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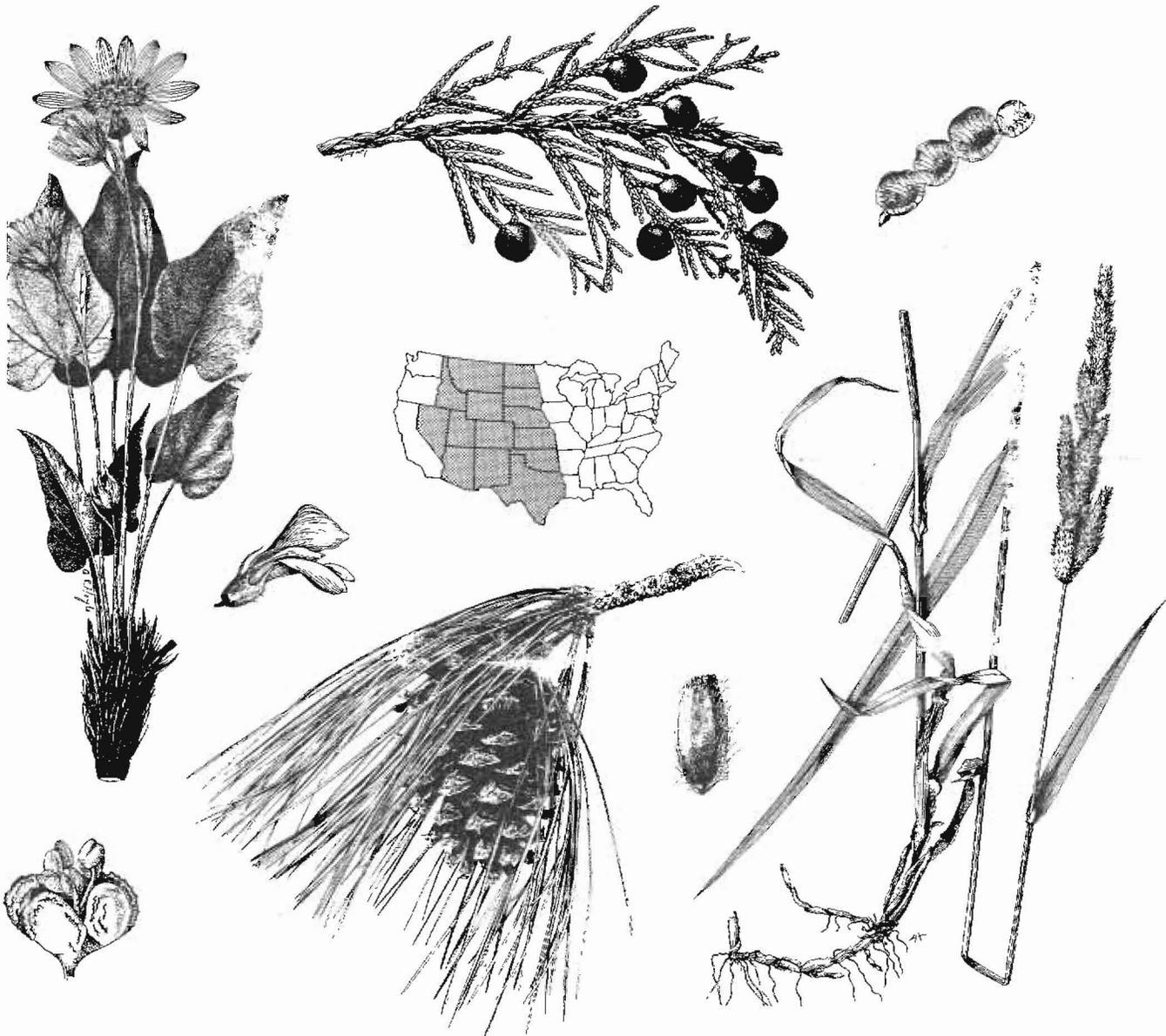
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## Biological Services Program

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# ECOLOGY AND CULTURE OF SELECTED SPECIES USEFUL IN REVEGETATING DISTURBED LANDS IN THE WEST



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FWS/OBS-82/56  
August 1982

## **ECOLOGY AND CULTURE OF SELECTED SPECIES USEFUL IN REVEGETATING DISTURBED LANDS IN THE WEST**

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## INTRODUCTION

This handbook is intended to present ecological information about 98 of the more important species commonly used in revegetation and reclamation projects in the Western United States. For the purposes of this handbook, portions of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, and States west of those States, except Washington, Oregon, and California, are included in the Western United States.

The species included in the handbook usually are important and commonly used for stabilizing and reclaiming surface mined and other disturbed lands. The recommendations for including these species came from a composite list from several university teachers and researchers, industry reclamation specialists, and others interested in, and familiar with, revegetation work in the Western United States.

Species reviewed herein are suggested for use only in the reclamation and rehabilitation of disturbed lands on suitable sites and accompanied by skillful management. Some may be weedy or too aggressive for adjacent croplands, particularly in predominantly farming communities or where croplands constitute significant portions of watersheds being revegetated. Certain species, e.g., prostrate summercypress (*Kochia prostrata*), are still in the testing stages of use and require careful control to avoid undesirable escape and spread onto better condition rangelands. Some plants may be poisonous or toxic to animal life and the user should obtain further information concerning the safe grazing/browsing of such materials before using them.

The approach of the handbook is to present ecological descriptions of the species. The ecological information includes both autecology and synecology. In most species descriptions, the autecological information is more complete than is the synecological information.

The condensed autoecological information given concentrates on species adaptation to site conditions and to the cultural techniques necessary to successfully plant and grow the species.

Each species description in the handbook includes the following information:

1. ORIGIN - the geographic area where the plant is indigenous.
2. SPECIES CHARACTERISTICS - major growth and morphological characteristics.
3. ENVIRONMENTAL RELATIONSHIPS - major soils relationships, climatic adaptations, geographic distribution, and related habitat relationships.
4. CULTURE - planting depth, rate, and time; seed cleaning and quality; and germination and seedling characteristics.
5. MANAGEMENT - uses and field management techniques.
6. ASSOCIATED SPECIES - synecology of the species.
7. PESTS AND DISEASES - identification of common insect and disease pests.
8. IMPROVED VARIETIES - major released improved varieties and their important characteristics.
9. REFERENCES - references used in developing the species description.

The phraseology style of the species descriptions is intended to maximize the information content in a limited number of pages. For the purpose of this handbook, we felt the information content was more important than the style. The literature cited section was similarly constrained to maximize information in minimum space.

The illustrations and text descriptions of species are to assist the reader in the identification of species and depict their general appearance. The insets are included to illustrate some of the more prominent identifying characteristics of the species. The purpose of the handbook, however, is not for identification per se. It is to assist the reader in a better understanding of the ecology and culture of the species.

The United States distribution maps are included to indicate the general distribution of native species and areas where exotic species can be used or in which they are naturalized. The date on the distribution maps indicate isolated or disjunct population distributions. The general character of habitats where the species occurs is thus generally indicated. More specific information is found in the text.

The growth form illustrations are included to show the general outline and overall appearance of the shrubs and trees. In a few cases, we were unable to obtain adequate samples or photographs for the growth form illustrations.

In the handbook, subspecies are identified by the name (genus, species, subspecies) in italics. Named varieties are usually cultivars formally tested, named, and released for production by the U.S. Soil Conservation Service solely, or in cooperation with, other State and Federal agencies. Named varieties are identified by 'Name'.

Abbreviations used in the text are as noted below. These were used to conserve space in the text and probably are somewhat familiar to most readers.

dbh - diameter breast height, tree diameter at 4.5 ft height

EC - electrical conductivity, a standardized measure of soil salinity

MAP - mean annual precipitation

PLS - pure, live seed; excludes impurities and nonviable seed

1-1 - first number is years in seedbed (greenhouse or shadehouse); second number is years transplants are grown in nursery or field plots to produce larger plants

C-3, C-4 - pathways of carbon synthesis in plants

Numerous regional and local revegetation/plant materials guides contain helpful, condensed matrix summaries of species characteristics; soil and climatic adaptations; and potential uses of the many native and introduced graminoids, forbs, legumes, shrubs, trees, and vines. Refer to the following concerning plant materials for your area and/or consult with specialists in State experiment stations, the USDA Agricultural Research Service, the U.S. Forest Service, and the U.S. Soil Conservation Service, including managers of the several plant materials centers of the latter agency.

The Plant Information Network, a computer-based data bank containing rapidly retrievable information, useful to reclamation planners, about native and naturalized vascular plants in the States of Colorado, Wyoming, and Montana. (Write to Plant Information Network, Western Energy Land Use Team, U.S. Fish and Wildlife Service, 2625 Redwing Road, Ft. Collins, CO 80526 for a guide for using this information retrieval system.)

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## DESERT WHEATGRASS OR STANDARD CRESTED WHEATGRASS

*Agropyron desertorum* (Fisch.) Schult  
[= *A. pectiniforme* Roem & Schult (1)]

### ORIGIN

Introduced from Russia, Siberia, and central Asia. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, long-lived, perennial bunchgrass of the C-3 type. Typically grows in widely-spaced bunches in dry sites or nearly as a sod in moister areas. Deep, finely-branched, fibrous root system resistant to drought, soil erosion, and uprooting. Seedheads distinctively different from other perennial wheatgrasses, except for others of the "crested wheatgrass complex."

Culms erect, 1 to 3 feet tall. Numerous green to dark green, mostly basal leaves with slender, pointed auricles and a short membranous ligule. Inflorescence a short, dense tassel- or crest-shaped spike, 1 1/2 to 3 inches long. Crowded spikelets overlap and diverge from spike's axis and are three to eight-flowered. Lemmas enveloping seeds and mostly awnless (1).

Starts growth in early spring, varying with latitude and elevation; makes most of vegetative growth before June, matures in early to midsummer, and becomes semidormant until cooler and/or damper weather. Makes fairly good regrowth in fall with adequate moisture. Medium palatability to livestock while green, less so after heading; fair palatability to elk yearlong; poor palatability to deer but herds sometimes concentrate on seeded stands in spring (2).

### ENVIRONMENTAL RELATIONSHIPS

Thrives on moderately deep and semifertile loam soils in cool, semiarid areas; much less productive on less fertile, thin, gravelly, sandy, and clayey soil. Good drought tolerance and excellent winter hardiness; less tolerant of drought combined with high temperatures of southern latitudes and lower elevations. Persistent where frost-free (32°F) growing season is less than 120 days. Well-managed stands have longevities of 30 years or longer in intermountain region and over 50 years in the northern Great Plains. Demands moderate fertility; plants soon become unthrifty in dense stands without persistent legumes in the mixture or nitrogen fertilization (3). Adapted to weakly acidic and moderately saline soils. Declines only 25 percent at E.C. = 10 mmhos/cm (4). Adaptation largely governed by effective precipitation or soil moisture. Generally adapted to the 9 to 15 inches MAP zones but used in less arid sites and with intensive culture in the 5 to 9 inches MAP zone (5). Seeded on selected sites in the central Rocky Mountains up to 9,000 feet in elevation but generally not below 5,000 feet in Arizona and New Mexico. Intolerant of spring flooding for periods longer than 2 weeks and not tolerant of high water table. Fair tolerance to partial shade, less tolerant than Fairway crested wheatgrass (*A. cristatum*); neither very persistent in dense brush or aspen. Withstands burning well in the dormant state. Moderately competitive but compatible with legumes and other cool season grasses not greatly different in aggressiveness or palatability (2).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed in a firm seedbed at 1/2 to 3/4 inch depths on loams; up to 1 inch deep on coarser, drier, or looser seedbeds; and 1/4 inch deep on clayey soils (6). Cover broadcasted seed shallowly with soil. Supplemental mulching aids establishment on steep, erosive sites (6). Fertilizers also may be needed on cut and fill materials. Drill seeding rates of 20 to 25 PLS per square foot usually needed for minimum satisfactory stand of 1 to 2 established plants per square foot on semiarid rangelands (7). Commonly used rates vary from 5 to 15 pounds PLS per acre for semiarid to subhumid sites. Use 50 to 100 percent more seed when broadcasting and for mine spoils reclamation and soil stabilization, especially where quicker protective cover is needed on harsh sites and on south and west-facing exposures. Denser plant populations from higher seeding rates provide quicker cover, often take longer to become fully established, with production about the same from all stated rates after stands fully established (8). Seed preferably before or very early

during the 2-month period with most favorable soil moisture and temperature for rapid germination and seedling growth and establishment. Options vary with locality, region, and elevation: late fall, early spring, late summer-early fall (Aug. to Sept.); either mid-June to mid-July or after start of the summer rainy period in the Southwestern Pine Zone; and June in higher mountainous areas (8,9,10).

#### Seed Cleaning and Quality

Combine seed in stiff dough stage; greatly reduce combine's wind blast. Clean seed in a fanning mill equipped with a top screen having 1/4 to 1/8 inch oblong openings and a 6 x 26- or 4 x 26-mesh bottom screen. Seed quality: 95 percent purity; 85 percent germination; 81 percent PLS; and 155,000-175,000 seed per pound. High viability is retained for 4 to 5 years.

#### Germination and Seedling Characteristics

Seed germinate in 14 days. Prechilling and germinating in KNO<sub>3</sub> substrate aids in breaking dormancy in seed testing. Chilling, wetting or soaking in water, and brief exposure to dry atmosphere hasten germination. Seedling vigor good and nearly equal to smooth brome (*Bromus inermis*) and cheatgrass brome (*B. tectorum*). Seedlings have lateral seminal roots, elongating coleoptiles, and deep adventitious roots, characteristics uniquely adapted to semiarid environments. Fungicidal seed treatment aids in controlling seed-borne seedling diseases. Germination is delayed and reduced on saline soils.

#### MANAGEMENT

Species is seeded for nonirrigated pasture and hay; landscaping; wildlife food and cover; and for the stabilization of roadsides, utility lines, industrial sites, and mine spoils. Upland birds use stands for food, cover, and nesting. Small seeded areas often attract wildlife. May need to seed less palatable species and/or fence high volume traffic areas. Weeds need to be suppressed on new seedings; herbicides are more effective than mowing. Stands more efficiently managed when fenced separate from native rangelands. Rotation spring grazing using only 65 percent of herbage reported to be best management for stands in intermountain region (11). Two-crop management system advocated where climate favors abundant fall regrowth. Spring and fall grazing of seeded stands complements summer use of Great Plains grasslands and permits their improvement by resting them during critical growth-cycle periods.

#### ASSOCIATED SPECIES

Compatible in simple mixtures with other grasses, legumes, forbs, and/or shrubs which may add diversity in cover, diet, and nutrients while providing greater protection against environmental stresses. Better establishment obtained when strongly competitive members of mixtures, such as legumes and shrubs, or cereal grains used for companion crop, are in alternate rows with grasses. Greater longevity usually expected when species used in seeding mixtures are of similar palatability and phenology. Species is often seeded alone; dense stands suppress annual and many herbaceous weeds. Single species stands require fertility management program.

#### PESTS AND DISEASES

Grasshoppers, rodents, and sometimes rabbits reduce stands and forage crop. The black grass bug (*Labops hesperius*) lays eggs in stems, and the larvae damage both the stand and forage crop.

#### IMPROVED VARIETIES

'Nordan', selected for superior seed and seedling vigor characteristics, was developed and released from North Dakota.

'Summit' is a Canadian release, reported to be taller, larger seeded, and more productive than Fairway crested wheatgrass in western Canada.

Crested wheatgrass or Fairway crested wheatgrass  
*Agropyron cristatum* (L.) Gaertn.

Introduced from Siberia via Canada. Similar to desert wheatgrass but plants are shorter and broader based; lemmas are mostly awned, seeds smaller, and leaves hairier. It has a weakly sodding growth form, is earlier maturing, and often less productive. It is more commonly used for soil stabilization, game range restoration, dryland lawns, and golf courses. Slightly more shade, moisture, and cold tolerant; it is used at higher elevations and in areas with open brush and open aspen. Reported to have slightly less seedling vigor and fire tolerance but similar in palatability and nutritive value and sometimes better. Culture is same as for desert wheatgrass.

'Ruff' is a cultivar developed in Nebraska from several sources of Fairway.

'Parkway', a taller, nonturf variety, was developed in Canada.

Siberian wheatgrass  
*Agropyron sibiricum* (Willd.) Beauv.

Introduced from U.S.S.R. Similar to desert wheatgrass but has finer stems; fewer, blue-green, lax, mostly stem leaves; narrower and flatter spikes; and mostly awnless glumes and lemmas. Growth and use characteristics also similar except it is tolerant of lighter textured soils and drier sites. Has good seedling vigor. More productive than 'Nordan' in more arid regions; 'Nordan' excels with ample moisture. Grows 1 to 2 weeks later into summer before maturing, providing later forage. Same culture applies. P-27 cultivar was developed from selected clones in Aberdeen, Idaho and Pullman, Washington, plant materials nurseries.

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Figure 1. Desert or standard crested wheatgrass (*Agropyron desertorum*). Plant x 1/2; spikelet x 5; floret x 5.

## THICKSPIKE WHEATGRASS

*Agropyron dasystachyum* (Hook.) Scribn.

### ORIGIN

Native of western U.S. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Drought-tolerant, cool season, long-lived, perennial sod-former of the C-3 type. Very similar to western wheatgrass (*A. smithii*) in life-form and appearance.

Single stemmed to small tufted, up to 3 feet tall, with widely spreading rhizomes. Root system dense fibrous, and including rhizomes that are somewhat shallow. Leaf blades narrow, usually inrolled and scabrous, mostly green but sometimes blue-green with relatively less conspicuous upper surface veins. Auricles pointed and semiclasping. Inflorescence an erect, terminal spike up to 8 inches in length. Spikelets irregularly flattened toward spike's axis, sometimes plump and divergent, about 1/2 inch long and three to eight-flowered. Glumes broadest at or above their middle (broadest at the base in western wheatgrass), pubescent and acute-tipped. Lemmas 3/8 inch long, usually hairy and acute- or awn-tipped (1).

Starts growth in spring and matures about 3 weeks earlier than western wheatgrass. Palatability good in summer and fair in winter to cattle, good palatability to elk yearlong, but only fair palatability to deer in spring. Makes fair summer and good fall regrowth.

### ENVIRONMENTAL RELATIONSHIPS

Most common on medium to coarse-textured soils, including sandy soils, but considered adapted for seeding on clayey soils. Tolerant of weakly saline soils. Occurs on well-drained sites with water tables at 3 feet or greater depths but moderately tolerant of early spring flooding. Demands fair level of fertility; full stands become sodbound and less productive in 3 to 5 years. Moderately shade and grazing-tolerant. Native stands occur in the 6 to over 20 inches MAP zones; seeded strains believed best adapted to the 12 to 18 inches zone but also used in the below 10 inches zone. Wide elevational occurrence from near sea level about Great Lakes up to 10,000 feet in the Wasatch Range in Utah (2). Remarkably fire-tolerant; remains green much of summer; low growing and less of a fire hazard than taller species, but soon spreads and dominates ground cover after planned sagebrush-grass fires (3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 inch deep on fine-textured soils and up to 1 inch deep on coarser soils. Firming seedbeds before seeding is beneficial. Cover broadcasted seed shallowly with soil. Supplemental mulch and light irrigation on erosive and droughty sites ensure better establishment. About 20 to 25 PLS per square foot usually needed to obtain 1 to 2 plants per square foot. Fewer seeds with rhizomatous species may suffice if erosion and weed infestations are not serious hazards during longer establishment period. Five to ten pounds PLS per acre are used for rangeland areas. Rate should be increased 100 percent for broadcasting with this species. About 50 PLS per foot of row used in tests on surface-disturbed lands in western Colorado; similar amounts used for harsh sites and south and west exposures (4). Drill seed either in early spring, late fall, or late summer-early fall (Aug.-Sept.) with ample moisture. Usually seed prior to the 2-month period with the most favorable moisture and temperature conditions for seedling establishment (cf. desert wheatgrass, *A. desertorum*, for alternatives).

#### Seed Cleaning and Quality

Combine seed directly. Use fanning mill to clean seed to commercial quality. Seed quality: 85 to 90 percent purity; 88 to 90 percent germination; 75 to 81 percent PLS; and 150,000 to 156,000 seed per pound.

## Germination and Seedling Characteristics

Germination occurs in 21 days under ideal lab conditions. Prechilling seed improves germination. Seedling vigor for the species is only fair, better than western wheatgrass but weaker than desert wheatgrass and intermediate wheatgrass (*A. intermedium*). 'Critana' variety reported to be good. Species spreads rather slowly in developing full stands; 'Critana' reported to be much improved. The earlier a full stand is attained, the sooner the stand becomes low-producing and sodbound and in need of nitrogen (5).

## MANAGEMENT

This species is considered a special purpose grass usable chiefly for soil stabilization of disturbed lands, including roadsides, airports, recreation areas, and construction sites receiving little maintenance; for drier parts of ditches, canals, and waterways; and for mine spoils. Also provides good upland bird cover. Weeds need to be controlled on new seedings. Avoid grazing of seedling stands until they are firmly rooted and headed. Moderate spring-fall grazing and rotation grazing among spring units recommended for ranges in satisfactory condition. Deferred grazing only in fall prescribed to improve ranges in unsatisfactory condition (6). Conservative fertilization program needed to maintain high forage production when species seeded alone.

## ASSOCIATED SPECIES

Common associates: big sagebrush (*Artemisia tridentata*) in the Great Basin; needle-and-thread (*Stipa comata*), sand dropseed (*Sporobolus cryptandrus*), and prairie sandreed (*Calamovilfa longifolia*) on coarse-textured soils of the West; and bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*) in the inland Pacific Northwest and westside Rocky Mountains. Often seeded alone but also used in mixtures for cover and/or forage. Seed the stronger competitors (e.g., alfalfa (*Medicago sativa*), shrubs, or grain) in alternate rows with grass. Species sometimes used as a spreading, undercover member in mixtures with taller species.

## PESTS AND DISEASES

Grasshoppers may thin stands. Seed and seedling diseases minor.

## IMPROVED VARIETIES

'Critana', only released cultivar, developed from plants growing on road cuts in northern Montana. Successfully used on mine spoils and for range seedings in Montana and Wyoming and on surface-soil disturbances in western Colorado (7).

### Streambank wheatgrass

*Agropyron riparium* Scribn. and Smith

[= *A. dasystachyum riparium* (Scribn. & Smith) Bowden (1)]

Similar in appearance to thickspike wheatgrass. Distinguished by mostly glabrous or smooth lemmas and by its common habitat of fine-textured soils. Moderately tolerant of saline-sodic soils and relatively unpalatable. Used for stabilizing disturbed soils and mine spoils; for ditch and canal banks, roadsides, fairways, and lawns; and to control rangeland erosion. 'Sodar', released in the Pacific Northwest, is widely used for low ground cover. Well adapted in the intermountain area. 'Critana' outperforms it east of the Continental Divide in the northern Great Plains (7).

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Figure 2. Thickspike wheatgrass (*Agropyron dasystachyum*). Plant x 1/2; spikelet x 2; floret x 2; glumes x 2.

## TALL WHEATGRASS

*Agropyron elongatum* (Host.) Beauv.

### ORIGIN

Indigenous to Turkey, Asia Minor, and Russia; common on saline meadows and seashores. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Coarse, cool season, tall bunchgrass of the C-3 type. Latest maturing cool season grass used for revegetation purposes in the West.

Plants large-tufted and up to 5 feet tall or taller under irrigation. Leaf blades green or blue-green, flat or inrolled, about 1/4 inch wide, 8 to 16 inches long, strongly veined and sparsely haired. Auricles erect and not clasping. Inflorescence an erect spike as much as 30 inches long. Spikelets far apart at base of spike, upper ones overlapping slightly; flattened against spike's axis early, diverging in an arc upon drying; and 6 to 12-flowered. Glume with truncate (square) apices (rounded or abruptly pointed in intermediate wheatgrass. *A. intermedium*); lemmas awnless (1).

Starts growth and matures 1 to 3 weeks later than western wheatgrass (*A. smithii*). Makes good volume of summer regrowth and fair amount of fall regrowth with adequate soil moisture. Moderately palatable to elk in spring and fall but only fair palatability to livestock; cattle use it well before heading, but sheep graze in patches. Deepest and most productive root system among common salt-tolerant grasses (2,3).

### ENVIRONMENTAL RELATIONSHIPS

Thrives on soils which vary from sandy to clayey; much less productive on clays and sands. Has been established on soils with a pH of 10.1 and has the highest tolerance of any cultivated grass to saline, saline-sodic, and nonsaline-sodic soils. Species only declined 10 percent in production at EC = 10 mmhos/cm (4). Moderate fertility demands; often becomes unthrifty in dense stands without legumes or fertilizers. Thrives under irrigation or subirrigation and conditions providing available moisture from spring throughout the summer. The species requires a minimum of about 14 or more inches MAP; optimum is 16 to 20 inches MAP on nonirrigated lands. It is recommended for seeding in the 5 to 9 inches MAP zone in Wyoming on salty, water accumulation sites (5). Species has good winter hardiness; successfully planted between 500 and 7,500 feet in elevation. Only fair shade tolerance. Good fire tolerance when dormant. Tolerates 5 to 7 weeks of early flooding, shallow water tables, and imperfectly drained sites, but intolerant of close, frequent grazing or defoliation (2,6).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 to 3/4 inch deep on fine-textured soils, 1 to 1 1/2 inches deep on coarse-textured soils, or up to 2 inches deep on drier and looser seedbeds (7). Use 6 pounds PLS per acre for drilling in 12 to 21 inch rows on semiarid rangelands and as much as 15 pounds PLS per acre in closely drilled rows on subirrigated land. Increase seeding rates 50 to 100 percent when broadcasting seed or for harsh erosive sites and south and west exposures. Seed before or very early in the 2-month period most favorable for rapid germination and seedling growth: late or early spring for northern and mountainous areas, spring on subirrigated sites; and Aug. 15-Sept. 15 below the 4,000 foot elevation in Great Basin and Pacific Northwest States (2).

#### Seed Cleaning and Quality

Cut seed with a binder in the soft dough stage or windrow and then combine. Farm-type fanning mills used to clean seed to commercial quality. Seed quality: 90 to 95 percent purity; 85 to 90 percent germination; 77 to 81 percent PLS; and 75,000 to 80,000 seed per pound.

## Germination and Seedling Characteristics

Seed germinate in 21 days under ideal conditions; prechilling hastens germination. Seedling vigor is good to very good. Stands usually established by the second and third seasons on irrigated and non-irrigated sites.

## MANAGEMENT

Species widely used for seeding lands for pasture, hay, silage, and standing winter feed; also planted in drill strips for upland bird nesting sites, cover, and food. This grass is also used for stabilizing and reclaiming saline-sodic areas for other uses and for shoreline protection (2). Recently found useful as snow and wind barrier to drift snow and reduce wind erosion in croplands. Sometimes planted for calving and lambing cover. Herbicides usually most effective in controlling weeds in newly seeded stands but careful grazing suppresses grassy weeds. Otherwise, protect seedlings from grazing until grass heads out and is well rooted. Species best seeded alone and fenced separately from other units for optimum management. Manage grazing and harvesting to maintain a 6-inch stubble. Mowing to a 10-inch stubble first year helps prevent too close grazing (6). Species fits well into long pasturing season rotations with earlier and later developing pastures.

## ASSOCIATED SPECIES

Usually planted alone; where adapted, useful, and manageable, seed in mixture with alfalfa (*Medicago sativa*) or yellow sweetclover (*Melilotus officinalis*). Plant legume and grass in alternate rows where possible.

## PESTS AND DISEASES

Insects not a problem. Gophers dislike species' coarse roots, Susceptible to leaf and stem rusts under moist and humid conditions but usually not a serious problem. Powdery mildew occurs with prolonged damp weather.

## IMPROVED VARIETIES

'Alkar', developed in Washington, is a late maturing, coarse cultivar with blue-green leaves and a dense, highly productive root system. 'Jose' is a less coarse, earlier maturing cultivar released from New Mexico. 'Largo', also from New Mexico, has been widely used in the southern intermountain and Rocky Mountain States. 'Orbit' was selected for superior winter hardiness and released from Canada. 'Platte', a Nebraska release, was developed near Cheyenne, Wyoming (7).

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Figure 3. Tall wheatgrass (*Agropyron elongatum*) (after Hafenrichter et al. 1968). Plant x 2/5; closeup (ligule, auricle) x 4 1/3; floret x 2 1/2; spikelet x 3 1/2.

## INTERMEDIATE WHEATGRASS

*Agropyron intermedium* (Host.) Beauv.

### ORIGIN

Native of U.S.S.R., around the Black Sea, and Manchuria. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, open sod former of the C-3 type.

Erect culms 2 to 4 feet tall with clumped, basal blue-green or green leaves and short, spreading rhizomes. Leaf blades smooth to slightly scabrous; sheaths hairy-margined. Ligule short, membranous and collar-like. Auricles well developed and clasping. Inflorescence a slender, erect spike up to 10 inches long. Spikelets three to eight-flowered, early pressed close to axis, later diverging slightly at tips, less so than tall wheatgrass (*A. elongatum*). Glumes oblong to lance-shaped with rounded or abruptly pointed tips (square-tipped in tall wheatgrass) and smooth or hairy. Lemmas broadly lance-shaped with rounded or acute tips, smooth and sparsely hairy (1).

Species starts growth about as early as crested wheatgrass (*Agropyron cristatum*), matures several weeks later, and has a longer vegetative period. Produces a dense mat of roots and rhizomes in surface soils and extensive fibrous roots nearly as deep as tall wheatgrass. Makes a fairly good volume of summer regrowth and a good volume of fall regrowth when adequate soil moisture is present or when irrigated. Palatability to elk good yearlong; good palatability to cattle when green, fair palatability in winter; fair palatability to deer in spring, although locally heavy spring use sometimes reported (2,3).

### ENVIRONMENTAL RELATIONSHIPS

Thrives on medium to fine-textured, medium to high fertility soil in cool, subhumid climates, but is used in sandy soils and in semiarid zones on moister sites. Tolerant to weekly acidic and basic soils and to moderate salinity. Moderately high fertility demand. Requires about 15 inches MAP with major portion available during growing season for good production and stands at lower elevations. Widely used on more favorable sites in the Rocky Mountains and adjacent foothills and mesas in the 10 to 15 inches MAP zone. More drought-tolerant than smooth brome (*Bromus inermis*) but less drought and cold-tolerant than desert wheatgrass (*A. desertorum*). Seeded on suitable sites up to elevations a little above 1,000 feet in the northeastern Great Plains to as high as 10,000 feet in the Rocky Mountains. Highest producing of six wheatgrasses at several Montana stations and in early tests in western North Dakota and in the Southwestern pine zone (4). Tolerant of the semishade of open shrub overstories and fire-tolerant, especially in the dormant state, due to rhizomes. Stand longevity often only 5 to 10 years in drier areas under close grazing (5); but, in some cases, up to 30 years under careful management or nonuse; e.g., Davis County, Utah terraced watersheds. Tolerates early spring flooding for 3 to 5 weeks and a water table at 3 foot depths (3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 inch deep on fine textured soils and to 1 inch deep on medium-textured soils. Tests show good emergence from 2-inch depths, which would be useful in drier sites, looser seedbeds, and coarser soils (6). Drill seed 5 to 15 pounds PLS per acre, varying rate according to moisture, desired stand density, ease and quickness of stand establishment, and seeding purposes and management. Use 50 to 100 percent more seed for broadcasting, harsh sites, and for south and west-facing exposures. Herbage production usually very similar for all rates after full stand establishment. Seed before or very early in the 2-month period with the most favorable conditions for rapid germination and seedling growth: early spring, late fall; late summer or early fall (Aug. or Sept.); mid-June to mid-July in the Southwestern pine zone; or in June in higher mountains (7). This species can be sodded on critical areas.

## Seed Cleaning and Quality

Combine seed when it is fully mature or windrow first in the hard dough stage. Clean seed in a fanning mill having 1/14 x 1/2-inch holes in upper screen and 6 x 18-mesh bottom screen. Seed quality: 90 percent purity; 85 to 90 percent germination; 77 to 81 percent PLS; and 80,000 to 100,000 seed per pound.

## Germination and Seedling Characteristics

After prechilling, seed germinates in 28 days in lab tests. Chilling, wetting, and soaking seeds hastens germination. Strong seedling vigor. Stand usually well established by second year under favorable growing conditions. Responds well to irrigation; light irrigations improve stand establishment.

## MANAGEMENT

Species widely used for pasture, hay, and in conservation plantings for stabilizing ditches and canal banks, roadsides, waterways, and disturbed lands. It provides good nesting and escape cover for game and nongame birds, as well as forage for big game and small game animals. New seedlings may require weed control; herbicides usually are most effective. Some warm season annual weeds might be tolerated where quick cover is critically needed. Withhold grazing until new seedlings are headed and firmly rooted. Moderate grazing essential with this species; leave a 4 to 6-inch stubble. Stand longevity may be improved by resting it from grazing for 1 to 2 months during the active growing period. Short longevity under grazing in drier areas suggests this species may need to be used for short term high production under intensive management or managed just for cover without much grazing. Fertility management or use in mixtures with legumes necessary with the first option.

## ASSOCIATED SPECIES

Suitable as a grass component in mixtures with other cool season grasses and with adapted legumes, forbs, and shrubs. Drill strong competitors, like alfalfa (*Medicago sativa*) and shrubs, in alternate rows with grasses for better establishment. This species and alfalfa is a very common mixture in subhumid and irrigated areas.

## PESTS AND DISEASES

Susceptible to damage from Banks grass mite (*Oligonychus pratensis*), black plant bug (*Irbisia pacificus*), black grass bug (*Labops hesperius*), grasshoppers, and cutworms. Pesticide controls available where economical to use. Seed treatment with fungicides gives some control of seed-borne seedling diseases, thus increasing stand density. Stem and leaf rusts and ergot occasionally affect forage quality.

## IMPROVED VARIETIES

'Amur', a New Mexico release, is taller, coarser, uniform gray-green cultivar that develops more rapidly than Greenar. 'Greenar', from Washington, is a dark green, moderate sod-forming type. 'Oahe', from South Dakota, is a tall, coarse, blue-green, rapid sod-forming type. 'Slate', developed in Nebraska, is an erect, slate-green, strongly spreading type. 'Tegmar', from Idaho, is a dwarf, strong sod-forming type for erosion control. 'Chief' is a gray-green type developed in Canada (8).

### Pubescent wheatgrass

*Agropyron trichophorum* (Link) Richt

[= *A. intermedium trichophorum* (Link) Halac. (1)]

Cool season, open sod former from U.S.S.R. Distinguished from intermediate wheatgrass by dense pubescence on spikes, spikelets, glumes, and lemmas. Adapted and used in nearly same zones as intermediate wheatgrass but slightly more drought, heat, and salt-tolerant. Somewhat less palatable than intermediate wheatgrass but some overlap among different varieties. Generally better stand ratings and persistence in sagebrush and pinyon-juniper zones; more commonly used for disturbed land stabilization despite somewhat less vigorous sodding habit. 'Luna', New Mexico cultivar with wide, lax, dark green leaves; 'Topar' a Pacific Northwest release with dense sod-forming habit; 'Trigo', early developing, less dense sod-former adapted to Mediterranean climates; and 'Mandan 759', a mixed pubescent and intermediate wheatgrass type with good seedling vigor and forage production (8).

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Figure 4. Intermediate wheatgrass (*Agropyron intermedium*) (after Hafenrichter et al. 1968). Plant x 1/2; ligule, spikelet, floret x 5; spike x 1/2.

## WESTERN WHEATGRASS

*Agropyron smithii* Rybd.

### ORIGIN

A native species of primary importance in the northern Great Plains. Occurs in every Western State. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium height, cool season, coarse-leaved, sod-forming perennial of the C-3 type.

Single or few stemmed, rigidly erect plants 1 to 3 feet tall, with strong spreading rhizomes. Blue-green leaves with hairy sheaths and strongly veined, flat or involute blades. Ligule very short and membranous; auricles clasping and often purple. Inflorescence a short, stiff spike 2 to 6 inches long. Spikelets tightly overlapping, somewhat flattened, and 4 to 10-flowered. Glumes narrowly lance-shaped and broadest at base, gradually tapering to a pointed or very short-awned tip (glumes broadest near middle in thickspike wheatgrass (*A. dasystachyum*) (1).

Starts growth during March or very early April in most central and northern Great Plains areas, matures during August, and makes fair volume of summer and fall regrowth. Moderately palatable to elk and cattle yearlong, less so in late summer, and palatable to deer only in spring (2).

### ENVIRONMENTAL RELATIONSHIPS

Thrives on fine to very fine-textured soils having moderate or higher levels of soil moisture. Tolerant of moderately coarse soils and seeded on such sites in the northern Great Plains; elsewhere, often replaced by thickspike wheatgrass and other native species better adapted to sandy soils. Tolerant to strong soil salinity and to saline-sodic soils. Moderate nitrogen fertility demanding for vigorous early spring growth and high sustained forage production in colder and moister areas; increases its composition in warm season grass mixtures after N fertilization. Mesic in moisture requirements; thrives in swales, overflow sites, and subirrigated lowlands. Tolerant of poor drainage, water tables within 6 inches of soil surface, and early spring flooding. Generally adapted to the 14 to 20 inches MAP zones but usable for seeding in moister sites in the 10 to 14 inches zone. Tolerant of moderately severe droughts if not greatly prolonged, surviving by underground rhizomes. Strong cold hardiness, especially with local strains and ecotypes. Species grows from lower Great Plains and Great Basin elevations in adapted sites up to about 9,000 feet in central mountain latitudes. Moderate tolerance to partial shade. Good fire tolerance in dormant state; usually survives fires during growing season but recovery delayed. Revegetates rapidly after planned burning of sagebrush-grass ranges. Stronger rooting habits than thickspike wheatgrass in preliminary tests of surface mined soils and flyash (3). Moderate grazing tolerance but suffers from close spring grazing. Responds as a decreaser in the below 20 inches MAP zones on upland sites in the central Great Plains and as an increaser in the over 20 inches zone (4). Moderately compatible with other species similar in palatibility and aggressiveness. Often increases in composition when mixed with taller or more palatable species or decreases with shorter grasses and warm season species when grazed in early spring.

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 to 1 inch deep on fine and medium-textured soils, respectively. Cover broadcasted seed shallowly with soil. Supplemental mulching and light irrigating aid stand establishment on arid, droughty, and erosive sites. About 20 to 25 PLS per unit area needed as seeding rate to establish one plant per unit area under moderately favorable nonirrigated conditions. Recommended drill seeding rates: 5 to 15 pounds PLS per acre for semiarid to subhumid areas. Increase rates 50 to 100 percent for broadcasting, quicker and denser cover, or for harsher south and west-facing sites. Seed before or very early in the 2-month period having the most favorable conditions for rapid germination and seedling growth: early spring, late fall; late summer to early fall (Aug. or Sept.); or June 15 to July 15 (only in Southwestern pine and pinyon-juniper zones). Species may be sodded on critical areas.

## Seed Cleaning and Quality

Combine seed directly or windrow first. Seed cleaned in a farm-type fanning mill equipped with an upper screen having 1/14 x 1/2-inch holes and a 6 x 20-mesh lower screen. Seed quality: 85 to 90 percent purity; 75 to 80 percent germination; 64 to 72 percent PLS; and 110,000 to 126,000 seed per pound. Seed retains good viability for 5 years and increases in germination percentage for 2 to 3 years after harvest.

## Germination and Seedling Characteristics

Germination occurs in 28 days under ideal lab conditions; prechilling seed aids germination. Seedling vigor of species only fair; some cultivars better. Plants spread slowly until established and often take several years to develop full stands. Very hardy and durable grass when well established.

## MANAGEMENT

Either native or seeded stands used for pasture and hay; also widely used for soil erosion control, critical area stabilization, and surface mine reclamation (5). Stands more easily managed when seeded alone but useful in mixtures with other grasses and species not differing greatly in palatability and phenology. Control weeds during early part of first growing season; Kansas studies indicate skillful grazing management, use of herbicides, and repeated mowing are satisfactory options (6). Grazing moderately to utilize no more than 50 to 60 percent of herbage, leaving an ungrazed stubble of 3 to 4 inches, and periodic resting from grazing during the growing season help maintain vigorous stands. Nitrogen fertilization sometimes cost effective in colder regions with ample moisture.

## ASSOCIATED SPECIES

Species grows in pure stands or mixed with alkali sacaton (*Sporobolus airoides*), basin wildrye (*Elymus cinereus*), green needlegrass (*Stipa viridula*), buffalograss (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*), and sometimes with big sagebrush (*Artemisia tridentata*), and black greasewood (*Sarcobatus vermiculatus*). Sometimes seeded in mixtures with desert wheatgrass (*Agropyron desertorum*), awnless bluebunch wheatgrass (*A. inerme*), blue grama, and sideoats grama (*B. curtipendula*) for forage and with sod-formers among these and rhizomatous wheatgrass species (*Agropyron spp.*) with or without forbs or shrubs for soil stabilizing cover. Seedings often planned in mixtures proportioned among species to restore approximate composition of the climax vegetation for each site. Better stand establishment and planned proportions may be obtained when strong competitors are seeded in alternate rows with weaker members of mixtures.

## PESTS AND DISEASES

Susceptible to grasshopper damage only during moderate to heavy infestations. Ergot and leaf and stem rusts may affect forage quality in prolonged wet periods.

## IMPROVED VARIETIES

'Arriba', Colorado selection developed in New Mexico, shows rapid germination, good seedling establishment, and high seed production. 'Barton', developed in Kansas, has high forage production and rust resistance. 'Rosana', from Montana, shows good adaptation in that State, Wyoming, and western Dakotas. 'Flintlock' is recommended for seeding in Nebraska and southcentral South Dakota. 'Mandan 456' was developed for its dense growth, leafiness, soft leaves, and rust resistance; it is considered useful in parts of the Dakotas and Montana (5).

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Figure 5. Western wheatgrass (*Agropyron smithii*). Plant x 1/2; spikelet x 4; floret x 3 1/2.

## BLUEBUNCH WHEATGRASS

*Agropyron spicatum* (Pursh) Scribn. & Smith

### ORIGIN

Native species of primary importance in inland Pacific Northwest; extensive occurrence in western U.S. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, long-lived, perennial bunchgrass of the C-3 type.

Culms erect, 1.5 to 4 feet tall, from medium-sized tufts. Leaves mostly cauline with narrow, flat, or loosely inrolled blades up to 8 inches long. Ligule short and membranous; auricles weakly to well developed and often purplish. Spike-type of inflorescence, 3 to 8 inches long. Spikelets borne far apart to barely overlapping, about 3/4 inch long, with four to eight florets. Glumes awnless or very short awned; lemmas enclosing seed usually awned with a strongly divergent awn 1/2 to 1 inch long (1).

Species starts growth in very early spring, about the same time as desert wheatgrass (*A. desertorum*), matures 1 to 3 weeks earlier, becomes semidormant concurrently, renews growth and makes moderate volume of regrowth in fall somewhat proportional to moisture supply. Good palatability to elk spring and fall, fair palatability to deer, and moderately good palatability to livestock all seasons but somewhat reduced during late summer dormancy. Some forage use made by antelope in spring (2).

### ECOLOGICAL RELATIONSHIPS

Optimum native stands occur on silty soils of loess hills in the Palouse prairies. Stands are fairly common on sandy and clayey soils and even occur on thin, rocky, and gravelly soils. Tolerant of weakly saline soils and of seeded wheatgrasses. Native stands occur in the 8 to 35 inches MAP zone; species is considered better adapted for seeding in the 10 to 20 inches zone. Its use is reported in the 6 to 9 inches zone in Wyoming and in the 8 to 12 inches zone in the Great basin. It is only marginally successful in the 9 to 10 inches zone in southern Idaho (2,3). Intolerant of high water tables, poor drainage, and much early spring flooding. Relatively nonresponsive to irrigation and fertilization of mature forage stands but such practices sometimes aid stand establishment. Drought resistance better than crested wheatgrasses, and there is greater root and forage production on drier sites (4). Good winter hardiness but considerable variation among local strains and ecotypes within species. Elevational range from 500 to 10,000 feet in the intermountain West. Species has only fair fire tolerance in the dormant state; it recovers and enlarges bunches and composition after planned sagebrush-grass burning. More productive in full sunlight although tolerant of semishaded habitats of open shrublands and woodlands. Moderate tolerance to grazing except in early spring (during May in eastern Oregon). Lowest internode of grass is threadlike and fragile; grazing removes whole stems. Seeded stands reported to have variable longevity depending on seeding success and management (5,6).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 inch, 1/4 inch, and 3/4 inch deep on loamy, clayey, and sandy soils, respectively. Cover broadcasted seed with soil to similar depths. Drill seeding rates vary from 5 to 10 pounds PLS per acre for rangeland revegetation purposes. Fifty to 100 percent more seed should be used for broadcasting and for harsh and south and west-facing sites. Seed before or very early in the 2-month period most favorable for seedling establishment; usually either early spring or late fall, but also possible in early fall (during August and September) in areas with good fall moisture or on summer-fallowed fields (4).

#### Seed Cleaning and Quality

Harvest seed either with a swather or binder while seed is in soft dough stage to minimize loss by shattering. Process awned seed for commercial purposes and for drill seeding in a swinging-type hammermill set to

run at 720 rpm cylinders speed and equipped with a 1/4-inch screen to remove awns. Use fanning mill to clean processed and unawned seed to commercial quality. Awned seed can be broadcasted without processing. Seed quality: 90 percent purity; 85 to 90 percent germination; 77 to 81 percent PLS; and 140,000 to 150,000 seed per pound.

### Germination and Seedling Characteristics

After prechilling, seeds germinate in 14 days in lab tests. Studies show that seeds germinate at a variety of constant and variable temperatures. Seedling vigor only fair, weaker than crested wheatgrasses and much weaker than cheatgrass brome (*Bromus tectorum*), a weedy competitor. Stands establish slowly and usually require a third year; crested wheatgrasses (*A. cristatum/A. desertorum*) attain full stands at least 1 year earlier. More consistent and greater production than crested wheatgrass reported after stands fully established on some adverse sites.

### MANAGEMENT

Species only used to limited extent due to problems with seed supplies, harvesting and processing seeds, and inconsistent stand establishment. Uses include seeding abandoned croplands, depleted ranges, and bare or disturbed lands. Shows some promise for revegetating mine spoils in zones of adaptation. New seedlings require control of competing weeds. Protect such stands from grazing, usually for two growing seasons or until plants head out and are firmly rooted. Avoid grazing established stand in May if possible; either defer them from spring use or rotate grazing among several pastures using a different unit in May. Still better, develop crested wheatgrass pastures for May grazing and graze bluebunch wheatgrass at other seasons. Grazing should remove no more than 50 percent of the current annual herbage crop. Species is superior in forage nutrients to crested wheatgrasses at same stages of plant development. Species deserves research attention to develop superior strains, particularly for drier areas and poorer sites within its range.

### ASSOCIATED SPECIES

Bluebunch wheatgrass occurs mixed in native stands with Idaho fescue (*Festuca idahoensis*), Sandberg bluegrass (*Poa secunda*), big sagebrush (*Artemisia tridentata*), western juniper (*Juniperus occidentalis*), and arrowleaf balsamroot (*Balsamorhiza sagittata*) and other species of the big sagebrush, juniper-pinyon, mountain shrub, open aspen, and subalpine park communities. Species commonly seeded alone due to special management requirements, but sometimes mixed with other cool season grasses, alfalfa (*Medicago sativa*), and, less commonly, with forbs and shrubs. Seed any strong competitors, such as alfalfa and cereal wheat or rye, in alternate rows to prevent suppression of weaker grass seedlings.

### PESTS AND DISEASES

Treat seed with insecticides and fungicides to control wire worms and soil-borne pathogens, especially in the Pacific Northwest. Gophers less troublesome with this species than with crested wheatgrass (4).

### IMPROVED VARIETIES

None.

Beardless bluebunch wheatgrass

*Agropyron inerme* (Scribn. & Smith) Rydb.

[= *A. spicatum* (Pursh) Scribn. & