spring that seeds are not damaged. Flowers are insect pollinated and attract large numbers of insects. Developing seed crops are frequently damaged by insects, causing some to abort. Seeds are formed in three-lobed capsules that are gummy and sticky when green. As the fruit ripens, the capsules split open and seeds are dispersed 1 to 6 ft (0.3 to 1.8 m) from the plant. Rodents eagerly gather the ripening fruits and cache the seeds. The seeds or fruits are difficult to harvest for commercial sale. Hand collection, a slow process, is required to remove the fruits from the bush. The fruits must be collected when slightly green before the seeds are dispersed. When green, the fruits adhere tightly to the plant and are not easily dislodged by beating or flailing. Once the fruit is collected, it is air dried to allow the capsules to dehisce. During drying, fruits should be covered with a light screen to prevent the seeds from being thrown off the drying tables. Seeds can be separated from the debris using fanning mills or screens. After screening, empty seeds can be removed on a gravity table or by floating the seeds in water. Cleaned seeds can be stored in open warehouses for 10 to 15 years without loss of viability (Plummer and others 1968).

Fresh collected seeds are dormant. Germination can be aided by immersion in hot water. The most effective treatment has been to place the seeds in boiling water for 1 to 2 minutes. The water is then allowed to cool to room temperature, and the seeds are removed and dried. Seeds are then fall seeded or wet prechilled for approximately 30 to 90 days before germination begins.

Martin ceanothus seeds should be fall seeded in a firm, weed-free seedbed. Seeds are relatively small, round, and easily planted. They should be planted 0.25 to 1 inch (0.6 to 2.5 cm) deep. Rodents will gather planted seed; consequently, late fall seeding is recommended. Seedlings appear early in the spring and are tolerant of frost. Young seedlings grow moderately well, but are not able to withstand competition from herbaceous plants. Martin ceanothus should not be seeded directly with herbs, but in separate spots or strips. Seedlings are well adapted to harsh sites, and survive well from plantings on well-drained, infertile soils free of herbaceous competition.

Transplants are easily cultured as bareroot nursery stock or container material. Bareroot and container stock must be dormant when field planted. If plants are lifted from the nursery bed and field planted after vegetative growth begins, serious losses will occur.

Uses and Management—Martin ceanothus is one of the most promising and useful shrubs for rehabilitation of big game winter ranges. It is well adapted to big sagebrush and mountain brush communities. It occupies some of the most critical wintering areas in Utah, including open south and west aspects, and it has established well when planted in these situations. Seedlings are sensitive to drought and must be planted in areas free of weeds. They grow at a moderate rate and can withstand heavy grazing even as young plants.

The shrub survives well on mine wastes and associated disturbances. It spreads slowly by natural recruitment, but it is persistent and long lived. It is adaptable to open slopes where big game may concentrate throughout the winter. The shrub has a low, rounded growth habitat; its forage is usually available to grazing animals.

Herbage quality is quite high, particularly for native stands in central Utah. Deer, elk, and livestock browse this species heavily (Diebert 1968). Tueller (1979), however, reported only minimal use by big game in Nevada. When planted on mine sites and on big game habitat improvement projects in Utah, the plants are heavily browsed by big game and livestock. Use can often be severe enough to reduce stand establishment. Big game animals seek areas occupied by the shrub in late fall and winter. Both leaves and stems are grazed during that season.

Seed production and harvesting are problems preventing the wide use of this species. Plants grown under protection and in nursery conditions produce abundant seed crops, but fruits are located amid the twigs in small clusters that are difficult to reach and detach. Plants are low growing and relatively uniform in size and shape. Consequently, mechanical harvesters could be developed to dislodge and collect the fruits. If such equipment were developed, use of this species would be greatly enhanced.

Varieties and Ecotypes—Collections of Martin ceanothus from Sanpete County in central Utah have proven well adapted to wildlife habitats throughout the State. This ecotype is a good seed producer, and is heavily browsed by big game. It appears well suited to infertile sites, including mine disturbances. Small seed production fields have been established, but seed yields are not sufficient to meet current demands. Commercial production should be encouraged.

Family Rhamnaceae

Ceanothus sanguineus
Redstem ceanothus

Description—Redstem ceanothus is an erect, deciduous, nonrhizomatous shrub, 5 to 10 ft (1.5 to 3.0 m) tall (fig. 41); with purple or reddish, flexible, glabrous twigs (Hitchcock and Cronquist 1973; Munz and Keck 1959). The leaves are thin, broadly elliptical to ovate or obovate, rounded or subcordate at the base, 0.4 to 3.9 inches (1.0 to 10 cm) long, subglabrous, and glandular-serrulate (Munz and Keck 1959). The flowers are numerous, white, and borne in showy compound clusters 2 to 4 inches (5 to 10 cm) long from previous year's wood (Kartesz and Kartesz 1980; Munz and Keck 1959). The fruit is a slightly lobed, 3-celled capsule about 0.2 inch (4 mm) long with one seed per cell.

Figure 41—Redstem ceanothus resprouts rapidly following logging in central Idaho.

Ecological Relationships and Distribution— Redstem ceanothus is distributed from British Columbia and Montana south to Washington, Oregon, Idaho, and California (Hitchcock and Cronquist 1973; Munz and Keck 1959; Reed 1974). This species is best adapted as an understory species in open or partially shaded areas (USDA Forest Service 1937). It occurs at mid to low elevations to 2,400 ft (730 m) in Montana (Dittberner and Olsen 1983), and 4,000 ft (1,200 m) in California (Munz and Keck 1959). It is most abundant throughout much of the Pacific Northwest at mid elevations in burned forest communities (Mueggler 1965). It is a principal component of extensive brush fields that develop after fires, logging, or clearing (Halpern 1988). The shrub is most prevalent in early seral stages of grand fir, Douglas-fir, western hemlock, and mixed conifer forests (Armour and others 1984; Conard and others 1985; Dahlgreen 1984; Franklin and Dyrness 1973; Schoonmaker and McKee 1988). It also grows as a scattered understory in mesic, open sites with ponderosa pine in central Idaho and the Northwest (Franklin and Dyrness 1973). Miles and Meikle (1984) reported that within the dry submontane Douglas-fir subzone, redstem ceanothus favors sites with low evapotranspiration.

Redstem ceanothus is less shade tolerant than other species that coexist in brush fields of the Northwest (Hooker and Tisdale 1974). It is often replaced by oceanspray and chokecherry as tree canopies close (Conard and others 1985), yet its presence with other shrubs provides extensive brush fields for 25 to 50 years (Morgan and Neuenschwander 1988). Miles and Meikle (1984) reported successional dieoff as a result of combined factors including drought stress, severe frost, utilization, and shade. Although the density of this species may decline rapidly as shade increases (Antos and Shearer 1980), it reestablishes quickly following disturbances and becomes a dominant cover (Zamora 1975). Nearly closed stands may develop within 3 to 5 years (Morgan and Neuenschwander 1988).

Like other species of Ceanothus, redstem ceanothus is primarily fire dependent for natural regeneration (Antos and Shearer 1980; Mitchell 1983; Wittinger and others 1977). Heat scarification stimulates seed germination (Lyon and Stickney 1976), and new seedlings flourish following wildfires or controlled burns. The species is capable of resprouting following burning and crown damage by deer (Miles and Meikle 1984). However, mature plants can disappear as shade increases. Periodic reburning maintains the species as an “obligate pioneer” (Laursen 1984). The shrub survives with 10- to 15-year intervals between burning (Lyon and Stickney 1976).

Plant Culture—Redstem ceanothus shrubs are normally robust and healthy plants, but abundant seed crops are infrequent. Individual plants may develop heavy seed crops, and the better bushes are normally “high graded” during seed collection. Most plants are tall, and hand stripping is difficult. Fruits are not easily dislodged from the plant by beating or shaking the stems. Seeds are dispersed as the capsule ripens; thus, capsules must be collected when still green and allowed to dry. Seeds are fully developed before the capsule dries; thus, seed quality or viability is not adversely affected by harvesting green capsules shortly before they dry. Rodents actively gather the ripening seeds (Conard and others 1985) and will collect entire seed crops as the fruits ripen.

Seedbanks develop through annual accumulation of seeds in the soil (Kramer 1984; Morgan and Neuenschwander 1985). Although seeds are eagerly eaten by rodents (Conard and others 1985), numerous seeds may accumulate in the soil and may remain dormant for decades (Furniss and others 1978). Seed densities ranging from 1.9 to 107 per ft^2 (20 to 1,150 per m^2) have been reported in Idaho (Kramer 1984).

Large amounts of redstem ceanothus seeds have not been collected for commercial sales. The shrub usually recovers satisfactorily by natural seedings so artificial planting is generally not necessary. However, seeds are easily cleaned for storage or seeding. Seeds are approximately 0.08 inch (2 mm) in diameter; smaller than those of most Ceanothus species. There are about 130,000 cleaned seeds per lb (287,000 per kg). Seed cleaning is quite simple. The capsules are allowed to air dry, causing them to break apart and propel the seed. Consequently, the capsules should be covered with a screen to prevent loss of seeds as fruits ripen. Seeds and debris can be separated using an air screen fanning mill.

Seeds have a hard, impermeable seedcoat and a dormant embryo (Heit 1967a; Kramer 1984). They require a heat treatment to open the seedcoat or hilar fissure (Furniss and others 1978). Immersing the seed in boiling water at temperatures between 190 and 212 °F (88 and 100 °C) (Heit 1967a; Niering 1981) for 1 to 3 minutes, followed by cooling in the standing water, reduces seedcoat imposed dormancy. Heat-treated seeds require wet prechilling for approximately 60 days to enhance germination (Heit 1967a; Reed 1974). Radwan and Crouch (1977) reported germination after 1 month of wet prechilling, but 4 months was the optimum period. Miles and Meikle (1984) suggested seeds collected from different aspects and elevations have different optimum wet prechilling periods. Seeds can be stored for many years in an open warehouse, but may be damaged by chalcids. Gratkowski (1973) and Radwan and Crouch (1977) recommended storage at 37 to 69 °F (3 to 21 °C) to reduce insect infestations.

Heat-treated seeds should be planted in fall in a firm, well-prepared seedbed at depths between 0.25 and 0.5 inch (6.4 and 12.7 mm). Broadcast seeding on a loose, rough seedbed or surfaces with considerable litter also is successful. When seeding on a bare mineral surface, seeds should be incorporated into the soil and not left on the surface. Lyon (1971), and Youngberg and Wollum (1976) found that seedling survival by natural recruitment was much higher following fall burning than spring burning. Most seedlings developing from spring burning emerged a year following the burn; thus, they were subjected to considerably more herbaceous competition. Leege and Hickey (1975) found that the amount of precipitation received from May through August had a significant effect on seedling survival.

Natural recovery following wildfire is often dramatic, as seedlings are able to establish with little site or surface preparation. A considerable number of seedlings naturally succumb the first or second year after disturbance (Lyon 1971; Youngberg and Wollum 1976). However, seedlings of this species are quite vigorous and can persist on exposed sites. High seedling losses from natural seeding is to be expected as seedlings compete for limited resources. Although less than 4 percent may remain after two growing seasons (Orme and Leege 1976), sufficient plants often survive to fully occupy the site.

Natural thinning is not as evident where controlled seedings are conducted. If sites are not overseeded, little dieoff or thinning will occur. Once seedlings attain 1 to 2 years of age, they are often of sufficient size and vigor to persist with herbaceous competition.

Redstem ceanothus is capable of nitrogen fixation (Torrey 1978), which enriches the biomass and density of associated species. Thus, this shrub serves as an important nurse plant in many situations (Rose and Youngberg 1981; Scott 1970). It has been particularly useful in seeding fresh disturbances where few other species are initially able to establish. Under many situations where little or no vegetation exists, redstem ceanothus can be seeded with herbs to provide a mixed composition of plants. The shrub competes with other herbs without serious loss of young seedlings.

Transplants are easily grown as bareroot or container stock. Bareroot plantings survive as well as container seedlings and are much cheaper and easier to transplant. Transplanting is a useful method of establishing the shrub on selected sites and locations. Transplants grow rapidly and furnish a rapid-developing cover, particularly if plants are inoculated with nitrogen-fixing organisms. Even when planted on mine or roadway disturbances, redstem ceanothus is an aggressive early developer.

Uses and Management—Redstem ceanothus is an important forage and cover plant for big game and other wild animals. In the Okanogan Valley of Washington and British Columbia, redstem ceanothus is one of two browse plants that provide 60 to 70 percent of the winter forage consumed by deer (Miles and Meikle 1984). Although it provides 11 percent of the available winter forage, it supplies 52 percent of the herbage consumed by big game.

In many burned or cleared sites, redstem ceanothus is often heavily grazed, and all annual growth is utilized. This species is particularly important for use by elk during the winter months (Kufeld 1973; Leege 1972; Leege and Hickey 1975). It is grazed in summer by both deer and elk, although the amount and period of use may vary (Conard and others 1985; Keay 1977; Keay and Peek 1980; Thilenius 1960). Game animals are frequently attracted to burned sites where this species is abundant. Important wintering ranges are dependent on burning and logging to maintain this shrub (Leege and Hickey 1975).

Redstem ceanothus is particularly palatable to wildlife. It furnishes considerable herbage in areas where the plant is not abundant or the dominant species. Grazing animals seek and utilize the new growth (Gaffney 1941; Leege 1968; McCulloch 1955; Thilenius 1960). Scattered plants growing in riparian areas and forest openings are selectively used at all seasons.

The age of the plant and seasonal period of grazing affect its palatability. Leege (1968) reported that new growth is much more palatable than older twigs, and following burning, the nutritional value decreases with age (Asherin 1973; Leege 1969; Leege and Hickey 1971). However, Miles and Miekle (1984) did not recommend burning to regulate or enhance the forage value of this shrub.

The protein content of this plant during winter is about 10.1 percent; this provides the protein level necessary for deer maintenance (Miles and Miekle

1984). In addition, the average fiber content is a relatively low 34.7 percent. Livestock also are attracted to plants with high nutritive quality and make considerable use of this species.

Redstem ceanothus provides important cover for wildlife including big game, small mammals, and birds. It is particularly important in winter. It is also an important ground cover, and provides soil stability on burned slopes where erosion potential is high. It provides protection for streambanks and moist areas. Following fires it recovers quickly and provides ground cover and soil stability on areas where slumping and surface runoff are common.

Seedling establishment is very good when redstem ceanothus is planted on disturbances; consequently, this species is utilized to seed abandoned roadway and logging disturbances. Both direct seedings and transplantings have been successful in conservation plantings to control erosion. The species, however, is not well adapted to mine wastes, and has been slow to invade road and logging disturbances where vehicle activity has occurred and soils are compacted. It has been very useful for restoring riparian disturbances, and withstands livestock use. However, grazing of young plants can weaken developing stands.

This shrub is able to establish with seeded herbs. It can be seeded with herbs or transplanted into new grass/forb seedings. It can be used as a pioneer species to restore harsh sites, and provides favorable areas for other plants to establish.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus velutinus
Snowbrush ceanothus

Description—Snowbrush ceanothus is a low-spreading, many-stemmed, evergreen shrub (fig. 42) (Countryman 1982; Welsh and others 1987; Zamora 1982) with olive-green to reddish brown bark. It attains heights of 3 to 9 ft (0.9 to 2.7 m) when growing in thickets or closed stands (Sutton and Johnson 1974). On open, windswept sites it may grow as low, rounded plants usually about 3 ft (0.9 m) tall; however, on fertile sites individual shrubs may be 12 ft (3.7 m) tall (Stanton 1974).

Leaves are 1.2 to 2.0 inches (3 to 5 cm) long with three main veins and a glossy dark-green surface (Miles and Miekle 1984; Stark 1966). They are alternate, thick, pubescent to glabrous, ovate to elliptic, and very fragrant (Sutton and Johnson 1974; Welsh and others 1987). The leaves often curl in drought conditions; this conserves water by reducing evapotranspiration (Miles and Miekle 1984).

The flowers are white, heavily scented, very abundant, and borne in more-or-less corymbose clusters on short branches (Mozingo 1987; Sutton and Johnson 1974). The fruit is a three-lobed capsule, with a single seed per locule. The seeds are small and dark brown or tan with shiny coats (Welsh and others 1987).

The plant forms a deep spreading root system, and nitrogen-fixing actinomycetes occur on the roots (Hickey and Leege 1970; Stanton 1974). Snowbrush ceanothus does not spread by layering or root suckering, but by resprouting from the crown. The plants have a distinct cinnamon odor if the leaves or stems are crushed (Welsh and others 1987).

Ecological Relationships and Distribution—Snowbrush ceanothus grows from the coastal ranges of California north to British Columbia and eastward to Alberta, Montana, South Dakota, and Colorado (Mozingo 1987; Reed 1974). Hitchchock and Cronquist (1973) reported that *C. v.* var. *hookeri* occurs on the west side of the Cascade Mountains from northern California to British Columbia. East of the Cascades, var. *velutinus* occurs in California, Nevada, Utah, Colorado, and South Dakota. In Utah, Wyoming, and Colorado, the species is less abundant and restricted to more specific communities. Goodrich and Neese (1986) reported the plant occurs primarily at elevations between 7,000 and 9,000 ft (2,100 and 2,700 m) in the Uinta and Blue Mountains and the west portion of the Tavaputs Plateau, where it is mostly confined to mountain brush, ponderosa pine, and aspen communities.

This shrub has a broad ecological amplitude and is considered a late seral species in some communities, and an early seral species in others. It is most often codominant with ponderosa pine and Douglas-fir. It

Figure 42—Snowbrush ceanothus is a common understory shrub in many ponderosa pine communities.

is also commonly encountered in various mountain brush, antelope bitterbrush, and forested shrub communities. It is a principal species in forested communities in Oregon and Washington (Franklin and Dyrness 1973) and Idaho (Steele and Geier-Hayes 1987, 1992). As an early seral species, it occupies Douglas-fir, white fir, grand fir, ponderosa pine, and lodgepole pine forests (Dyrness 1973; Franklin and Dyrness 1973; Halpern 1989; Schoonmaker and McKee 1988).

Although snowbrush ceanothus commonly grows on dry, open hillsides (Weber 1987), and is considered to be shade intolerant (Stanton 1974), it will persist as an understory in forested communities for considerable periods. Increasing closure of the canopy and competition affect removal of the shrub. The rate of succession is regulated by soil moisture, and snowbrush ceanothus can maintain a presence on xeric sites as an edaphic climax community (Miles and Miekle 1984). The shrub may persist as a midseral species with Douglas-fir, but if tree stands are somewhat open, it may remain as a permanent understory (Conard and others 1985).

The species responds well to disturbances, particularly fires (Halpern 1988). High-intensity fires are often followed by the rapid recovery and postfire dominance of this plant, usually within 1 year, if an adequate seedbank exists and climatic conditions favor establishment (Halpern 1989; Halvorson 1982). Seed germination is activated by burning (Halpern 1988; Marshall and Waring 1984; Mozingo 1987). This species is able to compete with pioneering herbs. Snowbrush ceanothus is, therefore, a major component of brush fields and shrubby communities that develop after wildfires (Gratkowski 1961b, 1978; Morris 1958). It is often a primary understory component on ponderosa pine sites. It may exist as a long-lived seral species or a climax dominant. Along with antelope bitterbrush, it forms important associations as a dominant climax shrub (Franklin and Dyrness 1973).

Snowbrush ceanothus grows across a wide elevational range from 3,500 to over 10,000 ft (1,100 to 3,000 m) (Mozingo 1987; USDA 1937). Aspect affects the distribution of the species due to increasing evapotranspiration demands on south and west slopes, particularly in pioneering systems (Miles and Miekle 1984). The shrub is unable to establish on south, southwest, or west aspects at elevations below 3,250 ft (990 m) in British Columbia because of xeric conditions. At high elevations it is not normally found on steeper east, northeast, or north aspects because of poor shade tolerance and competition (Miles and Miekle 1984).

