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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

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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

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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

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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

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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

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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.)

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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 *Agropyron desertorum*	Nordan	1953	Central Asia	ARS, Mandan, ND	Good seedling vigor, large seeds, high yields, cold hardy
	Summit	1953	U.S.S.R.	AC, Saskatoon, Saskatchewan, Canada	Excellent forage traits, high seed yields

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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.)

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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

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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

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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.

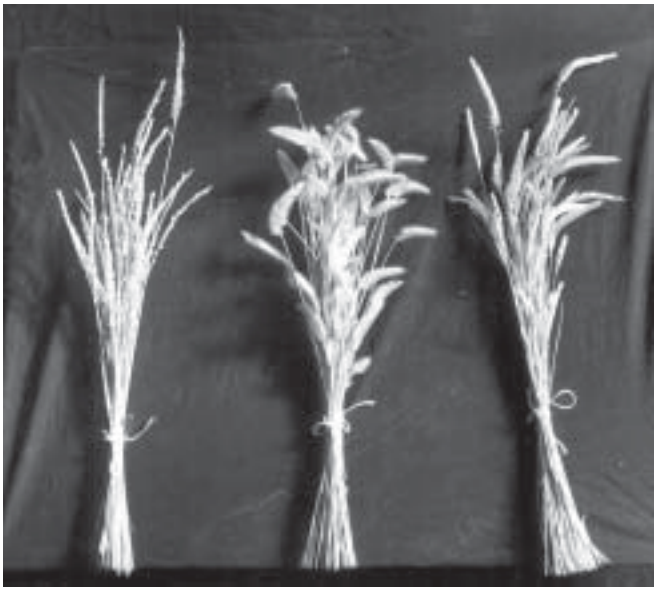

Figure 1—Spikelets of fairway crested wheatgrass (center) are divergent and comblike, while those of standard crested wheatgrass (left) and Siberian crested wheatgrass (right) grow upward (RMRS photo).

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).

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.

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

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

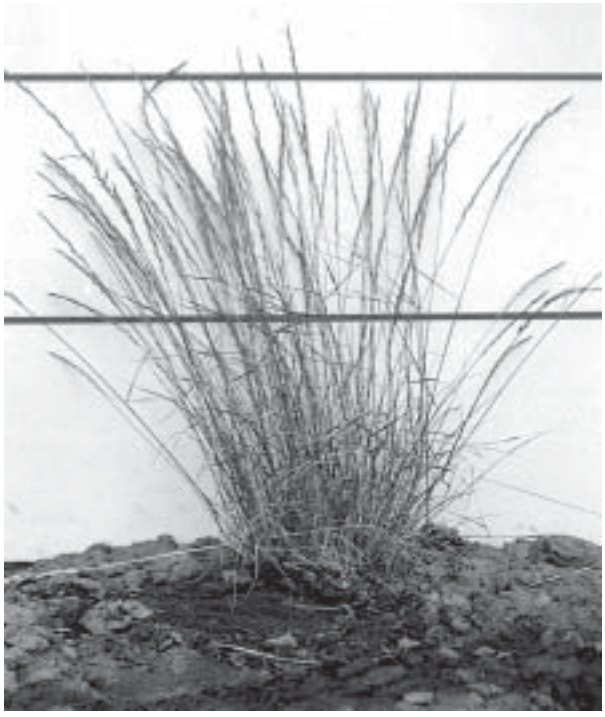

Figure 9—Bluebunch wheatgrass is one of the most important native bunchgrasses (photo courtesy of Kevin Jensen, USDA ARS, Logan, UT).

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.

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).

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).

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.

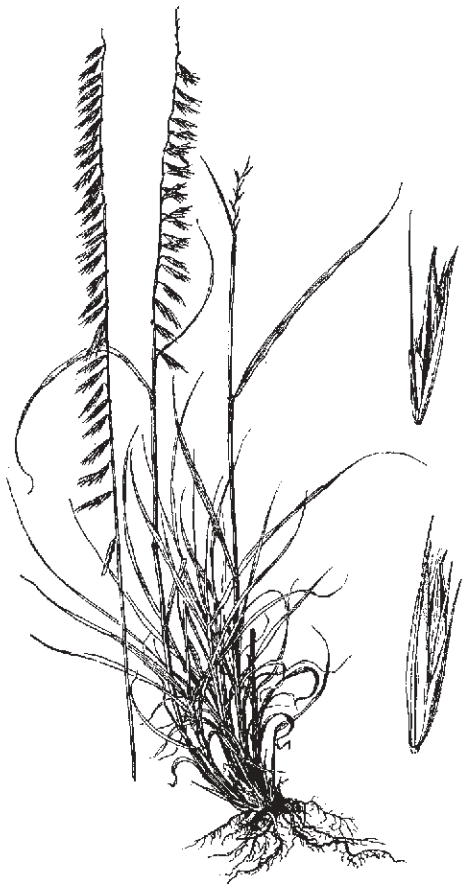

Figure 16—Sideoats grama, a native warm season perennial, is named for the spikes arranged largely along one side of the inflorescence (Hitchcock 1950).

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

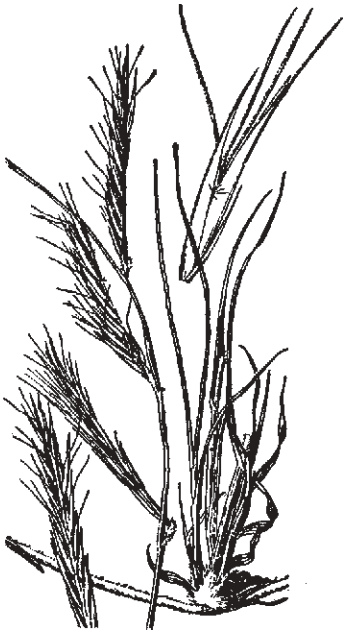

Figure 17—Black grama inflorescences consist of one to six slender, comblike spikes (Hitchcock 1950).

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.

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).

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

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.

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

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*.

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. o*vina*. 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).

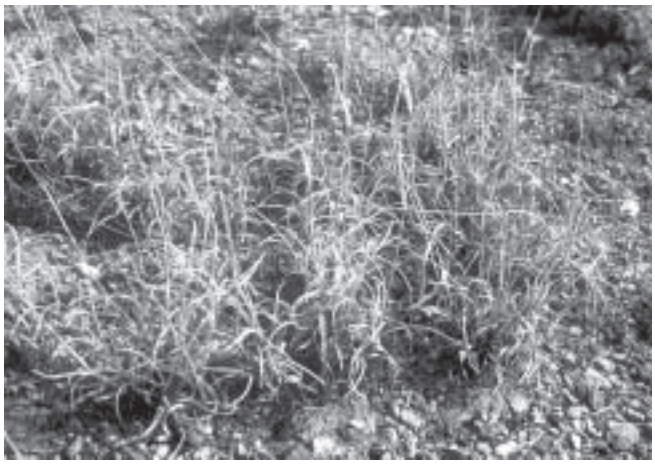

Figure 36—A strongly rhizomatous or stoloniferous species, galleta stems grow along the ground before bending upward (RMRS photo).

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

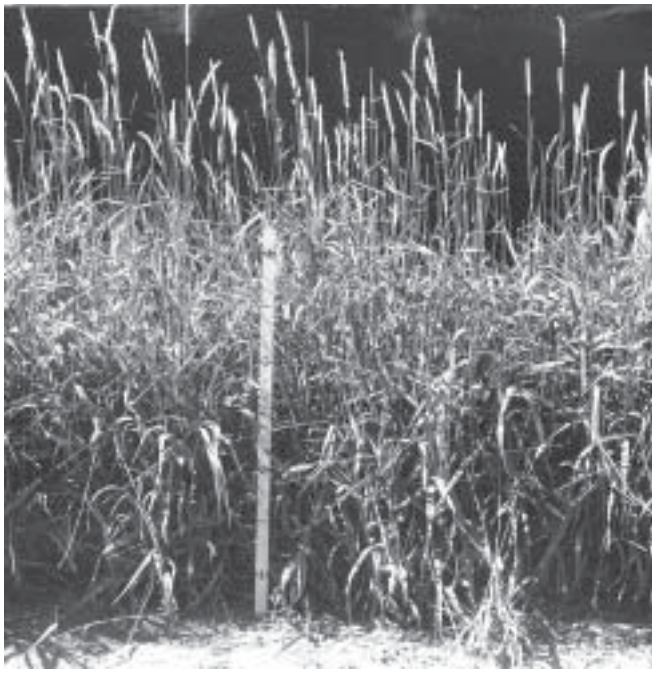

Figure 39—Reed canarygrass, invasive in many North American wetland areas, forms monotypic stands that displace native species (RMRS photo).

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). Sagegrouse 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).

Squirreltail 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

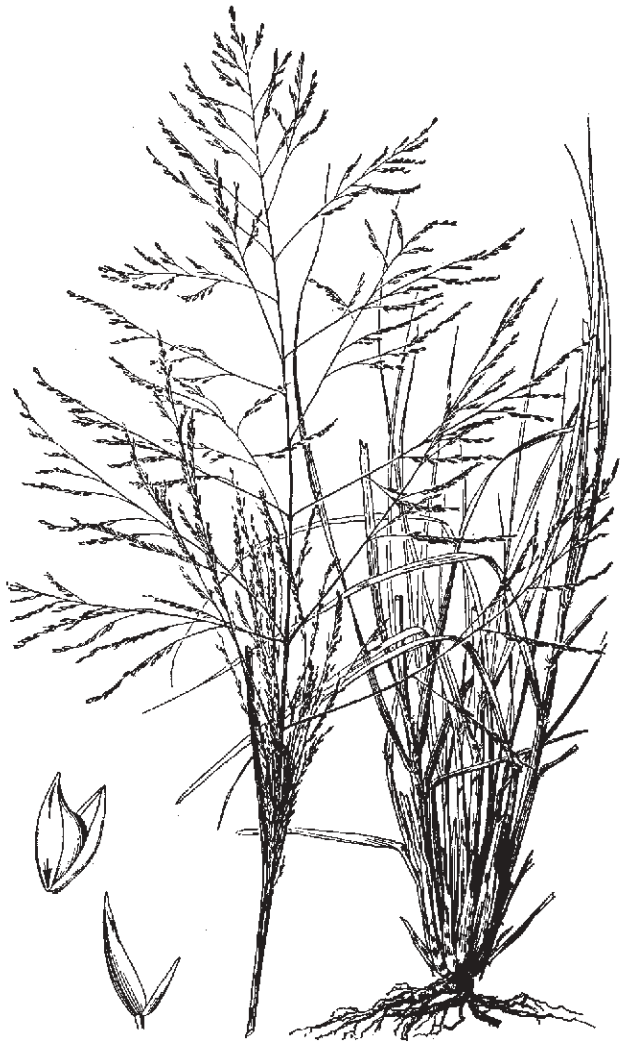

Figure 48—Alkali sacaton is a long-lived bunchgrass that forms large, dense clumps and produces wide, pyramidal panicles (Hitchcock 1950).

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.

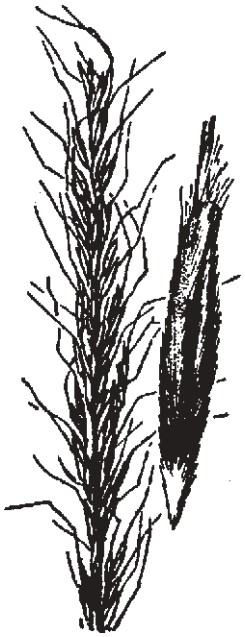

Figure 50—Panicles of subalpine needlegrass are narrow, compact, and up to 8 inches (20 cm) long; spikelets produce a single floret (Hitchcock 1950).

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

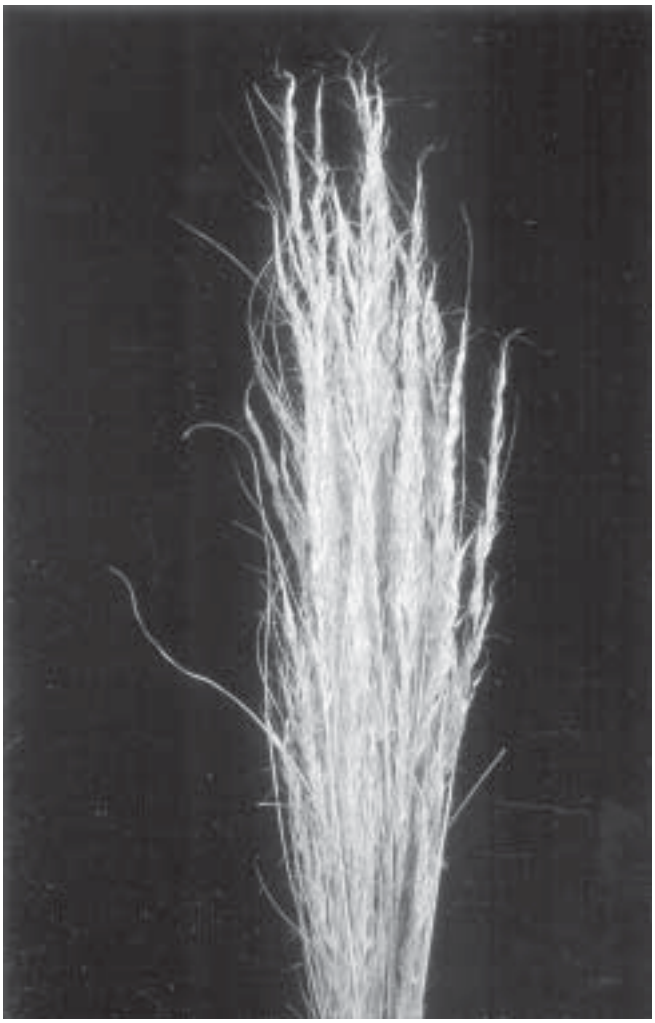

Figure 54—Most common in the northern Great Plains, green needlegrass provides forage for many wildlife species (photo courtesy of Tom Jones, USDA ARS, Logan, UT).

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.