Although snowbrush ceanothus is a fire-dependent pioneer species, successional dieoff is caused primarily by drought stress due to competition. Shading, frost damage, and utilization may hasten the process (Miles and Miekle 1984). Severe frosts frequently damage the shrub, particularly during years of low snow cover when the shrubs are exposed. Although plants may be killed to ground level, regrowth from the crowns can usually occur. Fires can damage and kill mature plants, but regrowth does occur, and stand regeneration is often accomplished with controlled burns.

Snowbrush ceanothus exists on a wide number of soil types and parent materials. It is able to grow on well-drained, coarse-textured soils (Stephens 1973), but water-holding capacity and nutrient availability greatly affect the presence of this shrub (Miles and Meikle 1984). Soils that contain sufficient moisture to sustain growth into July and August are important to its survival. Snowbrush ceanothus occurs on slightly acidic and neutral soils, and is particularly adapted to soils derived from granitic parent materials (Sutton and Johnson 1974; Watson and others 1980; Zavitkovski and Newton 1968).

Plant Culture—Plant growth and flowering are regulated by elevation. Vegetative growth normally begins by mid-April at lower elevations and as late as early June at higher sites (Noste and Bushey 1987). Flower development begins early in the season, often by mid-April. At higher elevations flowering may occur in June or July. Seed maturation occurs from July to August (Plummer and others 1968; Reed 1974; Stark 1966; Swingle 1939).

Plants usually produce a number of flowers each year, but viable seeds may not always mature. Seed production varies annually among wildland sites. Few areas produce abundant crops each year, but some shrubs will generally produce seed. Young plants that occur on open burn sites are not always better seed producers than those existing in mixed shrub/conifer forests. Normally, some sites will bear commercially harvestable crops each year, but sites must be located and inspected regularly.

Seed is harvested by hand stripping the fruits before they mature or the capsules dry. As capsules dry, seeds shatter immediately. Capsules ripen irregularly on the bush and fruits must be collected when still green. However, seeds are fully ripe before the capsules are dry, and harvesting of slightly green fruits does not diminish seed quality. Seed harvesting is slow and expensive, and is a principal deterrent to the wide use of this species.

Yields of 50 to 75 lb per acre (56 to 84 kg per ha) of cleaned seed have been obtained from sites in Idaho. Rodents actively gather the fruits and seeds, and will remove much of the seed as it matures. Nearly complete removal of the seed by rodents has been reported by Conard and others (1985).

Mature seeds have a hard impermeable seedcoat and a dormant embryo. Heat and wet prechilling are necessary for germination (Mozingo 1987). Soaking the seed in boiling water for 1 to 3 minutes normally enhances germination. Seeds are then germinated in a cool, moist environment at 34 to 41 °F (1 to 5 °C) for 63 to 84 days (Reed 1974). Germination is usually completed in about 14 days (Quick 1935). Seed germination is usually very high, exceeding 70 to 80 percent (Reed 1974). Mozingo (1987) suggested that the optimum period of exposure to heat varies geographically among ecotypes, but differences have not been noted in separate collections obtained from central Idaho.

Seeds can be stored for long periods without loss of viability. Good stands have developed from planting in the fall at a depth of 0.5 to 0.75 inch (1.3 to 1.9 cm). Seedings also establish well by broadcasting seeds on a rough seedbed in the fall or early winter. Plantings on bare mineral soil or amid surface litter are both successful if the soil surface remains wet throughout the germination period. Miles and Miekle (1984) reported that natural seedings that germinate in the autumn, following late summer or fall burning, survived much better than those that germinate in spring after spring burning.

Snowbrush ceanothus seedlings establish well on fresh, open disturbances and compete favorably with pioneering herbs. The species establishes very well from artificial seedings and is particularly adapted to unstable sites. Sutton and Johnson (1974) and Miles and Meikle (1984) reported young plants grow slowly, but Scott (1970) found that nodulated seedlings produced 2.5 times more dry weight than non-nodulated plants. Results from plantings conducted in Idaho and Utah do not support reports that seedling growth is slow. In fact, plantings on forested roads and study sites are vigorous and aggressive. Seedlings and young plants develop well and are able to establish and persist with herbaceous competition. However, considerable differences between nodulated and non-nodulated plants were also noted on these sites.

A large number of natural seedlings can be expected to emerge on burn sites. Natural thinning normally occurs soon after emergence (Lyon 1971), but sufficient numbers usually survive to provide an adequate stand. Winter frost, grazing, and lack of soil water contribute to seedling losses.

Snowbrush ceanothus is easily grown as bareroot or container stock, and transplanting is an excellent method for stabilizing disturbances. Snowbrush ceanothus forms a symbiotic relationship with *Streptomyces ceanothii* to fix nitrogen (Hickey and Leege 1970). These organisms form clusters of modified short roots, not typical nodules (Furman 1959; Torrey 1978). Seedlings grown for field plantings should be inoculated with these nitrogen-fixing organisms.

Uses and Management—Snowbrush ceanothus is a particularly important species for restoring and enhancing soil fertility. Annual fixation of nitrogen ranges from 21 to 62 lb per acre (23.5 to 69.5 kg per ha) (Rose and Youngberg 1981; Tiedemann 1981; Zavitkovski and Newton 1968). Nodulated plants can improve growth of associated species. Scott (1970) reported Douglas-fir trees growing in the open were half the size of seedlings nourished by snowbrush ceanothus.

Snowbrush ceanothus has been particularly valuable as a pioneer species for improving poor soils and disturbed sites. It has been extensively used to revegetate logging roads, mine wastes, and other disturbances. It is particularly adaptable as a pioneer species capable of stabilizing and improving soil conditions that can then be used to enhance the establishment of associated species (Conard and others 1985; Geier-Hayes 1987; Steele and Geier-Hayes 1992). The shrubs improve soil fertility, which promotes early establishment and growth of other plants (Franklin and Dyrness 1973; Steele and Geier-Hayes 1987, 1992).

This shrub has been one of the most successful species used to revegetate roadways and unstable slopes in the Idaho Batholith, where erosion control is needed during the year of disturbance. Plants establish quickly, and small seedlings or transplants grow rapidly to furnish excellent ground cover. The plant can be seeded in mixtures with fast-developing herbs including western yarrow, fireweed, and Canada goldenrod, or it can be transplanted at various spacings to reduce wind erosion and runoff.

Ecotypes with different growth habits have been selected and used for erosion control. Plants obtained from windswept sites have dense, low-growing growth forms, and have demonstrated adaptability to a wide range of sites. These collections maintain a low, dense, leafy growth habit that provides excellent ground cover. One-year-old bareroot stock normally develops a crown spread of 18 to 30 inches (46 to 76 cm) during the year of establishment.

Plantings established along roadways have persisted following wildfires, and their extensive root system stabilizes roadfills. Regrowth occurs quickly and new shoots protect the soil surface. The evergreen growth habit of this shrub also aids in furnishing yearlong soil cover. The plant has been widely planted for erosion control in the West (Dietz and others 1980; Fessenden 1979; Monsen and Christensen 1975; Plummer 1977; Stark 1966).

Snowbrush ceanothus provides forage and cover for game and wildlife. It is regarded as a primary winter forage for big game, but use varies considerably among geographic regions (Martinka 1976; Stanton 1974; USDA Forest Service 1976). Undoubtedly, differences occur among ecotypes, and collections from some regions are much more heavily grazed than others. Miles and Miekle (1984) reported that snowbrush and redstem ceanothus are the most important winter browse species for mule deer in the Okanogan Valley in British Columbia, and that 60 to 70 percent of the forage consumed in winter is supplied by these two shrubs. Plants in Idaho (Leach 1956), portions of Montana (Klebenow 1965; Youds and Herbert 1988), and some collections from central California received moderate to heavy use. Within the Great Basin this species receives much less use by big game (Tueller 1979). Although plants are browsed in winter, use is not excessive. Collections of this species have been assembled and field planted at various locations in Idaho. Collections from California, northern Idaho, and Oregon have received more use than most Intermountain region accessions. Use also varies by season (Martinka 1976; McCulloch 1955) and among big game animals (Kelbenow 1965; Peek 1974; Watson and others 1980).

Snowbrush ceanothus withstands considerable winter browsing and is able to recover without apparent loss in vigor. Snow cover and winter frost damage reduce both forage availability and animal use. Many sites are often covered with deep snow, and plants are unavailable for long periods (Miles and Miekle 1984).

Cattle generally make little use of this shrub (Curtis 1952). However, Miles and Miekle (1984) noted that they selectively used it in late fall and winter, thus competing with big game for winter browse. Sheep and goats browse new growth after fire (Stanton 1974).

Nutrient value varies among sites. In British Columbia, Miles and Miekle (1984) found snowbrush and redstem ceanothus were the only two native shrub species that provided maintenance level protein for deer in the winter months. Digestible energy was higher for snowbrush ceanothus than for all other native shrubs. The winter fiber content of snowbrush ceanothus was 26 percent, lower than any other shrub tested (Miles and Miekle 1984). This is due to the retention of leaves on the bush. This provided a much higher amount of forage with higher nutritive content than that of deciduous shrubs (Miles and Miekle 1984). In contrast, Dittberner and Olsen (1983) described protein and energy values for this shrub as poor. Blank (1984) and DeByle and others (1989) suggested that fire increases nutritive content, but Miles and Miekle (1984) concluded that the changes do not support the use of fire for nutrient enhancement.

The plant has considerable value in landscape and conservation plantings. Its growth habit, color, and evergreen features provide attractive cover. The plant is suited for extensive cultivation and will survive in organized plantings. In addition, it can be used in low-maintenance situations, and is particularly useful for restoring disturbances where native species are desired.

Varieties and Ecotypes—None. However, ecotypes with low growth forms, and selections that receive heavy browsing have been identified. These selections could quickly be advanced with more extensive seeding projects.

Family Salicaceae

Salix species
Willow

Introduction—There are about 300 species of willows worldwide; about 70 species are native to North America (Brinkman 1974i). Willows are constituents of many riparian zones in the Western United States. Their root systems stabilize streambanks, while stems and leaves dissipate flood energy and catch sediments. Willows contribute to the formation of overhanging banks that provide shade, cover, food, and travel corridors for a large number of vertebrates and invertebrates and microsites for establishment of many plant species (Clary and McArthur 1992; Kovalchik and Elmore 1992; Thomas and others 1979b).

Damage to many riparian ecosystems has resulted from improper grazing practices, logging, road construction, recreation, water impoundments, and other human activities. Land management efforts have recently centered on restoration and maintenance of these dynamic ecosystems. Research and riparian classification studies are rapidly providing knowledge of willow ecology and guidelines for management (Hansen and others 1988a,b, 1995; Kovalchik 1987; Manning and Padgett 1995; Padgett and others 1989; Szaro and Patten 1986; Youngblood and others 1985).

Natural regeneration processes and techniques for restoration of riparian communities have also received recent attention. Improvement of degraded riparian areas requires that factors causing degradation be addressed (Briggs 1995; Briggs and others 1994). Restoration efforts are unlikely to be successful unless the causes of degradation are first mitigated.

Most willow species are easily propagated; but little information is available for many individual species. General techniques for vegetative propagation and production from seed are provided below. Specific requirements, where known, are described in the plant culture chapter for each species.

Vegetative Propagation—Most willows can be propagated from hardwood cuttings. Techniques for harvesting and preparing cuttings are provided in Chapter 29 and in many books on plant propagation. Stems of most willows contain dormant, preformed root primordia. These are formed during the first year and quickly develop into roots when conditions are favorable (Haissig 1970, 1974). Upland species such as

Scouler willow do not produce root primordia. They root more slowly, and root initials appear only at the base of the cutting (Densmore and Zasada 1978).

Cuttings should be collected on or near the planting site whenever possible. Released varieties of some willow species are available from commercial nurseries, and can be used if restoration using local material is not an objective or if local material is unavailable (Carlson 1992; Darris and Lambert 1993; USDA Soil Conservation Service 1993a,b).

Unrooted cuttings may be used on sites with favorable planting conditions and long growing seasons. Dormant cuttings may be taken from fall through early spring. Densmore and Zasada (1978) found that cuttings taken in early spring rooted more readily than cuttings harvested in late fall. Rooted cuttings may be required for species that do not produce preformed root primordia and for plantings on sites with short growing seasons, rapidly declining water tables, or other factors that might slow establishment.

Rooted and unrooted cuttings should be planted in areas appropriate for each species. Cuttings or rooted stock should be planted at depths permitting the developing root system to remain in contact with the water table throughout the summer (Busch and others 1992). Plantings may be conducted in fall when water levels are low and appropriate planting areas exposed. This aids planters in placing the cutting base or root system at an adequate depth and permits early-spring root growth, but it also exposes cuttings or plants to spring runoff and flooding. Some plantings must be completed after spring runoff. Streams with artificially manipulated flows present special problems, as root growth may not be rapid enough to advance with a rapidly declining water table.

Survival and growth of willow plantings may require that vegetative competition be removed or reduced at the time of planting. Neiland and others (1981) found that competition with tall, dense grass stands adversely impacted survival. Svejcar and others (1992) and Conroy and Svecar (1991) obtained greater second-year survival of Geyer willow cuttings planted on bare ground than on Nebraska sedge/Baltic rush sites even though depth to the water table in midsummer was less on the Nebraska sedge/Baltic rush sites. They interpreted these results to represent an interaction of biotic and abiotic factors on willow establishment.

Large planting stock may be used when depressed water tables or browsing are problems (York 1985). Planting poles or dormant stubs permit the base of the cutting to be placed in the water table; foliage is produced beyond the reach of browsing animals, and cover and soil protection are obtained quickly. However, pole plantings are costly, and natural regeneration is generally unlikely to occur unless the water table is restored or browsing curtailed.

Willows may also be used to stabilize eroding streambanks and other disturbances. Such practices as wattling, brush matting, and branch packing are used to provide physical stability as vegetative cover develops (Gray and Leiser 1982; USDA Soil Conservation Service 1992). Live and dead plant materials including stems and branches are buried, planted, or placed on the soil to reduce soil movement, protect erosion control structures, and enhance vegetation development. Live willow cuttings used in these procedures often root, providing dense root systems and cover.

Propagation From Seed—Willows are dioecious; male and female flowers are borne on separate plants. Inflorescences are catkins or aments that, depending on the species, appear before, with, or after the leaves (Brunsfeld and Johnson 1985). The flowers are pollinated by bees. Fruits are capsules; each contains numerous tiny, hairy seeds. Seeds of most species ripen and are rapidly dispersed in early to midsummer (Brinkman 1974i). Dispersal may be timed to coincide with low water levels. Seeds are carried over long distances by wind and water. Hairs on the seeds may aid in dispersal; they may also function in the germination process (Martens and Young 1992). Summer-dispersed seeds may be viable for as little as 1 week (Densmore and Zasada 1983). They are nondormant and germinate rapidly, often in 24 to 48 hours, if deposited on wet, exposed substrates. Germination occurs rapidly over a wide range of temperatures. A requirement for exposure to light may ensure that germination occurs in areas free of vegetative competition. The ability to germinate over a wide range of temperatures may compensate for the short period of viability (Densmore and Zaszada 1983). Seed coats are transparent, and embryos contain chlorophyll. Consequently, germination and seedling development are rapidly initiated under favorable circumstances.

Wide dispersal enables willows to act as pioneer or early successional species following flooding, burns, or other disturbances that create suitable microsites for germination. Continued rapid growth enables seedlings to develop root systems that remain within reach of the declining water table in summer, compensate for the late period of germination, and withstand flooding during the succeeding spring.

Some arctic and high-elevation willows such as grayleaf willow mature seed in summer, but delay dispersal until fall (Densmore and Zasada 1983; Zasada and Viereck 1975). These seeds exhibit conditional dormancy; they are capable of germinating at high temperatures, but not at the lower ambient temperatures of the season. Embryos of late-dispersing species generally contain low amounts of chlorophyll. Wet overwinter chilling of these seeds releases dormancy, permitting seeds to germinate soon after snowmelt and maximizing the period for seedling development during the short growing season.

Willow seeds may be hand harvested once the capsules begin opening, or recently dispersed seed may be collected from drifts (Brinkman 1974i). Use of a commercial shaker has been suggested for harvesting yellow poplar seed; the feasibility of using this system for collecting willow seed has not been assessed (Cech and Keys 1987). However, because ripening within stands, plants, and catkins is uneven, it is often advantageous to harvest entire catkins just as the capsules turn from green to yellowish or as the first capsules begin opening (Brinkman 1974i; Martens and Young 1992). Catkins can then be spread to dry in an enclosed area until the capsules open. With either method, it is imperative that maturation be monitored closely.

Seeds may be planted without cleaning, other than removal of twigs, leaves, and catkin branches. Martens and Young (1992) suggested that hairs not be removed from the seeds; their function is not fully understood. However, the hairs do cause the seeds to cling together. They may be removed by gentle carding (Atchley 1989) or by forcing air through a series of sieves containing the seeds (Fung and Hamel 1993; Harder 1970). Both techniques are rather slow if large quantities of seed are to be cleaned.

Brinkman (1974i) reported willow seed could be stored for only 10 days at room temperature, but viability could be maintained for 1 month if seed is stored wet in sealed, refrigerated containers. Zasada and Densmore (1977, 1980) found that seed of several summer and fall-dispersing willows could be stored for up to 3 years if dry seed was placed in doubled 3-mil polyethylene bags and stored at 14 °F (–10 °C).

Seeds may be sown directly into containers or onto wet soil surfaces. In the bareroot nursery, seed may be covered lightly using a roller (Brinkman 1974i). It is essential that the soil surface be kept wet and shaded, if possible. Seeds may be broadcast on appropriate sites if surfaces remain wet. Little information is available on production of planting stock from seed or direct seeding. Use of seed may be advantageous if local cutting material is not available. The ability to store seed for up to 3 years provides some flexibility in planning propagation and in timing direct seeding.

Family Salicaceae

Salix bebbiana
Bebb willow, beaked willow

Description—Bebb willow is a thicket-forming shrub or small tree growing to 33 ft (10 m) in height. Roots are shallow and dense. Twigs are reddish or grayish brown and hairy when young. Leaves are elliptic, obovate or oblanceolate, mostly 1.2 to 2.4 inches (3 to 6 cm) long and 0.4 to 1.2 inches (1 to 3 cm) wide with entire to shallowly toothed margins. Upper surfaces are green, and lower surfaces are glaucous with prominently raised veins. Catkins emerge and mature with the leaves. Staminate catkins are 0.4 to 0.8 inch (1 to 2 cm) long. Pistillate catkins are whitish yellow and 0.6 to 2.4 inches (1.5 to 6 cm) long. Floral bracts are narrow, pale yellow to light brown, and sparsely to densely hairy. Capsules are very loosely arranged and borne on stipes 0.08 to 0.16 inch (2 to 4 mm) long. They are ovoid conic, 0.2 to 0.3 inch (5 to 8 mm) long, short hairy, and long beaked. Stigmas are two lobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Welsh and others 1987).

Plants begin flowering when 2 to 10 years old; optimum seed producing age is 10 to 30 years (Hansen and others 1988a,b; Rawson 1974). Bebb willow flowers from April to July or August (Gill and Healy 1974; ISTA 1966; Viereck and Little 1972). Fruits ripen and seeds are dispersed from May to August (Densmore and Zasada 1983; ISTA 1966).

Ecological Relationships and Distribution—Bebb willow is widespread in Canada and the United States, occurring from low to upper-middle elevations (Brunsfeld and Johnson 1985; Hitchcock and others 1964). It does not occur west of the Cascade Mountains or in California. At low elevations Bebb willow grows in broad meadows and on alluvial terraces and subirrigated slopes. It is most common on organic or mineral soils with textures ranging from silty to sandy or gravelly (Marchant and Sherlock 1984), and it will tolerate moderately alkaline to moderately acidic soils (pH 5.5 to 7.5) (Haeussler and Coates 1986). Water tables are usually within 3.3 ft (1 m) of the soil surface throughout the summer. Mottled or gleyed soils are common in the first 3.3 ft (1 m) (Hansen and others 1995). At upper elevations Bebb willow is found in drier riparian areas.

Uplands associated with Bebb willow may be dominated by Wyoming big sagebrush, mountain big sagebrush, Douglas-fir, or Engelmann spruce communities. Aspen, black cottonwood, and water birch are common overstory associates (Brunsfeld and Johnson 1985; Padgett and others 1989).

Bebb willow may dominate early seral willow communities along rivers and streams, overflow channels, or seeps (Boggs and others 1990). Seeds germinate on wet mineral substrates with full exposure to sunlight. Suitable seedbed microenvironments include recent alluvial deposits along streams and abandoned, silt-filled beaver ponds (Hansen and others 1988a). Seedlings colonize wet, exposed mineral soils following fires and have been noted to invade mine spoils in southwestern Canada (Marchant and Sherlock 1984; Watson and others 1980). Burned or otherwise damaged trees resprout readily. Plants may also develop from detached branch segments (Watson and others 1980).

Bebb willow communities are relatively stable once established. They may persist for long periods due to the presence of high water tables or short periods of flooding (Hansen and others 1988a,b). Bebb willow requires full sun and lacks shade tolerance (Watson and others 1980); it may be replaced by taller species.

Plant Culture—Bebb willow may be propagated as rooted cuttings, but reports of rooting capability vary. In Alaska, cuttings harvested in autumn after leaf fall or in spring following leaf expansion failed to root (Densmore and Zasada 1978). In contrast, rooting success of current year's softwood, also harvested in Alaska, was 42 percent (Halloway and Zasada 1979). In Montana, Atchley (1989) obtained 40 percent rooting when cuttings of 4-year-old wood were harvested in May. Platts and others (1987) reported dormant cuttings rooted readily. Growth was initiated in about 10 days and shoot growth in 10 to 20 days. Roots were formed along the entire length of the stem.

For production of rooted cuttings in Saskatchewan, Cram (1976) recommended that 6-inch (15-cm) cuttings be harvested in early fall and immediately placed in cold storage at 34 °F (1 °C) for spring planting in a bareroot nursery. Rooted cuttings were subsequently outplanted as 1-0 stock. Watson and others (1980) reported 30 to 70 percent survival of 1-0 rooted hardwood cuttings on mine overburden in northern Alberta; most mortality resulted from rodent damage. Unrooted cuttings are sometimes used. Hansen and others (1988a,b, 1995) recommended use of early spring-harvested dormant cuttings 12 to 20 inches (30 to 50 cm) long with diameters greater than 0.4 inch (1 cm).

Bebb willow seeds must be harvested immediately when mature; seeds are dispersed in a period of 1 or 2 days (Marchant and Sherlock 1984). Fruits are green when preripe and yellowish when ripe (Watson and others 1980). Seeds may be hand harvested from trees or from recently dispersed drifts. Seeds may be used with or without cleaning (Brinkman 1974i). Atchley (1989) found that carding was more effective than the air-blowing technique described by Harder (1970) for removing the dense hairs from the seeds. Seeds vary in size and shape. Atchley (1989) found that viability was greater for plump, green seeds compared to small dark-brown seeds or wrinkled seeds. There are about 2,500,000 cleaned seeds per lb (5,500,000 per kg) (Brinkman 1974i). Bebb willow seeds collected in Alaska can be stored dry for at least 3 years in doubled 3-mil polyethylene bags at 14 °F (–10 °C) (Zasada and Densmore 1980).

Fresh seeds collected in Alaska are nondormant. Germination at temperatures from 41 to 77 °F (5 to 25 °C) exceeded 90 percent (Densmore and Zasada 1983; Zasada and Viereck 1975). This adaptation permits the short-lived seeds to germinate in highly variable environments during the short Alaskan growing season. By contrast, freshly harvested Montana seeds were highly germinable at 59 to 77 °F (15 to 25 °C) and less germinable at 41 to 50 °F (5 to 10 °C) (Atchley 1989). Thus, germination may be inhibited by cool seedbed microenvironments. Bebb willow seedlings can tolerate some shade (Atchley 1989).

Uses and Management—Watson and others (1980) described Bebb willow as being a rapid grower, capable of recovering rapidly after browsing, moderately aggressive on suitable sites, a relatively good soil stabilizer, and exhibiting low drought tolerance. Stands stabilize streambanks, providing protection from flooding. Bebb willow often occurs in clumps rather than continuous canopies (fig. 43). Thus, it provides shading for fisheries while permitting good access to recreational fishing sites. Campgrounds cannot be established within Bebb willow sites because the soils are generally wet early in the season.

Figure 43—Thickets of Bebb willow dominate many riparian communities from low to upper mid elevations in western mountain ranges.

Bebb willow provides a major source of highly productive and palatable browse for moose, deer, rabbits, elk, beaver, and bighorn sheep (Marchant and Sherlock 1984; Watson and others 1980). It is more tolerant of browsing than Geyer willow, Booth willow, yellow willow, and Drummond willow, and may increase at their expense following heavy browsing (Hansen and others 1995). Use of Bebb willow increases in late winter. It remains accessible in deep snow as branches are bent down and become accessible to browsing animals (Dorn 1970; Viereck and Little 1972). Song birds and game birds use the species for nesting and food.

Bebb willow communities are often adjacent to meadows grazed heavily by livestock (Boggs and others 1990; Dorn 1970). Trees are usually widely spaced, allowing for easy access (Tesky 1992). Consequently, deferring grazing until sites are dry may be required to reduce livestock trampling and soil compaction (Boggs and others 1990). Heavy livestock use may restrict Bebb willow seedling establishment, resulting in stand degeneration.

Prescribed burns can be used to rejuvenate degraded Bebb willow stands (Hansen and others 1988a,b; Tester and Marshall 1962). Burned plants sprout rapidly from basal stems. The small seeds are dispersed over considerable distances (Haeussler and Coates 1986; Kovalchik and others 1988). Establishment from seed depends on timing of the fire and availability of wet mineral soils to support germination and seedling establishment (Chrosciewicz 1988; Viereck and Little 1972; Viereck and Schandelmeirer 1980).

Bebb willow is used as a "diamond willow" for carving canes, lampposts, and furniture (Watson and others 1980). Wood of this species has also been used for baseball bats, charcoal, and gunpowder (Viereck and Little 1972) .

Varieties and Ecotypes—"Wilson" Bebb willow was released in 1985 by the Alaska Plant Materials Center (Wright 1989). It exhibits wide adaptability and a dense growth habit; it is useful for windbreaks, living fences, and screens.

Family Salicaceae

Salix boothii
Booth willow

Description—Booth willow is a highly branched, rounded shrub with numerous basal stems 10 to 20 ft (3 to 6 m) tall. Young twigs are yellow to dark brown and hairy, becoming glabrous at maturity. Mature leaves are elliptical to broadly lanceolate, thick, firm, and about 0.8 to 3 inches (2 to 8 cm) long. Margins are entire to toothed with fine, gland-tipped teeth. Both leaf surfaces are moderately pubescent when young. Upper surfaces of mature leaves are green; lower surfaces are paler, but not glaucous. Catkins expand with or slightly before the leaves. Staminate catkins are 0.4 to 1 inch (1 to 2.5 cm) long; pistillate catkins are 0.8 to 1.6 inches (2 to 4 cm) long. Floral bracts are brown to black and pubescent with long, curly, tangled hairs. Capsules are borne on stipes less than 0.08 inch (2 mm) long. They are 0.12 to 0.24 inch (3 to 6 mm) long, oblong ovate, and glabrous. Stigmas are nearly entire (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Welsh and others 1987).

Ecological Relationships and Distribution— Booth willow occurs at midelevations from British Columbia to Alberta and south to northeastern California and Colorado (Brunsfeld and Johnson 1985). It may dominate or codominate early seral willow communities in fens, bogs, abandoned beaver ponds, wet meadows, and riparian sites, ranging from recently exposed rocky or gravelly deposits with high water tables to drier benches with deep sandy to clay-loam soils and water tables to 3.3 ft (1 m) below the soil surface (Brunsfeld and Johnson 1985; Manning and Padgett 1995; Padgett and others 1989; Youngblood and others 1985). Booth willow will tolerate moderately alkaline, but not strongly acidic or basic soils (Haeussler and others 1990).

Booth willow often grows in association with Geyer willow and whiplash willow in open bottom lands (fig. 44) and with Drummond willow in forested stream bottoms. Understory species range from beaked sedge and Nebraska sedge in wetter communities to various forbs and shrubs in drier areas. Kentucky bluegrass may be a dominant understory

Figure 44—Shrubby Booth willow is overshadowed by treelike whiplash willow.

species in areas with histories of grazing disturbances and dry surface soils (Hansen and others 1988a,b). Uplands associated with Booth willow support sagebrush, juniper, western spruce-fir, lodgepole pine, Douglas-fir, and alpine meadow communities (Esser 1992).

Booth willow resprouts following burning or mechanical damage. Resprouting is more vigorous if stem removal occurs during the dormant season (Kovalchik and others 1988). Booth willow is also tolerant of frost and flooding. Efficiency of gas exchange and root regeneration are increased by the presence of aerenchyma; adventitious rooting may occur above the level of flooded soil (Kovalchik 1992). However, growth is reduced by prolonged flooding above the level of the root crown.

Flowering occurs from May to June. Fruits ripen and seed is dispersed in late July and early August (Haeussler and others 1990; Zasada and Viereck 1975). Greatest quantities of seeds are produced by plants that are 2 to 10 years old (Brunsfeld and Johnson 1985; Haeussler and others 1990). Booth willow regenerates from short-lived seeds that are dispersed by wind or water. Suitable microsites for germination include wet sand or gravel surfaces receiving full sunlight (Hudak and Ketcheson 1992).

Plant Culture—Booth willow may be used to revegetate degraded riparian areas. Cuttings root readily and abundantly along the lower one-third of the stem (Platts and others 1987). New roots and stems are initiated in 10 to 15 days. Seedlings must be protected from browsing for at least 3 years to ensure establishment (Kay and Chadde 1992).

Fresh seeds harvested in Alaska germinated rapidly and nearly completely at constant temperatures ranging from 41 to 77 °F (5 to 25 °C) (Densmore and Zasada 1983). This behavior may be an adaptation to a short period of viability, the short growing season, and extreme variability in microsite conditions.

Uses and Management—Booth willow provides browse for moose, elk, deer, small mammals, birds, and other wildlife (Chadde and Kay 1988; Manning and Padgett 1995; Youngblood and others 1985). Excessive browsing can reduce Booth willow regeneration and seed production (Kay and Chadde 1992). Booth willow communities provide cover for many terrestrial species and shade and overhanging banks for fish (Brunsfeld and Johnson 1985; Manning and Padgett 1995). Streams in Booth willow stands may provide recreational fishing, but access is restricted by the dense canopies.

Palatability of Booth willow is fair for livestock and sheep; use increases late in the season (Manning and Padgett 1995; Padgett and others 1989; Youngblood and others 1985). Geyer willow, which is often abundant or dominant in Booth willow communities, is generally more palatable. Livestock use of both species should be restricted until soils are dry to avoid compaction (Hansen and others 1988a,b). Production of Booth willow stands is often high, while understory production is variable, depending on the amount of willow canopy present. Heavy use on sites with fine soils and palatable understory species must be avoided to preclude soil erosion and bank sloughing.

Prescribed burning may be used to rejuvenate decadent stands and increase sprouting for use by big game (Haeussler and others 1990; Manning and Padgett 1995). Plants also reestablish from offsite seed sources if burning occurs prior to seed dispersal and fires are severe enough to expose mineral seedbeds (Densmore and Zasada 1983; Zasada and Viereck 1975).

Varieties and Ecotypes—None.

Family Salicaceae

Salix drummondiana
Drummond willow, beautiful willow, blue willow

Description—Drummond willow is a multiple-stemmed shrub usually 10 to 13 ft (3 to 4 m) tall. Young twigs are finely hairy and yellow or green, later becoming glabrous and purple brown to yellow with a bluish glaucous bloom. Mature leaves are elliptic to lanceolate or oblanceolate, 1.6 to 3.5 inches (4 to 9 cm) long and 0.5 to 0.8 inch (1.3 to 2 cm) wide. Margins are entire and somewhat revolute. Leaf surfaces are dark green above and glaucous to strongly silvery pubescent beneath. Catkins expand before or with the leaves; flowering generally occurs in May (Dittberner and Olson 1983; Munz 1973). Staminate catkins are 0.4 to 1 inch (1 to 2.5 cm) long. Pistillate catkins are 0.6 to 1.6 inches (1.5 to 4 cm) long, densely flowered, and silvery pubescent. Floral bracts are black or dark brown, long hairy, and persistent. Capsules are 0.12 to 0.16 inch (3 to 4 mm) long and densely short hairy. Stigmas are lobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Sutton and Johnson 1974; Welsh and others 1987).

Ecological Relationships and Distribution—Drummond willow occurs from Yukon and Saskatchewan south to California and New Mexico and east across southern Canada and the Northern United States. It occurs at mid to high elevations from the upper sage to the spruce-fir zone (Brunsfeld and Johnson 1985; Hansen and others 1995; Manning and Padgett 1995). It is found around springs, seeps, beaver ponds, lakes, ponds, and on flood plains and benches adjacent to swift, rocky, high gradient streams (fig. 45). At the lower edge of its range it generally grows in wet, sandy or gravelly soils adjacent to streams. In cooler habitats at higher elevations it is more abundant and occurs across broad valley bottoms. In such areas it grows on moist, well-aerated mineral soils ranging from sandy to clayey loams. The water table may be near the surface in spring, but it drops below 3.3 ft (1 m) by late summer. Common associates are Booth willow and Geyer willow. Due to the similarity of their ecological requirements, community types in Utah, western Wyoming, and eastern Idaho dominated by either Drummond willow or Booth willow are classified as Booth willow types (Padgett and others 1989; Youngblood and others 1985). However, Goodrich (1992) noted that the dominance of this species and absence of Booth willow along rocky, high-elevation streams of the Uinta Mountains indicates a need to describe one or more riparian community types in which Drummond willow is the dominant woody species.

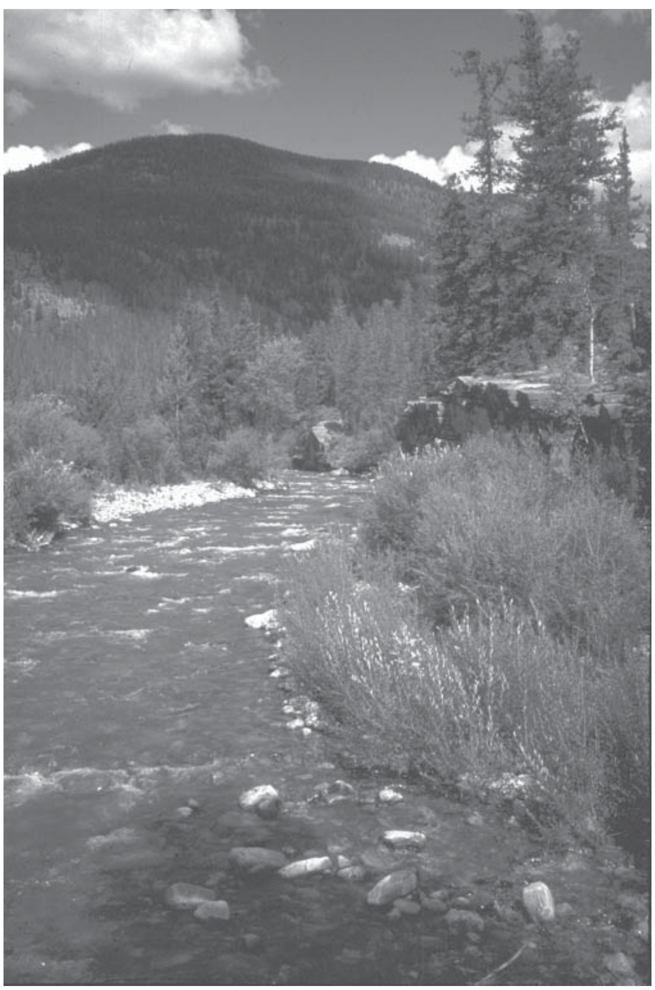

Figure 45—Drummond willow borders a high gradient stream in eastern Utah.

Plant Culture—Drummond willow is useful for stabilization of disturbed sites adjacent to streams and ponds. The species may be established from unrooted or rooted cuttings. Unrooted cuttings are most successful if planted on sites that remain wet throughout the growing season. Two to 4-year-old hardwood cuttings harvested in early spring root readily with root initials appearing along the length of the stem. Roots and shoots appear about 10 days after planting (Platts and others 1987). Seed biology of Drummond willow has not been studied. Seeds ripen in summer and remain viable for about 1 week (Uchytil 1991a).

Uses and Management—Drummond willow communities are long lived, but shade intolerant. Productivity is generally high. Stands provide stream stabilization, dense shade for fish, and habitat for beaver, birds, and other wildlife.

Moose and elk make heavy use of Drummond willow, particularly in winter (Peek 1974; Singer 1979; Stevens 1970). Plants in Yellowstone National Park have been stunted by moose and elk use (Chadde and Kay 1988; Patten 1968). In Oregon, Drummond willow is considered highly palatable to livestock, big game, and beaver (Kovalchik and others 1988). Heavy browsing by big game may lead to degradation or loss of this species. Loss of willows resulting from heavy use by beaver may result in an increase in graminoids, loss of beaver populations, and lowering of the water table.

Drummond willow communities stabilize streambanks and limit livestock access (Hansen and others 1988a,b). Heavy livestock use or trailing at streamside, particularly when soils are wet, however, may lead to highlining, dead clumps, stand loss, and bank compaction and sloughing. Decadent willows can recover rapidly if browsing is reduced. Excessive livestock grazing may also lead to a loss of palatable graminoids and their replacement by less palatable weedy species. Drummond willow stands may act as natural firebreaks in wet years, but during dry seasons they may burn (Crane 1982). Decadent Drummond willow stands may be rejuvenated using prescribed burning in late summer or early fall when sites have dried. Burning near streambanks should be carefully regulated. Livestock grazing must be curtailed for at least 2 or 3 years following burning. Plants recover by resprouting from the root crown following fire (Boggs and others 1990; Kovalchik and others 1988). Seed dispersed from unburned areas may germinate on exposed, wet mineral soils (Viereck 1982; Viereck and Schandelmeier 1980). Recovery from seed depends on seed availability, season of burning, and the presence of open, wet mineral soils.

Varieties and Ecotypes—"Curlew" Drummond willow was cooperatively released by the USDA Soil Conservation Service Pullman Plant Materials Center in 1993 (USDA Soil Conservation Service 1993a). Curlew is valuable for inclusion in conservation plantings for streambank stabilization, erosion control, improvement of wildlife habitat, naturalized landscaping, and shelterbelts. It grows on wet, sandy to gravelly sites in areas receiving 20 to 25 inches (51 to 64 cm) of precipitation. The release originates from a native population growing near the Curlew River, Ferry County, Washington. It is propagated from seed or cuttings. Hardwood cuttings taken in late winter are most commonly used.

Family Salicaceae

Salix exigua
Coyote willow, dusky willow, narrowleaf willow, sandbar willow

Description—Coyote willow is a colonial shrub that spreads underground to form dense thickets. Stems develop from shoot buds on lateral roots. Stems are numerous, slender, and up to 16 ft (5 m) tall. Young twigs are thinly to densely hairy; older ones are glabrous and brown to reddish brown. Mature leaves are linear to oblong, entire to minutely toothed, 0.8 to 4.3 inches (2 to 11 cm) long, and 18 to 30 times longer than wide. Leaf surfaces are gray green to silvery white, and glabrous to densely pubescent. Catkins terminate the twigs and emerge and mature with or after the leaves. Staminate catkins are yellowish and 0.6 to 1.8 inches (1.5 to 4.5 cm) long. Pistillate catkins are 0.6 to 2.4 inches (1.5 to 6 cm) long. Floral bracts are yellowish and hairy. Capsules are 1.6 to 2.8 inches (4 to 7 cm) long, sessile, and glabrous to hairy. Stigmas are deeply lobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Welsh and others 1987).

Flowering occurs from April to July (Dittberner and Olsen 1983). Fruits mature and seeds are dispersed from May to July (Brinkman 1974i; Noble 1979; Ware and Penfound 1949). Seed dispersal may correspond to low water levels (Youngblood and others 1985).

Ecological Relationships and Distribution—Coyote willow is widespread in North America, but occurs entirely east of the Cascade Mountains at low, or occasionally midelevations from the sagebrush to the spruce-fir zone. Coyote willow is one of the earliest pioneer species to colonize freshly deposited sand and gravel bars, which may be below the high water mark where it is subject to annual flooding, ice jams, and associated scouring and deposition (Hansen and others 1988a,b; Wasser and Hess 1982). It frequently occurs along streams and rivers in bottom lands, forming a narrow zone between the water's edge and adjacent cottonwood, water birch, thinleaf alder, or other willow communities (Kovalchik 1987; Szaro and Patton 1987; Youngblood and others 1985). It also grows on rocky, gravelly, and sandy lake and pond edges; wet, well-drained alluvial terraces and bottom lands that may have fine-textured soils (fig. 46); along irrigation ditches; and in wet areas along roadways (Brunsfeld and Johnson 1985). Soil surfaces in communities at the water's edge are often characterized by high percentages of exposed areas and rocky surfaces, and provide seedbeds for establishment of a wide array of annual and perennial herbaceous species (Youngblood and others 1985). Sandbar willow may continue to dominate repeatedly disturbed areas, regenerating by rootsprouting or establishing from seed. Stabilized communities of this shade-sensitive species may eventually be replaced by cottonwoods or other willow species.

Two subspecies of coyote willow are widespread in the Intermountain area; considerable variability occurs within each subspecies. *Salix exigua* ssp. *exigua* occurs primarily in the Wyoming big sagebrush zone of foothill areas and is distributed from southern British Columbia and Alberta to northern Mexico. This subspecies is characterized by entire or few-toothed, gray-green to silvery pubescent leaves; late-developing catkins; and narrow, acute floral bracts. *S. e.* ssp. *melanopsis* is distributed from Alberta to California and south to northern Colorado, and occurs at higher elevations than ssp. *exigua* (Hitchcock and others 1964). Subspecies *melanopsis* is distinguished by its toothed to subentire leaves that are glaucous beneath, glabrous capsules, and blunt floral bracts (Brunsfeld and Johnson 1985).

In addition to spreading by suckering, coyote willow produces numerous small seeds that are dispersed by wind and water (Arno and Hammerly 1977; Mozingo

Figure 46—Coyote willow forms a dense thicket along a dry streambed.

1987). Seeds germinate within 24 hours if exposed to freshly deposited, wet alluvium in full sunlight (Densmore and Zasada 1983). In the field, seeds generally do not remain viable for more than 1 week (Ware and Penfound 1949). Branches are flexible and resprout if buried in sediment. Plants may also regenerate vegetatively from broken stems and roots deposited on exposed, wet soils.

Plant Culture—Coyote willow is an excellent species for restoration of disturbed riparian areas and recently deposited sediments because of its early successional status, rapid growth, and ability to root sprout (Uchytil 1989a). Unrooted cuttings may be used successfully on low-elevation sites where the water table remains high throughout the growing season. Rooted stock should be used on sites with fluctuating water tables, high flooding potentials, or short growing seasons. Coyote willow cuttings develop roots along the entire length of the stem (Platts and others 1987). Roots and shoots appear in about 10 days.

There are about 10,000,000 cleaned seeds per lb (22,000,000 per kg) (Brinkman 1974i). At 72 °F (22 °C), Brinkman (1974i) obtained 83 percent germination in 4 days.

Uses and Management—Maintenance of coyote willow stands is important because of their ability to stabilize streambanks (Uchytil 1989a). Loss of this species as a result of browsing and human-caused disturbances can lead to serious erosion problems (Hansen and others 1988a,b).

Coyote willow is browsed by moose, elk, and to a limited extent, mule deer (Patten 1968; Van Dersal 1938). It is heavily used by beaver (Mozingo 1987). Thickets of sandbar willow provide valuable cover for birds and other wildlife species (Lindauer 1983). However, because of their upright growth habit, they provide only moderate amounts of shade for fish (Hansen and others 1988a,b). Dense stands of coyote willow bordering streams may limit access by fishermen. As such stands are seasonally flooded, they should not be used for campgrounds or roadways (Hansen and others 1988a,b). Coyote willow is used for forage and especially for cover by livestock (Van Dersal 1938). Forage production is low to moderate (Hansen and others 1988a,b).

Coyote willow communities often act as firebreaks due to their occurrence on sites with high water tables or near streams, but they may burn during unusually dry years. Burned plants may resprout from roots and spread from offsite seeds dispersed to wet mineral soils (Conrad 1987; Rowe and Scotter 1973; Zasada 1986).

Varieties and Ecotypes—"Silvar" coyote willow was cooperatively released by the USDA Soil Conservation Service, Pullman Plant Materials Center in 1993 (USDA Soil Conservation Service 1993b). The release originated from material collected on the Tucannon River, near Starbuck, Washington, at an elevation of 560 ft (170 m). It is recommended for use in conservation plantings for riparian area stabilization and restoration, wildlife habitat improvement, and shelterbelts. It is normally propagated from cuttings, but seed can be used.

Family Salicaceae

Salix geyeriana
Geyer willow

Description—Geyer willow is a large shrub or small tree with numerous slender, ascending stems 10 to 13 ft (3 to 4 m) in height arising from a tight basal cluster (fig. 47). The root system is deep, fibrous, and spreading (Sutton and Johnson 1974). Young twigs are densely hairy, but become glaucous; older twigs

Figure 47—Geyer willow forms clumps or corridors that provide cover and travel routes for big game.

are brownish purple and glabrous. Early leaves of the season are glabrous above with long, silky hairs beneath. Mature leaves are lanceolate to elliptical, entire to inconspicuously toothed, 1.2 to 3 inches (3 to 8 cm) long, and 0.3 to 0.5 inch (8 to 12 mm) wide. Surfaces are silvery to gray green above, glaucous below, and hairy on both sides. Catkins expand with the leaves on short, leafy branchlets. Staminate catkins are yellow to reddish and 0.3 to 0.6 inch (0.7 to 1.5 cm) long. Pistillate catkins are globose, reddish, 0.4 to 0.6 inch (1 to 1.5 cm) long, and loosely flowered. The persistent floral bracts are sparsely hairy and yellow to brown or blackish. Capsules are hairy, ovoid oblong, and 0.1 to 0.2 inch (3 to 6 mm) long. Stigmas are nearly entire (Brunsfeld and Johnson 1985; Hitchcock and others 1964).

Ecological Relationships and Distribution— Geyer willow occurs at low to upper elevations from British Columbia to Montana and south from California to Colorado. It grows in wet meadows and marshes, beaver ponds, valley bottoms along meandering streams, and on dry stream benches from the sagebrush to the spruce-fir zone (Brunsfeld and Johnson 1985; Uchytil 1991b). It most commonly grows on fine-textured silty to clay-loam soils that may contain some cobbles or gravels and have considerable organic material and mottling near the surface (Padgett and others 1989; Youngblood and others 1985). Plants usually grow in clumps, but may form a more or less continuous corridor near streamside. Communities in broad valleys are relatively stable and maintained by seasonal flooding and high water tables within 3.3 ft (1 m) of the surface. Associated willow species often include Bebb willow, Booth willow, yellow willow, plainleaf willow, Drummond willow, and Lemmon willow. The understory often includes a moderate to dense cover of graminoids and forbs.

Geyer willow flowers from May to August (Dittberner and Olson 1983; Munz 1973). In eastern Oregon seed dispersal begins in early July (Padgett 1981). Seedlings colonize wet, exposed, well-aerated mineral soils, but can withstand anaerobic conditions (Manning and Padgett 1995).

Plant Culture—Either unrooted or rooted Geyer cuttings may be used to revegetate disturbed sites. Cuttings form roots in about 10 days and shoots in about 10 to 15 days (Platts and others 1987). Conroy and Svejar (1991) and Svejcar and others (1992) found that establishment of Geyer willow was best if unrooted cuttings were planted with the base within 12 inches (30 cm) of the midsummer water table. Waterlogged conditions had no effect on growth of the cuttings.

Uses and Management—Geyer willow is used by moose and elk, especially in winter (Chadde and Kay 1988; Gaffney 1941; Padgett and others 1989). It is more palatable than Drummond willow, Wolf willow, and Booth willow (Boggs and others 1990). Geyer willow clumps and corridors provide excellent cover and travel routes for big game. Beaver use it for food and building material (Allen 1983). It also provides food and cover for birds and small mammals (Argus 1957). Roots of Geyer willow growing along streams contribute to formation of overhanging banks; the canopy provides shade for fish.

In eastern Oregon palatability of Geyer willow to livestock was rated as moderately high (Kovalchik and others 1988). Willows and understory species in these communities are often highly productive and may receive heavy use (Hansen and others 1988). Geyer willow communities provide easy access to livestock. Early season use by wild ungulates, livestock, or vehicles may adversely impact wet organic soils (Manning and Padgett 1995). Excessive use may lead to decreased willow vigor or stand loss, replacement of understory graminoids with less desirable species, lowering of the water table, erosion, and conversion to drier community types (Kovalchik 1987). Decadent Geyer willow can recover if released from browsing pressure.

Plants recover from burning or mechanical damage by sprouting or possibly by establishment of seedlings from offsite seed sources (Kovalchik and others 1988). Fires are infrequent in these areas, but may occur in dry years. Prescribed burning may be used to rejuvenate decadent stands. Areas must be protected from browsing until the stands recover (Boggs and others 1990; Kovalchik 1987).

Varieties and Ecotypes—None.

Family Salicaceae

Salix glauca
Grayleaf willow, glaucous willow

Description—Grayleaf willow is a low shrub 1 to 4 ft (0.3 to 1.2 m) tall. Young twigs are grayish and hairy, becoming reddish brown and glabrous as they mature. Bark of older plants may be rough and furrowed. Mature leaves are lanceolate to elliptical, entire to minutely serrulate, and up to 2.2 inches (5.5 cm) long and 0.3 to 0.9 inch (0.7 to 2.2 cm) wide. Mature leaf surfaces are pale green above and glaucous beneath. They are grayish hairy when young, becoming glabrous as they mature. Catkins expand with the leaves and remain on the plant through summer. Staminate catkins are 0.6 to 1.6 inches (1.5 to 4 cm) long. Pistillate catkins are 0.6 to 2 inches (1.5 to 5 cm) long and densely flowered. Floral bracts are persistent, hairy, and pale brown to black. Capsules are 0.2 to 0.3 inch

(5 to 7 mm) long, long beaked, and densely hairy, becoming nearly glabrous as they mature. Stigmas are bilobed (Brayshaw 1976; Brunsfeld and Johnson 1985; Hitchcock and others 1964; Viereck and Little 1972).

In Alaska and Yukon, grayleaf willow flowers in June. Fruits ripen in July and August and seeds are dispersed in late August and September (Densmore and Zasada 1983; Viereck and Little 1972).

Ecological Relationships and Distribution— Grayleaf willow is a circumboreal species, extending south in North America to alpine and subalpine sites in eastern Idaho, Utah, Montana, Wyoming, Colorado, and northern New Mexico. In the Intermountain area it occurs along streams and in other wet places, on talus slopes, and in snow concentration areas in alpine meadows and forest openings (Padgett and others 1989; Welsh and others 1987). It is found on soils ranging from well drained to poorly drained and usually waterlogged (Alaska Rural Development Council 1977). A low-growing form occurs in open, alpine situations (fig. 48); plants in somewhat protected, subalpine environments are more erect and shrublike (Dorn 1970). An early successional species, grayleaf willow pioneers fresh alluvial deposits, burns, and other disturbed areas with exposed mineral soils (Viereck and Little 1972).

Densmore and Zasada (1983) and Zasada and Viereck (1975) reported that grayleaf willow produces large numbers of small, lightweight seeds that remain on the plant through summer and are dispersed in fall. These seeds remain viable through winter and germinate in spring following snowmelt; this permits seedling development to occur over the entire growing season. Spring ripening populations, however, have been reported (Watson and others 1980). Grayleaf willow often becomes highly abundant following fire, establishing from seed sources in unburned areas (Foote 1983). Seedlings have been noted to invade disturbed sites in Arctic areas (Densmore and Zasada 1983; Viereck and Little 1972). Grayleaf willow sprouts following mechanical damage or burning (Haeussler and Coates 1986). It also spreads vegetatively through rooting of horizontal stems (Sampson and Jones 1977).

Figure 48—Grayleaf willow occurs in alpine areas and exhibits a low, spreading growth habit.

Plant Culture—Densmore and Zasada (1978) found that untreated cuttings of 2-year-old wood, taken in autumn following leaf fall or in spring following leaf expansion, produced few roots. Cuttings treated with rooting hormones produced few to moderate numbers of roots along the entire length of the cutting (Platts and others 1987). Roots and stems appeared in about 10 days. Cuttings have been used to plant unstable sand dunes in northern Alberta (Hardy BBT Limited 1989).

Seed may be used to propagate planting stock. Direct seeding may also be practical (Uchytil 1992). Densmore and Zasada (1983) and Zasada and Viereck (1975) found that fresh seeds were conditionally dormant. Germination increased with constant incubation temperatures from 41 to 77 °F (5 to 25 °C). Wet chilling for 90 days released dormancy; germination was initiated during wet chilling, and nearly all seeds germinated when incubated at constant temperatures in the 41 to 77 °F (5 to 25 °C) range. Environmental conditions may influence the level of seed dormancy; this was indicated by variability in germination of seeds by year of collection and geographic origin. Germination also varied among seeds from different catkins on the same plant.

Seeds may be stored at 14 °F (–10 °C) in doubled 3-mil polyethylene bags for up to 3 years without loss of viability (Zasada and Densmore 1980; Zasada and Densmore 1977). The initial dormancy of some seed lots is lost in storage.

Use and Management—Grayleaf willow is browsed by moose, but it is generally less palatable than other co-occurring willows (Milke 1969). Caribou make use of the species, primarily in summer; snowshoe hare use is concentrated in winter (Cody 1965; Smith and others 1988). Nutrient quality of grayleaf willow for ungulates is good in winter (Risenhoover 1987; Scotter 1972), but lower growing forms may be covered by snow. Plants are tolerant of heavy browsing. The cover value of grayleaf willow for large ungulates is also limited by its low-growing habit, but dense stands provide good cover for small animals (Uchytil 1992).

Erosion control value of grayleaf willow is considered moderate due to its intermediate growth rate (Alaska Rural Development Council 1977). Established plants, however, provide good soil stabilization.

Varieties and Ecotypes—There are no releases.

Family Salicaceae

Salix lasiandra var. *caudata*
Whiplash willow

Description—*Salix lasiandra* plants growing in the Intermountain region belong to *S. l.* var. *caudata*, whiplash willow. Whiplash willow ranges from 10 to 20 ft (3 to 6 m) in height (fig. 49). It is treelike at lower elevations, becoming shrubby at higher elevations. Young twigs are finely hairy, becoming glabrous and yellowish with age. Large branches are yellow to red or brown in winter, while small branches are orangish (Sutton and Johnson 1974). Mature leaves are lanceolate to elliptic, widest at or below the middle, and serrulate. Leaf surfaces are green and glabrous. The lower surface is paler than the upper, but not glaucous. Petioles often bear glands on the upper side near the junction with the leaf blade. Catkins expand with the leaves. Staminate catkins are white to yellow and 0.6 to 1.8 inches (1.5 to 4.5 cm) long, with three to five stamens. Pistillate catkins are pale green to yellow or white and 0.8 to 2.8 inches (2 to 7 cm) long. Floral bracts are deciduous, yellow green, hairy on the lower part, and glabrous distally. Capsules are narrowly ovate, glabrous, and 0.16 to 0.3 inch (4 to 8 mm) long. Stigmas are lobed. Flowering occurs in April or May, and fruiting and seed dispersal from June to August (Brinkman 1974i; Hitchcock and others 1964).

Figure 49—Pistillate catkins of whiplash willow are conspicuous, white to green, and appear with the leaves.

Pacific willow (*S. l.* var. *lasiandra*) occurs mostly west of the Cascade Mountains, but also in wetter portions of eastern Washington, northern Idaho, and northwestern Montana. It is distinguished by the glaucous lower surface of its leaves (Brunsfeld and Johnson 1985).

Ecological Relationships and Distribution—Whiplash willow is distributed from Alaska to Saskatchewan and south from southern California to New Mexico at low to mid elevations (Welsh and others 1987). Associated uplands support communities ranging from Wyoming big sagebrush to pinyon-juniper, mountain big sagebrush, and Douglas-fir (Uchytil 1989b). Whiplash willow is commonly a pioneer or early seral species on alluvial sands and gravels adjacent to fluctuating streams and rivers or abandoned river channels (Brunsfeld and Johnson 1985). Stands are maintained by periodic flooding. Whiplash willow may maintain its dominance on stabilized sandbars, as they develop into benches within the flood plain, but it is eventually replaced by later seral willow or cottonwood species (Manning and Padgett 1995). It often occurs with coyote willow, another pioneer species; they form intermittent linear communities between the high water level and later successional woody species growing further from water. Whiplash willow exhibits high tolerance to deposition and flooding and low tolerance of drought and salty soils (USDA Soil Conservation Service 1992). Its productivity is generally low due to repeated flooding.

Whiplash willow spreads primarily from seeds that are dispersed by wind and water (Zasada 1986). Broken twigs or branches of whiplash willow transported downstream and deposited on wet alluvial surfaces may sprout, developing new plants vegetatively (Argus 1973).

Plant Culture—Whiplash willow is widely used for stabilizing streambanks due to its early seral status. It may also be used on appropriate sites to provide naturalized landscaping, screens, or windbreaks. Unrooted or rooted cuttings may be used. Unrooted cuttings are most successful in areas with high water tables throughout the summer and a long growing season. Whiplash willow roots readily along the entire length of the stem. Roots initiate growth in about 10 days and shoots in 10 to 15 days (Platts and others 1987).

Seeds are green when preripe and yellowish when ripe (Brinkman 1974i). There are about 11,500,000 cleaned seeds per lb (25,300,000 per kg). Brinkman (1974i) reported 25 percent germination at 72 °F (22 °C) in 3 days. Densmore and Zasada (1983) found that fresh seed collected in Alaska germinated rapidly and nearly completely at constant incubation temperatures ranging from 41 to 77 °F (5 to 25 °C).

Uses and Management—Whiplash willow colonizes and stabilizes recent alluvial deposits. Roots provide streambank stability; the canopy provides shade for fish. Consequently, management to maintain these stands is critical. Whiplash willow provides valuable habitat for deer and nongame birds (Argus 1973; Arno and Hammerly 1977; Bernard and Brown 1977; Gray and Greaves 1984). Although palatability of whiplash willow for wildlife is generally considered poor or fair, it is an important browse for mule deer (Sampson and Jespersen 1963; USDA Forest Service 1937). Beaver use it heavily in winter (Kindschy 1985).

Palatability of whiplash willow is greater for sheep than for cattle. On wet sites, healthy whiplash willow stands are not easily accessed by livestock because of the dense overstory. Therefore, these stands are only moderately susceptible to overgrazing, trampling, and compaction (Manning and Padgett 1995). Communities with coarse, dry surface soils and limited herbaceous cover are more vulnerable to heavy grazing. With prolonged heavy use, willow recruitment is decreased, mature plants are highlined, and plants become decadent or die. Willows may be replaced by more mesic shrubs, introduced grasses such as Kentucky bluegrass, or weeds (Hansen and others 1995). With reduction or elimination of browsing, existing plants often recover quickly.

The response of whiplash willow to burning has been poorly documented, and its resprouting capability is not known. Windblown seeds play an important role in reestablishing the species in burned or disturbed areas (Miller and Miller 1976; Shaw and Clary 1996; Zasada 1986).

Varieties and Ecotypes—"Nehalem" Pacific willow is a male clone released by the USDA Soil Conservation Service Corvallis Plant Materials Center in 1978 (Darris and Lambert 1993). It originated from a native population growing near the Nehalem River in northwestern Oregon. Nehalem was selected for its high basal stem density and attractive foliage. It may be used to stabilize streambanks, improve riparian and aquatic habitat for wildlife and fish, and provide natural area landscaping and screens. Nehalem is adapted to planting sites on sandbars, lakeshores, and riverbanks at elevations below 4,900 ft (1,500 m) on the west side of the Cascade Mountains from Washington to northern California. It may be planted on soils ranging from sandy loams to gravelly or rich, rocky soils where soil water is adequate. Nehalem is tolerant of flooding and may be planted in reservoir drawdown areas. Stands may be established from cuttings; suitable materials may be used for wattling, brush matting, and branch packing to provide slope protection.

"Roland" whiplash willow was released in 1985 by the Alaska Plant Materials Center (Wright 1989). It is used for landscaping and stream revegetation and protection throughout Alaska.

Family Salicaceae

Salix lasiolepis
Arroyo willow

Description—Arroyo willow is a shrub or small tree 13 to 20 ft (4 to 6 m) tall (fig. 50) with multiple stems, a large root crown, and a fibrous root system. Young twigs are hairy and yellowish olive to reddish. Mature leaves are coriaceous, oblong or oblanceolate, and entire or rarely minutely serrate with somewhat revolute margins. They are 0.6 to 1.6 inches (1.5 to 4.1 cm) long and 0.2 to 0.5 inch (5 to 13 mm) wide. Leaf surfaces are dark green, glabrous above, and glaucous beneath. Catkins expand before to slightly after the leaves. Staminate catkins are 0.9 to 1.8 inches (2.2 to 4.5 cm) long. Pistillate catkins are densely flowered and 0.9 to 1.8 inches (2.2 to 4.5 cm) long. The persistent floral bracts are purplish black and densely hairy. Capsules are ovate, glabrous, and 0.1 to 0.2 inch (3 to 5 mm) long (Hitchcock and others 1964; Welsh and others 1987).

In northern Arizona, arroyo willow flowers from mid-March to mid-April (Sacchi and Price 1992). Seeds are dispersed over a 3-week period from late April to mid-May.

Figure 50—Arroyo willow grows along washes, ditches, and well-drained sites along ephemeral streams.

Ecological Relationships and Distribution—Arroyo willow is distributed at low elevations from British Columbia to Idaho and south from Baja California to west Texas and northern Mexico. It occurs entirely east of the Cascade Mountains. Arroyo willow may be found growing along streams, ditches, and washes (Welsh and others 1987). It is adapted to well-drained, ephemerally wet riparian sites (Manning and Padgett 1995). In Nevada, arroyo willow occurs on streambenches with coarse-textured or dry surface soils, along incised or ephemeral streams, and near seeps (Manning and Padgett 1995).

Plant Culture—Arroyo willow may be propagated from cuttings. Rooting ability ranges from erratic (Platts and others 1987) to very good (USDA Soil Conservation Service 1992). Roots form from the callus and over the lower one-third of the stem (Platts and others 1987). Stem and root growth are initiated in about 10 days.

Seed biology of arroyo willow has received little study. Seeds are nondormant and remain viable in nature for only 1 to 3 weeks (Sacchi and Price 1992).

Uses and Management—Arroyo willow has good habitat value, high tolerance to flooding and sediment deposition, moderate drought tolerance, and low salt tolerance (USDA Soil Conservation Service 1992). Management to preserve arroyo willow communities in otherwise arid areas is critical; they provide important habitat for a wide range of invertebrate and vertebrate species.

Native seedlings of arroyo willow establish on fresh fluvial deposits and open or partially vegetated streambanks (Sacchi and Price 1992). High seedling mortality is associated with drying of the soil surface; competition and herbivory play minor roles. Seedling growth is reduced by shading, and small seedlings have low overwinter survival. Seedlings surviving for 3 growing seasons may be considered established.

Varieties and Ecotypes—"Rogue" arroyo willow was cooperatively released by the Corvallis USDA-SCS Plant Materials Center in 1990 for use in stabilizing streambanks of low velocity meandering streams, improving freshwater fish and wildlife habitat, naturalized landscaping, and windbreaks or screens in riparian or moist upland situations (Darris and Lambert 1993).

Rogue is a male clone derived from a population growing along the Rogue River in Curry County, OR (Darris and Lambert 1993). Plants are large, multi-stemmed or occasionally single trunked with spreading crowns. Rogue was selected for its rapid, early growth rate and low incidence of insect and disease pests. It is widely adapted to riparian areas and moist upland sites receiving greater than 35 inches (890 mm) of annual precipitation from Washington to northern California on the west side of the Cascade Mountains. The release is propagated from cuttings and can be used for wattling, brush matting, and branch packing in combination with mechanical site treatments (Darris and Lambert 1993).

Family Salicaceae

Salix lutea
Yellow willow, shining willow

Description—Yellow willow is a rounded shrub or rarely a small, usually multi-stemmed tree 10 to 20 ft (3 to 6 m) tall (fig. 51). Young twigs are sparsely hairy and yellowish to reddish, becoming glabrous and yellowish white, gray, or brownish with age. Mature leaves are lanceolate to elliptical, entire to serrulate, 0.8 to 2.2 inches (2 to 5.5 cm) long, and 0.4 to 0.8 inch (10 to 21 mm) wide. They are dark green to yellow green above and pale green and glaucous below. However, a nonglaucous form has been reported (Manning

Figure 51—A low- to mid-elevation species, yellow willow frequently occurs as an early seral species on periodically flooded streambars.

and Padgett 1995). Catkins expand slightly before or with the leaves. Staminate catkins are 0.8 to 2 inches (2 to 5 cm) long. Pistillate catkins are 0.8 to 2.8 inches (2 to 7 cm) long and densely flowered. The persistent floral bracts are hairy and brown to blackish red. Capsules are glabrous and 0.1 to 0.2 inch (3 to 6 mm) long, produced on stipes less than 0.1 inch (2.5 mm) long. Stigmas are often scarcely lobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Welsh and others 1987).

Flowering and fruiting dates vary within and among populations (Martens and Young 1992). Catkins appear in late March or early April on stands near Reno, NV. Flowering has been reported to occur from May to June in California (Munz 1973). Capsules ripen about a month following flowering (Martens and Young 1992). Catkins on a single branch vary in phenological development, and flowering within each catkin is indeterminate. Consequently, fruit ripening is not uniform. Seeds are dispersed by wind and are buoyant in water. Hairs on the seed may aid in dispersal, but they may also be important in germination and seedling establishment (Martens and Young 1992).

Ecological Relationships and Distribution— Yellow willow is distributed from Washington to Manitoba and south from California to Nebraska (Brunsfeld and Johnson 1985). A common species within its range, it grows along streams and ditches in valleys and canyon bottoms. It generally occurs at low to mid elevations, but may be found at higher elevations, particularly in the southern portion of its range. Associated upland communities include mountain big sagebrush, pinyon-juniper, mountain mahogany, Jeffrey pine, or lodgepole pine (Uchytil 1989c).

Yellow willow is capable of withstanding prolonged inundation and often occurs as a pioneer or early seral species on periodically flooded streambars. On such sites it may occur with, or replace, whiplash willow or coyote willow. Understory cover on such sites is often sparse. Yellow willow stands also occur on wet alluvial benches or terraces with well-developed, usually fine-textured soils. Water tables are generally high, but may fall below 3.3 ft (1 m) in summer. Understory species include beaked sedge, Nebraska sedge, bluejoint reedgrass, and other graminoids (Hansen and others 1995; Manning and Padgett 1995; Youngblood and others 1985). Understory productivity and accessibility to livestock depend on the extent of willow canopy. Yellow willow communities may occur in mosaics with other riparian community types dominated by cottonwoods, Booth willow, or Drummond willow.

With excessive livestock grazing in yellow willow communities, the water table falls, surface soils dry, and streams may become incised (Hansen and others 1995; Manning and Padgett 1995). Associated species may be shifted to shrubs such as Woods rose, mesic forbs, or with prolonged excessive grazing, Kentucky bluegrass and other weedy and exotic species.

Plant Culture—Yellow willow may be planted as unrooted or rooted cuttings. Unrooted cuttings are better able to establish on sites with a high water table that persists throughout the summer and allows roots to develop. Roots are initiated along the entire length of the stem, but are most abundant along the lower one-third. Under greenhouse conditions, new roots and stems are initiated in about 10 days (Platts and others 1987). Although cuttings root rapidly, only moderate numbers of roots are produced.

Seed of yellow willow may be collected by harvesting the inflorescences as the capsules begin to open (Martens and Young 1992). Developing fruits should be monitored carefully because seed is dispersed quickly when mature. Harvested catkins can be spread to dry in a warm room until capsules open, releasing the seed.

Fresh yellow willow seed harvested near Reno, NV, exhibited greatest germination in the dark at 50 to 77 °F (10 to 25 °C) (Martens and Young 1992). Germination at 36 °F (2 °C) exceeded 10 percent; no seeds germinated at 95 to 104 °F (35 to 40 °C). When germinated in the dark at 55 alternating temperature regimes, utilizing temperature combinations between 32 and 104 °F (0 and 40 °C) (8 hrs/16 hrs), greatest germination (52 percent) occurred at 50/36 °F (10/2 °C). Temperatures corresponding to very cold, cold, and moderate seedbed conditions enhanced germination; alterations corresponding to warm and warm/fluctuating seedbed conditions reduced germination.

Yellow willow seeds can be stored for short periods of time (Martens and Young 1992). Seeds exhibited some viability after 7 weeks when stored in water at 36 °F (2 °C), in paper bags at 32 °F (0 °C), or at room temperature (Martens and Young 1992). Viability of seeds stored in a desiccator over calcium chloride at 32 °F (0 °C) declined from 25 to 2 percent after 2 weeks.

Uses and Management—The USDA Soil Conservation Service (1992) described yellow willow as having good habitat value, good rooting ability, moderate tolerance of flooding, moderate drought tolerance, and low salt tolerance. Yellow willow often forms a thick corridor that provides streambank stabilization. The fibrous root system contributes to the development of overhanging banks; the canopy provides shade and litter, enhancing fish habitat.

A dense canopy cover of yellow willow provides food and cover for big game, beaver, birds, and other wildlife. Moose and elk use yellow willow in summer and winter. Excessive browsing, however, can result in stand opening or loss of willows (Gaffney 1941; Hansen and others 1995; Van Dersal 1938).

Livestock may make heavy summer and fall use of palatable understory species associated with some yellow willow stands. Heavy livestock use of willows may reduce their vigor, or if prolonged, result in stand loss. Wet soils are easily damaged by livestock trampling early in the season, resulting in soil compaction, early drying of the soil surface, and bank sloughing. Decadent stands resulting from excessive browsing by livestock or big game will regenerate if browsing pressure is reduced. Fire may also be used to rejuvenate decadent stands (Hansen and others 1995). Recreation and travel within these communities require careful consideration due to the dense willow canopy and early season wet soils (Hansen and others 1995). Campsites and trail or road routes should skirt these areas when possible.

Varieties and Ecotypes—None.

Family Salicaceae

Salix planifolia
Plainleaf willow

Description—Plainleaf willow is a shrub growing to 13 ft (4 m) in height. Twigs are glabrous and black to purplish black, exfoliating in translucent flakes. Mature leaves are elliptical, entire, dark green, shiny above, strongly glaucous beneath, and not permanently pubescent on both sides (fig. 52). Veins are prominent and partially parallel. Catkins expand before or with the leaves. Staminate catkins are 0.4 to 1 inch (1 to 2.5 cm) long. Pistillate catkins are densely flowered and 0.8 to 1.6 inches (2 to 4 cm) long. Floral bracts are persistent, black, and long hairy. Capsules are short hairy and 0.1 to 0.3 inch (3 to 7 mm) long. Stigmas are lobed (Hitchcock and others 1964).

Figure 52—Plainleaf willow is a small- to medium-sized shrub with dark green elliptical leaves that are shiny above and glaucous beneath.

Three varieties are recognized. *Salix planifolia* var. *planifolia* ranges from 6.6 to 13 ft (2 to 4 m) in height with elongate leaves 1.4 to 3.1 inches (3.5 to 8 cm) long. The leaves are usually red tinged and sparsely hairy. The other two varieties are generally less than 6.6 ft (2 m) in height. *S. p.* var. *monica* is usually 3.3 ft (1 m) or less in height with leaves that are 1 to 1.4 inches (2.5 to 3.5 cm) long. *S. p.* var. *pennata* is 3.3 to 6.6 ft (1 to 2 m) tall with leaves 1.8 to 2.6 inches (4.5 to 6.5 cm) long (Brunsfeld and Johnson 1985; Hitchcock and others 1964).

Ecological Relationships and Distribution—Plainleaf willow is circumboreal and extends southward in North America from California to New England (Welsh and others 1987). It is found along streams, around the margins of lakes and ponds, and in other wet areas.

Salix planifolia var. *planifolia* occurs east of the mountains in Western Canada and the Northwestern United States at low to moderate elevations. In the United States, it is distributed from the upper sagebrush to the Douglas-fir zone in northern Idaho, Montana, and Wyoming (Uchytil 1991c). It grows on mineral soils with textures ranging from gravelly to sandy or clayey. Water tables on these sites may fall below 3.3 ft (1 m) by midsummer. Associated species often include other tall willows such as Bebb willow, Booth willow, or Geyer willow.

Salix planifolia var. *monica* occurs in valley bottoms at high elevations and on wet, open, subalpine slopes from central Idaho to west-central Montana, and south from the Sierra Nevada Mountains of California to New Mexico. It often occurs in upper cirque basins with cold air drainages (Brunsfeld and Johnson 1985). It usually grows on wetter sites than *S. p.* var. *planifolia*. *S. p.* var. *monica* is often associated with Wolf willow, but grows on saturated soils with finer textures. Soils on *S. p.* var. *monica* sites usually have an organic surface horizon overlying alluvial sands, silts, clays, or sometimes gravels. Soils are often gleyed near the upper horizon (Youngblood and others 1985). Soil pH is generally slightly to strongly acidic (pH 4.4 to 6.3). Stands may be flooded in spring, and the water table generally remains within the rooting zone throughout the growing season. Lowering the water table may lead to an increase in Wolf willow. *S. p.* var. *pennata* is more narrowly distributed. It occurs in the Cascade Mountains from northern Washington to northern Oregon.

Plant Culture—Rooted or unrooted plainleaf willow cuttings may be planted. Unrooted cuttings root rapidly, but rooted cuttings are recommended for high-elevation sites with short growing seasons and rapidly drying soils. Stems produce low to moderate numbers of roots along their entire length (Platts and others 1987). Root formation is initiated in about 10 days; shoots require 10 to 15 days to develop under greenhouse conditions.

Densmore and Zasada (1983) found that seeds collected in Alaska were nondormant at maturity. Germination was rapid and nearly complete at constant temperatures ranging from 41 to 77 °F (5 to 25 °C).

Uses and Management—Roots of plainleaf willows growing in riparian areas contribute to the formation of overhanging banks. Plants also furnish shade for fish habitat. Beaver use the plant for food and building materials. Stem pieces not consumed may sprout and develop into new plants (Cottrell 1995). Big game use plainleaf willow communities for forage, cover, and as travel corridors (Hansen and others 1995; Manning and Padgett 1995; Padgett and others 1989). Moose make heavy winter use of *S. p.* var. *planifolia*, but use by elk and mule deer is low (Dorn 1970; Mattson 1984; Van Dersal 1938). Winter use of *S. p.* var. *monica* may be limited due to its low stature. However, in some areas, moose browse all branches that are accessible in winter. Plainleaf willow communities also provide valuable cover and food for small mammals and birds (Douglas and Ratti 1984; Finch 1987).

Open stands of *S. p.* var. *planifolia* provide moderate amounts of forage for livestock (Hansen and others 1995) compared to other willow communities. Production of these communities is moderate. Palatability of *S. p.* var. *planifolia* to cattle is low (Dorn 1970), but palatability of some associated understory species is high. Early season or season-long use by livestock should be avoided as trampling of saturated sites will damage plants and soils (Manning and Padgett 1995). Short growing seasons and continually wet soils usually limit livestock use to late summer and early fall (Hansen and others 1995). The grazing value of sites dominated by *S. p.* var. *monica* is limited due to its small stature, low productivity, and association with wet soils.

Subalpine and alpine areas occupied by plainleaf willow provide an array of recreational opportunities including hiking, wildlife viewing, and fishing (Hansen and others 1995). These communities, particularly the wetter *S. p.* var. *monica* sites, are easily damaged by hikers, livestock, horses, and offroad vehicles. Heavy use can cause soil compaction, rutting, loss of vegetation, formation of multiple trails or roads, streambank erosion, and other long-term damage that cannot be easily repaired. Travel should be restricted to existing trails or roads, and these carefully maintained. New travel routes should be constructed on adjacent uplands.

Response of the species and its varieties to burning and its ability to resprout have not been examined (Hansen and others 1995). Short-term productivity of understory sedges can be increased by burning. Protection from grazing by livestock during the growing season leaves a thick cover of dry vegetation that burns well in spring before new growth is initiated. Burns along streambanks should be conducted with caution to avoid loss of the bank stabilization provided by these communities. Burned sites should be protected from grazing for 2 to 3 years to prevent overuse of recovering plants.

Varieties and Ecotypes—None.

Family Salicaceae

Salix scouleriana
Scouler willow, fire willow, black willow, mountain willow, nuttall willow

Description—Scouler willow is a shrub or multistemmed tree arising from a massive root crown and a deep, spreading root system. Mature trees may be 5 to 60 ft (1.5 to 18 m) tall. Young twigs are gray and short hairy, becoming dark reddish brown and glabrous. The crushed bark has a distinctive skunklike odor. Mature leaves are oblanceolate to lanceolate or ovate, entire to crenate or serrate, 0.8 to 2.4 inches (2 to 6 cm) long, and 0.4 to 1.2 inches (1 to 3 cm) wide. Leaf surfaces are dark green and glabrous above and sparsely reddish hairy beneath. Leaves turn yellow in autumn. Catkins usually expand before the leaves and are soon deciduous. They are nearly sessile. Staminate catkins are yellowish white, 0.6 to 1.4 inches (1.5 to 3.5 cm) long, and about as long as wide. Pistillate catkins are reddish, densely flowered, 0.8 to 2.4 inches (2 to 6 cm) long, and 0.5 to 0.7 inch (1.3 to 1.7 cm) wide. Floral bracts are brown to black and long hairy. Capsules are hairy, 0.2 to 0.3 inch (5 to 8 mm) long, and more or less long beaked. Stigmas are entire to bilobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964).

Scouler willow is one of the earliest willows to flower. Flowers appear from April to July (Orme and Leege 1980); fruits ripen and seeds disperse from May to July (Brinkman 1974i). Seeds remain viable for only about 1 week (Densmore and Zasada 1983).

Ecological Relationships and Distribution—Scouler willow is distributed from Alaska to Manitoba and south to California, South Dakota, and New Mexico (Brunsfeld and Johnson 1985). At low to mid elevations, it occurs in valley bottoms, along streams, and around springs, where it attains a treelike stature. Scouler willow, however, is generally an upland species, growing on well-drained slopes at higher elevations, where it occurs as a minor understory species in late seral Douglas-fir, subalpine fir, western hemlock, and western red cedar forests (Arno and Hammerly 1977; Froiland 1962). It is slightly tolerant of shade and capable of persisting on these sites at low frequencies (Cooper and others 1987; Steele and Geier-Hayes 1989, 1992). Scouler willow may be found on mineral soils of varying textures and on peaty soils (fig. 53). It is tolerant of acidic, but not salty, soil conditions.

Scouler willow proliferates following disturbance. It often becomes widespread following stand-destroying wildfires, slash burning, clearcutting, road building, or other disturbances that expose mineral soil and provide suitable sites for seed germination and establishment of seedlings (Arno and others 1985; Steele and Geier-Hayes 1989, 1992, 1995). It is particularly abundant where soils have been disturbed in such a manner as to trap water. Some broadcast burn operations and wildfires that leave 50 percent or more of the preburn overstory intact, however, do not provide suitable seedbeds for Scouler willow, and an increase in snowbrush ceanothus may be favored (Forsythe 1975; Steele and Geier-Hayes 1995).

High seedling densities on exposed, wet mineral soils may result from heavy seed rain originating from unburned areas (Lyon 1971; Stickney 1986). Scouler willow seeds sown on burns of differing severities on upland black spruce sites in Alaska germinated only on moderately (organic soil layers partially consumed) and severely (ash layer present, organic material in soil consumed or nearly so to mineral soil) burned seedbeds (Gruell and others 1982; Lyon and Stickney 1976). Germination was greatest and seedlings survived after 3 years only on severely burned sites.

Burned Scouler willow plants resprout vigorously from the rootcrown; multiple sprouts sometimes appear a few days after a fire (Foote 1983). Some plants regenerate even following burns that destroy the entire canopy (Lyon and Stickney 1976). Regenerating trees grow rapidly, particularly during the first two growing seasons (Leege and Hickey 1971; Lyon 1971). Vegetative spread occasionally occurs through rooting of branch segments (Watson and others 1980).

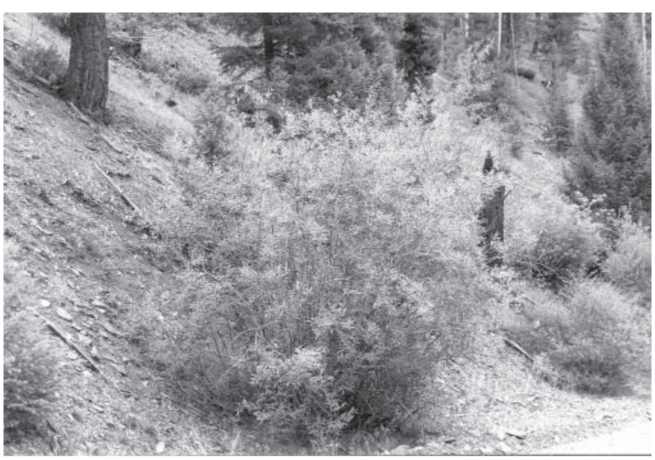

Figure 53—Generally an upland species, Scouler willow grows on dry slopes as an understory in conifer forests.

Dense stands of Scouler willow seedlings and regenerating plants may form shrub fields following fire. These may persist for varying periods of time with willow coverage decreasing as conifers mature (Steele and Geier-Hayes 1995).

Plant Culture—Scouler willow has been used to stabilize cut-and-fill areas along logging roads and other disturbed upland areas, but cuttings do not root as readily as those of many other willows (Monsen 1975; Plummer 1976). Roots develop in moderate numbers from the callus area; they do not develop along the length of the stem. Formation of roots normally requires about 10 to 15 days under greenhouse conditions (Platts and others 1987). Densmore (1978) found that total percent and rate of rooting were greater for cuttings of second-year wood harvested in the spring following leaf expansion (10 percent in 30 days, 1 root each) than for dormant cuttings harvested in the fall (4 percent in 60 days, 4.5 roots each). Second-year wood was collected from a population near Fairbanks, AK.

In a field test, 8- to 10-inch (20- to 25- cm) dormant cuttings of 2- to 3-year-old-wood harvested near Fairbanks, AK, were stored fully imbibed at 14 °F (–10 °C) until planted soon after soil thaw. Cuttings were planted vertically with 0.8 to 2 inches (2 to 5 cm) of stem above ground. Survival following one growing season was 17 percent. Nearly 100 percent of all stem cuttings collected in late fall and early winter from sites in Idaho stored in a moist cold environment, and spring planted in nursery beds, rooted and produced healthy plants. Plants grown under nursery conditions for one season developed large, robust root systems. When outplanted, the rooted plants established quickly and provided cover on road cuts and fill slopes.

Scouler willow may also be propagated from seed. There are about 6,500,000 seeds per lb (14,300,000 per kg) (Brinkman 1974i). Germination of seeds incubated at 85/70 °F (29/21 °C) reached 95 percent in 1 day. Densmore and Zasada (1983) obtained rapid and nearly complete germination of an Alaskan collection when seeds were incubated over a range of constant temperatures from 44 to 71 °F (5 to 25 °C).

Uses and Management—Scouler willow is a highly valued browse species for big game. Seral brush fields of Scouler willow and other shrubs are important winter ranges (Leege 1968). Moose, elk, white-tailed deer, and mule deer use the species throughout the year, but primarily in winter (Kufeld 1973; Kufeld and others 1973; Singer 1979; Smith 1953). In south-central Alaska, moose sometimes remove the bark (Viereck and Little 1972). Recent sprouts are most palatable; greatest production may occur on branches browsed the previous year. Much of the browse on mature plants is unavailable because plants are quite tall. Scouler willow also provides cover for birds and small mammals (Steele and Geier-Hayes 1992; Vories and Sims 1977). In seral brush fields Scouler willow provides excellent cover for big game. Isolated plants in late-seral coniferous stands are not as effective. Scouler willow is highly palatable to cattle and sheep (Dayton 1931). It may receive greater use than other willow species due to the high accessibility of the willow clumps.

Prescribed burning in fall or spring has been used to stimulate sprouting of Scouler willow shrub fields that have grown beyond the reach of big game (Leege 1968, 1969, 1979a). Spring burning may be preferable; fall burning destroys winter browse. Considerable growth may occur during the first growing season following spring burning. Leege (1979a) found that sprouts 5 ft (1.5 m) long were produced following a spring burn in Idaho. Burning at 5-year intervals did not decrease productivity (Leege 1968). Plant nutritive value increases only slightly after burning, but new shoots are within reach and more palatable than older shoots.

Scouler willow in clearcuts may enhance shade-tolerant spruce and Douglas fir establishment by protecting plants from wind and temperature extremes (Steele and Geier-Hayes 1989, 1992). In the absence of a conifer overstory, Scouler willow's growth habit is altered from a narrow, upright form to a more shrublike form with a broad, rounded canopy. These vigorous plants compete strongly with shade-intolerant seedlings of ponderosa pine. Because the two species have similar growth rates for the first 6 to 8 years, the pine seedlings may not survive to overtop the willow. Mechanical treatments to remove Scouler willow are generally impractical due to the plants' deep, spreading root system. Consequently, plantations of Douglas-fir are more likely to be successful.

Scouler willow has been recommended for use in watershed plantings (Monsen 1975). Rooted cuttings establish quickly when planted on road fills and other disturbances. They grow quickly and provide excellent ground cover on exposed unstable slopes. They also may be used in naturalized landscaping to provide screens or background plantings.

Varieties and Ecotypes—None.

Family Salicaceae

Salix wolfii
Wolf willow

Description—Wolf willow is a low-statured shrub 2 to 5 ft (0.6 to 1.5 m) tall with a fibrous, spreading root system. Young twigs are yellow to orange and more or less persistently thin hairy, becoming chestnut brown when mature. Mature leaves are entire, elliptical to lanceolate or oblanceolate, 0.5 to 1.6 inches (1.2 to 4.2 cm) long, and 0.2 to 0.5 inch (0.5 to 1.3 cm) wide. They are gray green to silvery and sparsely to densely hairy on both sides. Catkins expand with the leaves. Staminate catkins are yellowish and 0.2 to 0.6 inch (0.5 to 1.5 cm) long. Pistillate catkins are globose, fuzzy, white, densely flowered, and 0.4 to 0.8 inch (1 to 2 cm) long. Floral bracts are persistent, long hairy, and blackish or pale at the base. Capsules are 0.1 to 0.2 inch (3 to 5 mm) long and glabrous or rarely hairy. Stigmas are lobed (Hitchcock and others 1964; Sutton and Johnson 1974; Welsh and others 1987).

Ecological Relationships and Distribution—Wolf willow is distributed from northeastern Oregon south to Nevada and east to Montana and Colorado (Brunsfeld and Johnson 1985). In central Idaho it occurs from cooler sites at mid elevations in the Douglas-fir zone to subalpine areas, where it grows along streams and around lakes and ponds. Wolf willow community types in southeastern Idaho, northern Utah, western Wyoming, and Montana occur in broad meadows, on alluvial terraces, around seeps, and in old beaver ponds at mid to upper elevations (Hansen and others 1995; Padgett and others 1989; Youngblood and others 1985). Wolf willow often dominates a low shrub overstory, although scattered taller willows may be present. At high elevations, Wolf willow may occur in pure stands (fig. 54). Wolf willow occurs on soils with a relatively thick organic surface horizon that develops from deposition of leaves and twigs. Some sites with lower amounts of organic matter have fine mineral soil with high water-holding capacity. Oxygen is provided by lateral movement of water through such soils. The water table is generally within

Figure 54—Wolf willow forms dense patches of low-statured shrubs in narrow valley bottoms at high elevations.

3.3 ft (1 m) of the surface throughout the growing season. Stream channels in Wolf willow communities are often small and meandering. Streambanks are stable due to the high density of willow roots in the soil. Overland flow is common during snowmelt.

Plant Culture—Wolf willow may be used to revegetate streambanks and ponds, although growth may be slow. Rooted cuttings are advised for use on high-elevation sites with short growing seasons. Hansen and others (1995) recommended use of dormant 2- to 4-year-old wood. Cuttings should be 12 to 20 inches (30 to 50 cm) long and 0.4 inch (1 cm) or more in diameter. Rooting is erratic; few to a moderate number of roots normally form along the length of the stem (Platts and others 1987). Ten to 15 days are required for root and stem initiation. The seed biology of Wolf willow has not been studied.

Uses and Management—Wolf willow communities should be managed to maintain willows along stream margins and provide vegetative cover throughout the community. Wolf willow communities provide valuable streambank stabilization (Hansen and others 1995). The low overstory and diversity of plant species often present in these communities provide cover for birds, small mammals, and other small vertebrates and invertebrates. Cover value for big game is fair. Biomass production of Wolf willow is moderate. The species is palatable to sheep, beaver, and big game. Winter use is minimal when plants are leafless and snow covered. Understory graminoids and forbs vary in palatability. Species such as water sedge or tufted hairgrass may receive heavy use by cattle, but accessibility may be restricted by the dense shrub overstory. Excessive grazing may lead to replacement of the understory by less palatable species. Grazing and equipment use should be restricted until soils are dry as they are easily compacted and become erodible if the vegetative cover is lost. The response of Wolf willow to fire has not been documented (Hansen and others 1995).

Varieties and Ecotypes—None.

Family Saxifragaceae

Philadelphus lewisii
Lewis mockorange

Description—Lewis mockorange (fig. 55), known as syringa, Lewis syringa, mockorange, or Indian arrowwood was named for Captain Meriwether Lewis, who first collected it on the Clark Fork River near Missoula, MT, on July 4, 1806. Plants are long-lived perennials, ranging from open to densely branched, erect to rounded, fibrous rooted shrubs 3 to 12 ft (0.9 to 3.7 m) in height (Carson and Peek 1987; Dittberner and Olsen 1983). Clusters of arching stems develop on older specimens. Young branches are divaricate and glabrous to pubescent with red to chestnut brown bark. Conspicuous transverse cracks develop in the bark during the second season; the bark later turns gray and eventually exfoliates. The light green leaves are opposite, sessile, or short petiolate and ovate to oblong with acute to acuminate tips. They are 1 to 3 inches (2.5 to 7.6 cm) long and 0.4 to 1.6 inches (1.0 to 4.1 cm) wide. The thin blades are entire, 3 to 5 veined, usually glabrous above, but pubescent around the edges and along veins beneath.

Attractive terminal cymes of attractive white flowers develop on lateral branches, each with 3 to 11 perfect, regular flowers. Flowers arise from the axils of gradually reduced leaves. There are four white petals, 20 to 60 unequal stamens with conspicuous yellow anthers, and three to five persistent styles that are more or less connate. Fruit is a woody capsule with four cells attached to the persistent calyx. The light brown fusiform seeds are numerous (Hitchcock and others 1961; Welsh and others 1987). Flowering occurs from late May to July. Fruits develop from July to September or October when the capsules dehisce and seeds are wind and gravity dispersed (Orme and Leege 1980; Young and Young 1986).

Lewis mockorange exhibits a high degree of local variation in floral and vegetative characteristics. This variability has been assigned taxonomic status by some workers (Hitchcock and others 1961).

Ecological Relationships and Distribution—There are about 50 species of *Philadelphus* in North America, Mexico, Asia, and central Europe. Only two species, Lewis mockorange and littleleaf mockorange (*Philadelphus microphyllus*), occur in the Intermountain region. Lewis mockorange is distributed from

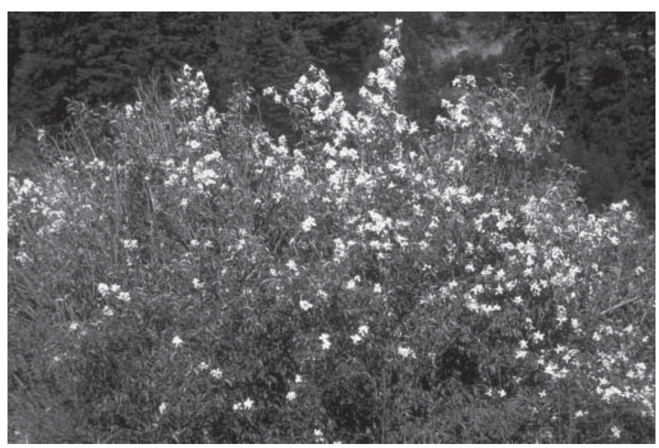

Figure 55—Lewis mockorange survives on a low foothill site following many years of excessive grazing.

British Columbia south to northern California and east to Montana (Hitchcock and others 1961; Lackschewitz 1986). It grows from near sea level to 7,000 ft (2,100 m), but is most common at mideleva-tions. It is a dominant shrub in some climax ponderosa pine communities and a common shrub in some seral ponderosa pine communities (Wright 1978). It is also found in sagebrush deserts, lodgepole pine forests, and coastal Douglas-fir and redwood forests. It commonly occurs in foothills and low mountains on all aspects, but primarily on northern and eastern slopes (USDA Forest Service 1937). The species grows on soils ranging from dry, rocky, gravelly loams on open hillsides, to deep, rich alluvial humic loams near riparian zones (USDA Forest Service 1937). It generally occurs in small scattered clumps in moist, open, or partially shaded transitional areas along gullies, canyon bottoms, riparian areas, and seeps (Carson and Peek 1987; Hopkins and Kovalchik 1983). It also grows on cliffs, talus slopes, and rocky hillsides with other shrubs such as serviceberry and ocean-spray (Carson and Peek 1987; Franklin and Dyrness 1973).

Plant Culture—Seeds may be collected by hand stripping the capsules from the plants after maturity, but before the valves begin to open. Dried capsules are crushed to release the seeds, and trash is removed with an aspirator or fanning mill. There are 3,500,000 to 8,000,000 seeds per lb (7,716,000 to 17,637,000 per kg) of clean seed (Stickney 1974b). Seed fill is often low. Seeds may be stored in airtight containers for periods of up to 1 year. They require an 8-week wet prechilling at 41 °F (5.0 °C) to release embryo dormancy (Stickney 1974b). Germination is tested at 72 to 79 °F (22 to 26 °C).

Seeds may be broadcast seeded on a rough seedbed and covered lightly or spot seeded in selected, prepared areas. They may also be surface seeded using a Brillion seeder or similar device. Best results are obtained if seeds are planted in well-drained sites free of herbaceous competition. Seeds may be mixed with other shrub seeds that require shallow or surface planting.

Bareroot stock may be produced by fall seeding or by seeding wet prechilled seeds in spring. The tiny seeds may be diluted by mixing them with rice hulls to improve uniformity of seeding. Seeds should be covered very lightly. Seedlings develop rapidly and can be transplanted as 1-year-old stock. Container stock may also be grown from seeds.

Due to a lack of commercial seed sources and ease of vegetative propagation, planting stock is frequently grown from cuttings. Dormant 3 to 4 inch (7.6 to 10.2 cm) hardwood cuttings may be planted in a closed cold frame with bottom heat for rooting. Softwood cuttings gathered in early summer or early fall are also easily rooted in a cold frame (Doran 1957; Marchant and Sherlock 1984). Digging rooted suckers and dividing the crown of mature plants with a sharp spade or axe are alternate means of vegetative propagation.

Lewis mockorange is a valuable plant for transplanting on disturbed steep, rocky, unstable slopes where it provides soil stabilization and vegetative cover. Seedlings or larger stock are recommended for such sites. Lewis mockorange is also useful for planting in transitional areas of degraded riparian zones.

Uses and Management—Lewis mockorange is not normally grazed heavily by livestock, but in some areas it does receive fair amounts of use by cattle and sheep (Leege 1968; USDA Forest Service 1937). It frequently occurs with other species that are more palatable to big game and, consequently, it may receive little use, except under severe conditions. However, in some areas it does provide good browse for deer and elk, especially on winter ranges (Kufeld 1973; Leege 1968; Marchant and Sherlock 1984; Stubbendieck and others 1986). New growth is generally highly palatable to big game (Leege 1968). Leege (1969) reported that elk use of Lewis mockorange increased by 30 percent following a spring burn. The plants provide cover for birds and other small animals.

Lewis mockorange is classified as a fire resistant or survivor species (Fischer and Bradley 1987). Although shoots may be consumed by fire, Lewis mockorange is capable of resprouting from the root crown or caudex during the first season following burning (Fischer and Bradley 1987; Rowe 1983). Consequently, it is found in early to late seral as well as in climax communities. Lewis mockorange is not as prolific a sprouter as co-occurring shrubs (Leege 1969). Leege and Hickey (1971) found that spring-burned Lewis mockorange in northern Idaho seral brush fields (grand fir/pachistima habitat type) resprouted within 1 or 2 months, while fall-burned shrubs did not resprout until the following spring. Sprouts were more numerous following fall burning. The historic burn interval in climax ponderosa pine communities is thought to be 6 to 22 years; thus, Wright (1978) prescribed burns at 10 to 15 year intervals to enhance shrub growth.

Lewis mockorange is the state flower of Idaho and is one of the more extensively used native shrubs for landscaping (Marchant and Sherlock 1984). It is valued for its showy white flowers; the fruits and leaves are less attractive. Dense branches and foliage make it suitable for hedges. Native Americans used the long woody shoots for arrow shafts (USDA Forest Service 1937).

Lewis mockorange seedlings establish well, but should be protected from competition and browsing. Landscape plants should be pruned after flowering because flowers are produced on twigs of the previous year. The species is normally free of insect and disease problems, but seedlings are sometimes susceptible to damping off.

Varieties and Ecotypes—The Colfax germplasm of Lewis mockorange originated from the Colfax, WA, area. St. Maries germplasm originated from St. Maries, ID. Several commercial cultivars of Lewis mockorange have been developed. "Waterton," selected from the Waterton Lakes area of Alberta, is a hardy, bushy shrub with flowers scattered over the crown of the plant (Marchant and Sherlock 1984). *Philadelphus coronarius*, introduced from Europe, is the commonly cultivated mockorange (Welsh 1987).

Littleleaf mockorange is a smaller, short-lived shrub, growing from 3 to 7 ft (0.9 to 2.1 m) in height and 4 ft (1.2 m) in width. Shrubs have ascending stems and a rounded crown with reddish-tan exfoliating bark. Leaves are narrower than those of Lewis mockorange, and flowers are solitary or in clusters of three. Littleleaf mockorange occurs from Utah to Wyoming and south to Texas in pinyon-juniper, mountain brush, aspen, lodgepole pine, and Douglas-fir/white fir forests (Goodrich 1985; Sutton and Johnson 1974; Welsh and others 1987). Littleleaf mockorange receives some use by mule deer (Patton and Ertl 1982) and other wildlife. Littleleaf mockorange may be propagated from seed or cuttings. It is easily transplanted and is a strikingly attractive ornamental (Sutton and Johnson 1974).

Family Saxifragaceae

Ribes aureum
Golden currant

Description—There are more than 100 species of *Ribes*, primarily occurring in the temperate and colder regions of the northern hemisphere and the Andes mountains of South America. They are particularly common in the Western United States (Pfister 1974; Welsh and others 1987). Species with jointed pedicels, several flowers per raceme, and glabrous to glandular berries that are generally unarmed are grouped as currants. The remaining species, usually armed with spines, are referred to as gooseberries (Hitchcock and others 1961).

Golden currant is an unarmed, irregularly shaped, multiple-stemmed shrub 3 to 10 ft (0.9 to 3.0 m) tall (Welsh and others 1987) that spreads by suckering (fig. 56). The reddish bark of young twigs turns gray with age. Leaves are alternate, deciduous, and petiolate. Blades are ovate with a cuneate to chordate base, usually glabrous, and palmately three-lobed with the lobes entire, toothed, or lobed. Ascending bracteate racemes occur on the ends of lateral spur branches with two to 15 flowers (Harrington 1964). Flowers are complete and regular with a spicy odor (Stark 1966). The hypanthum is cylindrical with five spreading calyx lobes alternating with five shorter, erect petal lobes. Young flowers are golden yellow, but turn reddish with age. The edible fruit is a globose, glabrous, many-seeded berry. Fruit color varies from yellow to red orange or black. The minute embryo is embedded in a large amount of endosperm (Goodrich and Neese 1986; Hitchcock and others 1961; Munz and Keck 1959; Pfister 1974; Welsh and others 1987).

Ecological Relationships and Distribution—Golden currant is distributed from north-central Washington to Saskatchewan and South Dakota and south to California and New Mexico (Welsh and others 1987). Hitchcock and Cronquist (1973) reported that the shrub occurs along streambanks and washes, and from grasslands and big sagebrush deserts to ponderosa pine forests throughout the Pacific Northwest. In California it grows along moist streambanks and in bottom lands at elevations between 2,500 and 7,800 ft (760 and 2,400 m) (Munz and Keck 1959). Golden currant occurs in many Utah riparian and palustrine habitats in greasewood-shadscale, sagebrush, pinyon-juniper, mountain brush, ponderosa pine, and Douglas-fir communities at 4,395 to 8,490 ft (1,340 to 2,600 m) (Goodrich and Neese 1986; Welsh and others 1987). It occupies similar areas in Colorado and New Mexico, and is common in the plains and foothills of South Dakota and Saskatchewan (Harrington 1964).

Golden currant is generally not widely abundant (Wasser 1982); it occurs as scattered plants, patches, clumps, and in corridors along waterways. It does not occur as even a minor component of aspen or conifer forests in the Intermountain area (Mueggler 1988; Steele and Geier-Hayes 1987; Youngblood and Mauk 1985), but it does grow in aspen/chokecherry communities. It normally grows on fertile, well-drained sites such as moist streambanks, washes, ditches, seeps, and springs. It has been widely cultivated as an

Figure 56—Golden currant planted as a low-maintenance species in a recreation site.

ornamental (Goodrich 1985; Pfister 1974), and now occupies drier sites within abandoned farmlands, ranches, and wildland areas.

Although considered a species for moist sites (Thornburg 1982), golden currant is found on well-drained soils receiving in excess of 16 inches (40 cm) of annual precipitation. It usually occurs on sandy to silty loam soils (Thornburg 1982), but is also adapted to clay-loam soils. Plants generally grow in full sun to partial shade on soils ranging from slightly acidic to slightly basic (Dittberner and Olsen 1983; Wasser 1982).

Plant Culture—Golden currant flowers appear with or slightly before the leaves in April or May. Fruits ripen in June or July and are dispersed by birds and mammals (USDA Forest Service 1948). In central Utah berries may ripen as late as mid-August (Plummer and others 1968).

Fruits or berries are hand harvested by stripping them from branches or by flailing them into containers as soon as they ripen; this reduces losses to birds (Pfister 1974). Few wildland stands are large enough to produce many pounds of seed; consequently, cultivated ecotypes are usually the sources sold for wildland plantings. Native stands are capable of producing good seed crops, but only about 4 lb (1.8 kg) of clean seed are extracted from 100 lb (45.4 kg) of fruits (Pfister 1974). Seed collection costs are high, and tend to restrict use of the shrub in large-scale seeding projects. However, viable seed crops are usually produced each year at most locations, and local ecotypes can be collected and propagated for specific plantings. Most seeds are harvested from cultivated plantings, fence-line plantings, or irrigated seed fields. Plants in these situations generally produce more consistent and abundant crops. In addition, the bushes are more uniform in stature, and are closely spaced, which aids in harvesting.

Collected fruits should not be allowed to overheat prior to extraction. Fruits are processed by maceration using a Dybvig cleaner and water to separate the berry or pulp from the seeds (Plummer and others 1968). Dried fruit should be soaked in water to aid cleaning or maceration. Pulp and empty seeds may be separated from sound seeds by flotation. There are 200,000 to 285,000 seeds per lb (441,000 to 628,000 per kg) (Pfister 1974).

Heit (1971) recommended that tetrazolium chloride staining be used for testing viability, but embryo excision is difficult. Seed viability is generally quite high, usually in excess of 75 percent. Seeds retain good viability for 5 to 17 years if stored dry in sealed containers (Pfister 1974) or in open warehouses (Plummer and others 1968; Stevens and others 1981a). Seed may remain dormant in the soil for many years (Moss and Wellner 1953; Quick 1954).

The degree of dormancy varies among seedlots and among seeds within a seedlot; this provides an adaptive advantage. However, this characteristic reduces the effectiveness of seed pretreatments. Most seeds require a long period of wet prechilling to break embryo dormancy. Germination can be hastened and increased by wet prechilling at low temperatures. A wet prechilling of 60 to 90 days at 28 to 36 °F (–2.2 to 2.2 °C) is often used to release embryo dormancy (Pfister 1974). Stidham and others (1982) recommended that seeds be prechilled on blotters moistened with potassium nitrate.

Seeds should be fall planted to provide a cold, moist period for wet prechilling. Spring plantings should use only prechilled seeds. Seeds are small, round, and easily dispensed through most seeders. Golden currant can be seeded alone or in mixtures with selected shrubs and forbs. It should not be seeded directly with grasses or broadleaf herbs that germinate and grow rapidly. Seeds are usually sown at a rate of 0.25 to 2 lb per acre (0.3 to 2.2 kg per ha), depending on the method of seeding and row spacings. Wildland seedings are usually conducted using seed-dribblers mounted on tractors. Seeds are often hand planted in selected areas. Only a small portion of an area is actually planted using these techniques.

Under nursery conditions, seeds are usually sown at a rate of 60 to 80 seeds per ft^2 (650 to 860 per m^2) or 40 viable seeds per linear ft (130 per linear m) of row (Pfister 1974). Seeds should be planted 0.25 inch (6 mm) deep on a firm seedbed. Planting on sites having some surface mulch or debris aids in germination and seedling establishment. Adding mulch to the soil surface is recommended for nursery beds subject to rapid drying and crusting.

Seed germination is usually only moderate or fair. However, seeds that germinate often do so uniformly, and initial emergence is usually very good even under range or wildland conditions. Compared with most shrubs, seedlings of golden currant are very persistent. Seedlings grow rapidly and generally attain heights in excess of 6 to 12 inches (15 to 30 cm) the first growing season. Although natural thinning occurs, seedlings are vigorous; normally enough survive to provide a full stand. Seedlings of few other shrubs are as vigorous as this species.

Planting sites should be cleared of competition to improve shrub seedling success. Golden currant seedlings and young plants are able to compete and establish with some competitive understory. The shrub is more sensitive to competition when planted along streams or in moist situations, yet seedlings of this species are able to compete well with aggressive herbs that exist in riparian communities. New seedlings appear from natural seeding throughout native ranges, which attests to the survival attributes of this species.

Bareroot or container-grown transplants can be quickly grown, although overseeding is usually recommended to assure emergence of the desired number of seedlings. Planting beds are normally thinned to the proper spacing and density. One-year-old transplants develop a dense, well-branched root system, and field survival of 1-0 transplants is usually very high. Transplants establish very well on harsh disturbances due, in part, to the well-developed root system of young plants. Container stock is grown from seed or hardwood or softwood cuttings (Doran 1957).

Uses and Management—Golden currant has been widely planted for wildlife habitat (Patton and Ertl 1982), ground cover, watershed protection, and conservation plantings (Pfister 1974). It establishes with good success in most wildland plantings; consequently, it is often used to assure the establishment of a desirable species.

Golden currant is a highly preferred spring and midsummer browse for big game, and is recommended for planting in mountain brush, pinyon-juniper, big sagebrush, and wet meadow communities that receive more than 20 inches (51 cm) of annual precipitation (Plummer and others 1968; Wasser 1982). Kufeld and others (1973) reported moderate summer use, but only light fall use by big game animals. The plant is eagerly grazed in early spring and summer, and can be planted on riparian sites and upland ranges to provide seasonal grazing by birds and big game.

Golden currant is commonly planted with a combination of other species to furnish diversity, early developing forage, fruits, and habitat for big game and birds. It provides preferred roosting and nesting cover for several songbirds (Johnson and Anderson 1980). Chukar partridge feed on the ripe fruits (Gullion 1964). Dayton (1931) reported that this shrub species has about average palatability for domestic livestock. Although Dittberner and Olsen (1983) reported considerable variation in palatability among golden currant populations in the West, this species produces an excellent amount of herbage annually.

Golden currant is an excellent species for stabilization of roadways (Wasser 1982) and other disturbances, particularly if transplant stock is used. Both bareroot and container-grown transplants establish and survive well on most disturbances. Transplants grow rapidly and furnish excellent ground cover in 2 to 3 years. If planted at close spacings, 3 to 4 ft (0.9 to 1.2 m) apart, an effective cover can develop quickly. Plants are reasonably adapted to disturbances where portions of the topsoil remain or where the topsoil has been mixed with the planting media. Disturbed areas that lack good fertility and consist of coarse fragments are less likely to sustain this shrub. However, golden currant is quite drought tolerant and can persist on harsh mine sites. Ferguson and Frischknecht (1985) recommended use of this species to reclaim coal fields in south-central Utah. The species prefers fertile, well-drained, neutral, loamy soils (Dittberner and Olsen 1983; Wasser 1982). Haeussler and Coates (1986) reported the plant grows best on soils supplied with humus.

Golden currant is widely used for hedges, windbreaks, and conservation and landscape plantings (Cook 1981; Wasser 1982). It is usually planted in combination with other woody species, particularly evergreens or less open deciduous species. It is often planted as a conservation or wildlife habitat species, but other shrubs provide more acceptable forage for birds (Miller and others 1948). This species is commonly planted in rows or hedges to provide berries for jam and jelly.

Golden currant is widely distributed along streambanks, floodplains, and drainageways (Hitchcock and others 1961; Wasser 1982). It can be used to reclaim riparian disturbances, particularly moist sites where the water table has been lowered by erosion and downcutting of gullies.

Golden currant is moderately fire tolerant (Hopkins and Kovalchik 1983; Rowe 1983), and recovers by resprouting or natural seeding (Rowe 1983). Pfister (1974) reported that golden currant seedlings establish well on mineral soils where the organic duff is removed by fire. Currants are subject to defoliation by the western tent caterpillar (Furniss and Barr 1975); they are also an alternative host for white pine blister rust (Quick 1954).

Varieties and Ecotypes—None.

Family Saxifragaceae

Ribes cereum
Wax currant

Description—Wax currant (fig. 57) is a spreading, unarmed, multicrowned, deciduous shrub, usually 2 to 5 ft (0.6 to 1.5 m) tall with puberulent and more or less stipitate glandular young branches (Hitchcock and others 1961; Welsh and others 1987). Leaves are fragrant, clustered on short spurlike branches (Sampson and Jespersen 1963), usually shallowly three- to five-lobed. The upper surface of the leaves is subglabrous to shiny, and the lower surface is waxy glandular dotted (Stubbendieck and others 1986). The inflorescence is pubescent and sticky glandular. Two or three flowers occur in short drooping clusters. Flowers are greenish white to pink (Welsh and others 1987). Fruits are dull to bright red, glandular to glabrous, and usually between 0.2 to 0.3 inch (6 to 8 mm) long.

Ecological Relationships and Distribution—Wax currant is found from British Columbia to southern California on the east slopes of the Cascade and

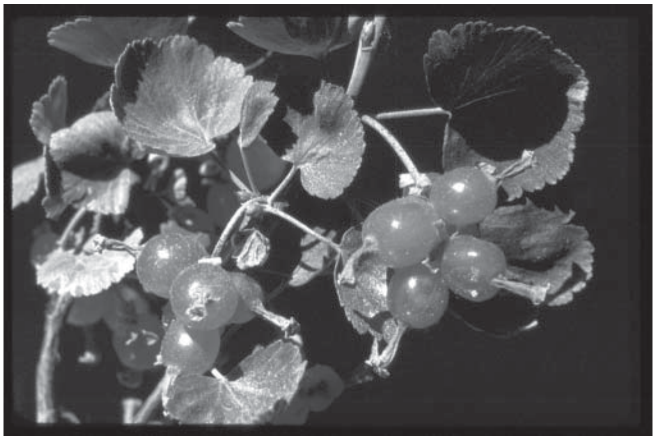

Figure 57—Wax currant growing on a rocky outcrop above timberline.

Sierra Mountains, and eastward to Montana, Nebraska, and New Mexico (Hitchcock and others 1961). It is one of the most widely distributed of all western currants, because it occurs from sagebrush deserts to alpine areas (Great Plains Flora Association 1986; USDA Forest Service 1937). *Ribes cereum* var. *cereum* is found from British Columbia to southern Arizona and southern California, and east to central Montana, Idaho, and western Nevada. The *R. c.* var. *inebrians* is more common eastward from central Idaho and Montana, south and east to Nebraska, New Mexico, Utah, and eastern Nevada. Welsh and others (1987) reported that most plants in Utah are *R. c.* var. *inebrians*, but intergradation of morphological features is common, and no geographical correlation is apparent in Utah. *R. c.* var. *colubrinum* is confined to the Snake River Canyon and related tributaries in Idaho, Washington, and Oregon (Hitchcock and others 1961).

Goodrich and Neese (1986) reported the plant is common and widespread in mountainous communities between 6,500 and 11,000 ft (2,000 to 3,400 m) in Utah. Sampson and Jespersen (1963) reported that wax currant is more widely distributed in California than sticky currant, although their distributions overlap. Wax currant is common in various plant communities, but not as a dominant species. It is often associated with antelope bitterbrush in the Central Rocky Mountains (USDA Forest Service 1937). It is prevalent in various ponderosa pine/Douglas-fir forest types in Colorado and several lodgepole pine associations in Oregon (Volland 1985b). It occurs in aspen communities (Mueggler 1988) and conifer forests of Utah (Youngblood and Mauk 1985) and Idaho (Steele and Geier-Hayes 1987), but only as a minor species.

Plant Culture—Wax currant plants flower from April to June; fruits ripen in August (Pfister 1974). Fruits are harvested by hand picking or flailing the bush to dislodge the berries. Fruits are macerated to remove the seed; the material is then dried, and seeds are separated from the dry pulp using a fanning mill. Seeds are quite small (Vories 1981), averaging about 251,000 per lb (553,400 per kg) (Pfister 1974). Seed production from wax currant is generally lower than from golden currant and sticky currant. In addition, seed germination is usually low and a longer period of wet prechilling is required to overcome dormancy. Pfister (1974) recommended that seeds be wet prechilled for 120 to 150 days at 28 to 32 °F (–2.2 to 0.0 °C).

Seeds should be fall sown at a depth of 0.2 to 0.5 inch (6 to 13 mm) on a firm seedbed. Haeussler and Coates (1986) recommended seeding on moist mineral soils with high percentages of organic matter. Plummer and others (1968) reported that seeds of this species have low seed germination, and the initial establishment of new seedlings is only fair. Young plants grow slower than golden currant seedlings, but persistence of established plants is excellent. Plants spread well from natural seeding. It is less successfully established by transplanting than golden currant. Wax currant is easily cultured in nursery beds.

Seeds of wax currant may be spread by birds or small mammals (Kramer 1984) or by being deposited directly below the shrub (Moss and Wellner 1953). Seeds may remain viable for a long period (Lyon and Stickney 1976). Pfister (1974) reported seeds retained good viability after 27 years of storage.

Although seeds are relatively thin walled and can be destroyed by severe fires (Kramer 1984), they benefit from fire scarification (Morgan and Neuenschwander 1985; Young 1983). New seedlings often appear following low-severity fires that remove little surface litter (Rowe 1983). Plants have large and deeply buried root crows that resprout from belowground tissue if not destroyed by fire (Bock and Bock 1984).

Uses and Management—Wax currant is somewhat less palatable throughout the entire year than golden currant (Plummer and others 1968). Kufeld and others (1973) reported that big game made only light use of the shrub in the spring and fall, but Plummer and others (1968) reported it was heavily browsed during all seasons.

Palatability of wax currant is low for livestock, but it is an important browse due to its abundance, productivity, and availability (Dittberner and Olsen 1983; Mueggler and Stewart 1980; Sampson and Jesperson 1963). This shrub has been principally used for wildlife habitat improvement, although limited plantings have been established for watershed and groundcover protection. It is an important shrub for use in restoration of mountain brush, aspen, and subalpine communities (Plummer and others 1968).

Wax currant has not been widely used for control of severe erosion problems or disturbed land plantings. It has been used to stabilize watersheds, small gullies, and moist streambanks in aspen and conifer forests if topsoil is present. Plants are adapted to disturbances related to fire and logging. Natural regeneration frequently occurs after these disturbances, and this species provides considerable ground cover and herbage. It can be seeded and transplanted on areas exposed by logging or fires with acceptable success. The shrub grows well with understory herbs, and can be planted with a number of species to control erosion and protect unstable sites. It does not spread rapidly to occupy harsh disturbances, and has not performed well as a pioneer species on mines, roadways, or similar disturbances. This shrub grows well with some overstory trees, and can be used to plant campgrounds and recreation sites where a dense tree cover may be desired. This species could be more widely used to restore native communities.

Varieties And Ecotypes—None.

Family Saxifragaceae

Ribes viscosissimum
Sticky currant

Description—Sticky currant (fig. 58) is a spreading, unarmed, uneven, aromatic shrub, mostly 3.3 to 6.6 ft (1.0 to 2.0 m) tall. Stems, leaves, inflorescences, and fruits are sparsely to thickly glandular (Welsh and others 1987). Leaf blades are orbicular, three- to seven-lobed with the main lobes crenate or dentate, round in outline, heart shaped at base, and hairy or glandular on both surfaces (Sampson and Jespersen 1963). Flowers are green, white, or pink, with three to 12 flowers occuring in a cluster. Berries are 0.4 to 0.5 inch (10 to 13 mm) long, black, rather dry, and glandular (Welsh and others 1987).

Figure 58—Sticky current generally occurs above timberline on windswept ridges.

Ecological Relationships and Distribution— This species is common from British Columbia to California on the east side of the Cascade and Sierra Nevada Mountains, and extending east to Montana and Arizona (Hitchcock and others 1961; Sampson and Jespersen 1963; Welsh and others 1987). Hitchcock and others (1961) divided it into two intergrading geographic races. *R. v.* var. *hallii* is distinguished by its glabrous ovaries and glaucous berries; it occurs throughout the eastern Cascades south of Mt. Rainier and the Sierras. *R. v.* var. *viscosissimum* has glandular and more or less pubescent ovaries and nonglaucous berries; it occurs over the remainder of the species' range. Welsh and others (1987) concluded that plants occurring in Utah are unique; the herbage has dense stipitate-glandular and nonglandular hairs and long, broad hypanthia.

Sticky currant grows in shady woods and rocky places in the Sierra Nevada Mountains at elevations between 6,000 and 9,000 ft (1,800 and 2,700 m) (Sampson and Jespersen 1963). Goodrich and Neese (1986) reported the species is common throughout the Uinta Basin in Utah, existing with aspen and conifer woods at 7,500 to 10,000 ft (2,300 to 3,000 m). Welsh and others (1987) reported that this shrub occurs throughout most of north, central, and eastern Utah, growing in the shade of aspen, fir, Douglas-fir, lodgepole pine, and spruce woodlands, but is less common in mountain brush and open meadows. Steele and Geier-Hayes (1987) reported sticky currant as a principal species with grand fir in central Idaho where it is often an early seral shrub, and may be the first shrub to dominate scarified sites following logging. These authors concluded that plants have a low tolerance for shade and begin to decline as a canopy taller than their own develops. Sticky currant plants attain mature stature within 5 years following logging. Their canopy is sparse, and the shrub does not seriously compete with the establishment of tree seedlings (Steele and Geier-Hayes 1987). However, plants of sticky currant remain longer than some species of ceanothus as overstory shade develops. Sticky currant is not a principal species in any conifer forest (Youngblood and Mauk 1985) or aspen type (Mueggler 1988) in Utah.

Plant Culture—Sticky currants flower in May or June, and fruits ripen in August or September (Pfister 1974). Fruits are harvested by hand picking or beating the bush to dislodge the berries onto canvas or other collection tarps. Fruits are cleaned by maceration using a Dybvig separator. Filled seeds will sink or settle in water, and the pulp and empty seeds can be decanted (Pfister 1974). Following maceration, large seedlots can also be dried and the seeds separated from the debris using fanning mills (Plummer and others 1968). There are 255,000 to 349,000 cleaned seeds in 1 lb of cleaned seed (562,000 to 769,000 per kg) (Pfister 1974).

Most plants produce some fruits each year. New or young stands produce the most consistent crops. Although fruits are large, seed collection is slow and costly. Seed costs and poor availability discourage the use of this species in large projects. Enough seeds can be economically harvested most years from specific locations to supply seeds for rearing transplant stock. Seeds can be stored for extended periods, exceeding 17 years (Pfister 1974), if kept in dry sealed containers. Steele and Geier-Hayes (1987) reported seed buried in soil and duff remain viable long after the parent shrubs disappear.

Seeds require a wet prechilling period of 140 days at 28 to 32 °F (–2.2 to 0 °C) to initiate germination (Pfister 1974). Seed germination is only moderate. Seeds gathered from different collection sites can exhibit variable germination patterns. Plummer and others (1968) reported that initial establishment was only fair because of poor germination and relatively slow growth of small seedlings. Growth of young plants is somewhat slow, but improves as plants attain mature stature. However, plants that reach 2 to 3 years of age may succumb under adverse conditions; final establishment of seeded plots is only moderate or good. Plants are not rhizomatous, and natural spread is slow unless sites are cleared by logging, fires, or related disturbances.

This species can be produced as bareroot nursery stock or container material. Initial establishment is poor even under controlled rearing conditions; replanting is often required to produce full stands. Once established, nursery stock grows well, and when transplanted to range or wildland sites, survives quite well.

Uses and Management—Sticky currant is recommended for planting aspen, Douglas-fir, spruce woods, and less commonly mountain brush communities (Plummer and others 1968). It has been used to enhance wildlife habitat (Pfister 1974; Plummer and others 1968). Plants have only fair or poor palatability, but are quite tolerant of grazing. In Utah the plant is most commonly used during spring and summer periods by big game (Plummer and others 1968); heavy browsing may occur during these periods. Sampson and Jespersen (1963) reported that plants in California produce abundant herbage, which is heavily cropped by sheep and deer, particularly in fall.

Sticky currant grows well with other species, and frequently occurs with many other shrubs and herbs. It can be planted to stabilize disturbances following fire and logging. It grows well on undisturbed soils, but is less vigorous and poorly adapted on sites where the topsoil is disrupted or removed. The species is more site specific than other shrubs in its genus. Planting unadapted ecotypes on disturbances reduces survival; however, site factors affecting adaptation are not well understood.

The plant can be used as a nurse crop to improve seedling establishment of tree seedlings. It is also relatively abundant in localized areas and should be maintained for game habitat and ground cover. This species frequently increases following logging and becomes important for watershed protection.

Varieties and Ecotypes—None.

Family Scrophulariaceae

Penstemon fruticosus
Bush penstemon

Description—Bush penstemon is one of approximately 230 species of *Penstemon* that occur in Western North America (Hylton 1974). Most are herbaceous plants, but the list includes a few suffrutescent or woody shrubs. Bush penstemon is a woody species that normally reaches a height of 2.5 ft (76 cm). Plants form a persistent, woody crown that is usually wider than tall. They develop into wide, dense clumps when young and spread by stem layering, but natural dieback leaves the center open. Stems are erect, and clusters of leaves form at the base of current year's stems (Hitchcock and Cronquist 1976). Leaves are mostly lustrous, evergreen, lanceolate or oblanceolate to elliptic, entire or serrulate or denticulate, 0.4 to 2 inches (1 to 5 cm) long, and 0.2 to 0.6 inch (5 to 15 mm) wide. Flowers are bright lavender blue, 1 to 1.5 inches (25 to 38 mm) long, 0.3 to 0.5 inch (7 to 12 mm) wide (Davis 1952). Three varieties were described by Hitchcock and Cronquist (1973); they differ in regard to leaf length, width, margins, and size of flowers. *Penstemon fruticosus* var. *serratus* is mainly confined to the Snake River Canyon of Oregon and Idaho; *P. f.* var. *scouleri* occurs in northeastern Washington, northern Idaho, and adjacent British Columbia; and *P. f.* var. *fruticosus* is more widespread and variable, but generally does not occupy the range of the two other varieties (Hitchcock and Cronquist 1973).

Ecological Relationships and Distribution—Bush penstemon generally occurs at elevations over 4,000 ft (1,200 m) on rocky slopes in forest openings from the Cascades of Washington and Oregon across Idaho to the Rocky Mountains of Montana and Wyoming (Davis 1952). Although widespread, this species is not particularly abundant. It is not a principal understory with any forest community in the Intermountain region (Mueggler 1988), northern Idaho (Cooper and others 1987), or eastern Washington

(Daubenmire and Daubenmire 1968). Plants normally occur on ridge crests, talus slopes, and forest openings. They invade roadcuts and are noticeable on abandoned disturbances. Bush penstemon is encountered in scattered stands of ponderosa pine and Douglas-fir. At higher elevations it exists in openings with subalpine fir. It does not occur in dense shrub fields or mixed grass/herb communities.

Plant Culture—Bush penstemon usually occurs as scattered plants on rocky outcrops (fig. 59). Following disturbances or clearing of overstory species, this shrub flourishes. It invades openings and forms patches dominating small rocky areas. Young plants are vigorous and robust. Disturbances often become excellent seed production centers.

Plants are evergreen; a high percentage of leaves remain on the shrub throughout the winter. New growth begins early in spring before most other plants initiate growth. Leaves develop rapidly to form a dark green clump.

Plants usually produce a profusion of flowers each year. Flowering begins in early June and may continue for nearly 1 month. Seeds ripen from mid-August to late September. Numerous seeds develop each year, but not all are viable. Seed quality varies widely among collection sites and years. Although the plant flowers for an extended period, seeds ripen fairly uniformly and remain in the capsule for nearly a month before shattering.

Seeds are collected by hand stripping the dry capsules, or by clipping the inflorescences. They must be harvested soon after the capsule dries, but before it opens and seeds shatter. Sites that are good seed producers have remained so for nearly 20 years. Most plants within a stand produce good seed crops each year. Seeds are easily harvested and can be cleaned by allowing the capsules to dry and dehisce, releasing the seeds. Seeds are small, but can be separated from the debris using a fanning mill or gravity table.

Figure 59—Bush penstemon, a low-growing mounding shrub, generally grows on rocky outcrops.

Some seeds will germinate soon after harvesting if exposed to favorable conditions, but a period of afterripening and wet prechilling is normally required to assure uniform germination. Seeds that are fall seeded receive natural wet prechilling and germinate uniformly in spring. Bush penstemon seedlings are vigorous and normally grow rapidly.

New seedlings spread quickly from existing plants. Although seedlings increase rapidly, the young plants are not highly competitive with grasses and broadleaf herbs. New seedlings are well adapted to harsh sites and compete well with other species under these conditions, but they are not able to compete with grasses and broadleaf herbs on deep, fertile soils.

Seedlings establish well by broadcast seeding on a rough seedbed or by drill seeding at shallow depths, about 0.24 inch (6 mm) on a firm seedbed. Seed germination and establishment occur uniformly; erratic stands are uncommon.

Bush penstemon is well adapted to drill or broadcast seeding. The seeds can be planted separately or in mixtures with most drills or broadcast seeders. The seeds are small and need not be planted at rates exceeding 2 to 3 lb per acre (2.2 to 3.4 kg per ha). Seeding at a rate of 2 to 4 lb per acre (2.2 to 3.4 kg per ha) is recommended for drill seeding. Broadcast seeding on unprepared road disturbances may be increased to 4 to 6 lb per acre (4.5 to 6.7 kg per ha), depending on whether other species are seeded and the condition of the seedbed. This is one species that responds well to the amount of seed sown. Increasing the seeding rate usually results in an increase in the number of plants to establish. Thus, plant density of this species can be regulated by adjusting the seeding rate. If seeded concurrently with species having larger seeds, it is recommended that the smaller seeds of bush penstemon be planted in separate drill rows to better regulate planting depth.

Small seedlings are quite vigorous. When seeded in barren openings, bush penstemon matures within 2 to 3 years. When grown in competition with grasses, the young plants can be seriously stunted. However, bush penstemon can be planted with certain grasses and forbs. Germination and seedling emergence of this shrub occur at about the same time as most herbs. Consequently, bush penstemon seedlings are able to compete favorably with many native grasses and broadleaf forbs. Bush penstemon seedlings are not able to persist when seeded with a dense cover of aggressive grasses, including smooth brome, intermediate wheatgrass, or timothy.

Bush penstemon grows quickly from direct seeding or transplanting. Transplants can be reared as bareroot nursery stock, greenhouse-grown container stock, or rooted stem cuttings.

Bush penstemon seedlings begin growth early in spring, often before nursery lifting is completed. If bareroot stock initiates growth prior to lifting, field survival of the transplants declines significantly. Fall lifting and overwinter storage may be most practical. Plants stored in bags or crates should have the tops exposed. Plants can be fall lifted and planted in sawdust or other media for overwinter storage in open lath houses. Bareroot stock transplants very well and can provide effective ground cover within 1 to 2 years.

Bush penstemon is easily grown from seed or stem cuttings. However, plants grow rapidly and can be easily stunted if reared in containers that are too small. Container stock grows best in a well-drained, neutral potting media. Stem cuttings taken in midwinter and early spring root readily.

Uses and Management—Bush penstemon is well adapted for revegetation of road disturbances, mine sites, and other drastic disturbances (Hungerford 1984; Monsen and Christensen 1975; Plummer 1977; Tiedemann and others 1976). From roadway plantings in northwestern Montana, Hungerford (1984) rated bush penstemon as the second most useful species for revegetation of forest roads. Only Woods' rose exceeded this species in overall usefulness. The plant is extremely vigorous, matures quickly, and spreads rapidly by natural seeding and crown spread (Hungerford 1984; Monsen and Christensen 1975). It provides excellent ground cover due to its dense, low-profile growth habit. It furnishes effective protection throughout the entire year, as plants are evergreen, and provides aboveground protection at all seasons. It is able to persist and spread when buried by shifting soil. It is one of few species that is well adapted to both rocky, shallow soils, as well as deep, well-developed soils. This species can be successfully seeded or transplanted on rocky roadcuts. It establishes very well from broadcast seedings with minimal soil coverage. Few other species, including most grasses or broadleaf herbs, establish as successfully from broadcast seeding as this shrub.

Bush penstemon is an attractive shrub that flowers throughout most of the summer and provides an attractive leafy cover. It is able to spread and occupy rocky sites, providing an interesting pattern of ground cover. Both the flowers and leaves furnish an attractive background for other species. The shrub can be used to treat roadways, mine sites, and recreational areas where aesthetic values are important. It has considerable usefulness for formal plantings in landscaping commercial or residential sites. Its evergreen growth habit suggests this native shrub would be particularly useful for planting around summer homes and dwellings to prevent the spread of wildfires.

This species is also an important plant for wildlife habitat. It occupies sites that are open and exposed during midwinter. Game animals are often confined to these sites and rely heavily on this shrub. It has considerable promise for many situations, and could be more widely used in restoration programs if seeds were more available.

Varieties and Ecotypes—None.

Family Ulmaceae

Celtis reticulata
Netleaf hackberry

Description—*Celtis* is a large genus of about 70 species of shrubs and trees of the Northern Hemisphere. Netleaf hackberry is a variable taxon, and includes varieties that are difficult to separate due to the many intergradations encountered (Harrington 1964). Netleaf hackberry, also known as hackberry, western hackberry, and palo blanco, is a large deciduous shrub to small globose tree growing to 30 ft (9.1 m) in height and 6 to 12 inches (15 to 30 cm) in diameter, depending on available water (Bonner 1974a; Hitchcock and others 1973). Crowns are open and irregular with stout, ascending branches. Young twigs are glabrous to pubescent. Bark of older branches is reddish gray with prominent ridges and furrows. Plants develop a spreading and fibrous root system. Leaves are short petiolate and leathery with scabrous surfaces and entire to serrate margins. They are ovate or ovate-lanceolate, usually somewhat acuminate and acute to chordate at the base, 1 to 4 inches (2.5 to 10.2 cm) long and 0.74 to 1.5 inches (1.9 to 3.8 cm) wide. Leaf surfaces are dull green to yellow green, but paler with conspicuous reticulate veinlets below. They are three nerved near the base and short pilose along the veins. Foliage turns yellow in fall (Hitchcock and others 1973; Welsh and others 1987).

Plants are polygamo-monoecious with greenish flowers that emerge with the leaves clustered on short shoots of the current season. Flowers develop on slender, pubescent pedicels. Lower flowers are mostly staminate and several per axil. Upper flowers are one or two per axil and mostly perfect, but some may be pistillate. Perfect flowers consists of five membranous perianth segments, five stamens, and a one-seeded ovary with spreading style tips. Fruit is an orange-red to yellow, thin-walled, globose drupe with a datelike flavor (Treshow and others 1970).

Ecological Relationships and Distribution—Netleaf hackberry grows on dry foothills, open slopes, rocky bluffs, watercourses, and canyons from the Snake River drainage of the Northwestern States, east to Colorado, and south to west Texas and southern California (Bonner 1974a; Preston 1968; Thornburg 1982). It grows at elevations ranging from 2,000 to 6,000 ft (610 to 1,800 m) (Sutton and Johnson 1974; Thornburg 1982) on well-drained soils ranging from silty to rocky, shallow to deep, and neutral to calcareous (Sutton and Johnson 1974; Thornburg 1982; Van Dersal 1938). Plants grow in full sunlight and are drought tolerant and wind resistant (fig. 60). Netleaf hackberry is well adapted to watercourses and canyons where it may grow on limestone and gravelly and rocky soils (Thornburg 1982).

Netleaf hackberry occurs as scattered plants in big sagebrush and mountain brush communities at 3,000 to 5,000 ft (910 to 1,500 m) in Utah (Welsh and others 1987). It is prevalent on steep south and west slopes with pinyon-juniper, antelope bitterbrush, Stansbury cliffrose, and other mountain brush species throughout the Wasatch Mountains. It is particularly important on exposed slopes with other persistent species.

Plant Culture—Flowering occurs in March and April; fruits ripen in late fall, and seed disperses in fall and winter (Swingle 1939). Fruits persist on the trees for several months after ripening, providing a prolonged period for collection. Although this plant often grows in harsh environments, some seeds are usually produced every year. They are gathered by hand or by knocking them onto tarps. Collection may be easier in winter after leaves have fallen (Bonner 1974a). Drying may not be required if seeds are collected late in the season, but seeds are more difficult to remove from dry fruits. Twigs and other debris are removed by fanning. Extraction of the pulp by macerating the fruits in water apparently aids in improving germination. Bonner (1974a) reported that fermenting the fruits for 3 days at room temperature prior to depulping and wet prechilling improved germination. Approximately 80 lb (36.3 kg) of seed may be recovered from 100 lb (45.4 kg) of fruits; there are about 4,870 cleaned seeds per lb (10,736 per kg) (Swingle 1939). Dry fruits or cleaned seed may be stored in sealed containers at 41 °F (5.0 °C). Seeds require either fall sowing or a 120-day laboratory wet prechilling at 41 °F (5.0 °C) prior to spring sowing in the nursery (Hartmann and others 1990).

Figure 60—Netleaf hackberry growing on a dry, open slope protected by a rocky outcrop.

Germination is usually quite low as seed from most wildland collections has poor fill (Bonner 1974a). Undeveloped seeds are difficult to separate and remove during cleaning.

Seedlings grow slowly and are sensitive to competition from herbs. Nursery grown transplants and rooted cuttings are often recommended for field plantings to reduce problems associated with establishment from seed. Nursery or container-grown stock develops well, and field survival is excellent. One or 2-year-old planting stock is recommended for outplantings.

Seed and planting stock are rarely available on the commercial market; thus, it is necessary to arrange for collection of seed or propagation of seedlings. Although extensive testing of different ecotypes has not been reported, considerable differences in vegetative traits and areas of occurrence would suggest that planting success is dependent on the use of an adapted seed source.

Uses and Management—Netleaf hackberry currently receives limited use in artificial plantings. However, it is one of the tallest native species on sites within its range of adaptation, and provides important habitat for wildlife. It occupies exposed windblown slopes where big game animals concentrate, providing important cover and protection. The shrub is considered fair to good forage for deer and livestock (Sampson and Jespersen 1963). It frequently grows as clumps or in groups to furnish pockets of cover where few other shrubs are able to grow.

The species grows as a border along riparian zones and significantly enhances these communities. It is particularly adapted to steep slopes and well-drained sites aligning stream bottoms. Fruits persist on the tree well into the winter and provide food for birds (Thornburg 1982). Montezuma quail reportedly eat the seeds during winter months (Bishop and Hungerford 1965). Gambel quail also forage on the fruits (Gullion 1964; Martin and others 1951), as do various small mammals (Bailey 1936).

This species has established well from plantings on big game ranges in central and south-central Utah when planted on shallow soils and exposed slopes within the lower mountain brush zone. It has been planted in groups or patches to provide concealment and winter cover in areas where upright vegetation is required. Game animals and livestock may graze new plantings, but not seriously enough to adversely affect plant growth. This species has survived years of drought without appreciable reduction in plant size and vigor. Once established, the young plants are very hardy and persistent. They are able to compete and grow with understory herbs.

Netleaf hackberry can be used to provide shade in recreation sites, and for windbreaks, shelterbelts, or domestic landscaping. It can be used on sites receiving at least 14 to 16 inches (36 to 41 cm) of annual precipitation. It does not require maintenance in landscape plantings, and could be more widely used in these situations.

Young plants do not grow rapidly. More rapidly developing species are recommended for unstable watershed or mine disturbances. This plant provides important ground cover on sites where high-intensity summer storms may occur. Plants are generally very hardy and long lived. Twigs and leaves are frequently infested by insect galls (Welsh and others 1987), but vigor is not seriously affected. Plants are not especially fire tolerant, and can be killed by wildfires, although resprouting does occur. Many native stands persist on rocky sites that provide some protection from wildfires. Plants that do survive fires usually recover slowly. Plants do not spread rapidly by natural seeding. Few new seedlings appear following fires or other disturbances. Seedlings appear to require shading, but seedbed requirements are not well understood.

Improved Cultivars and Other Species—None. In the Midwest, "Oahe," a released cultivar of *Celtis occidentalis*, has been used as substitute for Siberian elm, Russian-olive, and green ash, although vigor and ease of establishment are lower (Soloman 1985). The cultivar has received little testing in the Intermountain region.

Index

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

Y

Z

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Winterfat seedstalk *Photo by Nancy Shaw*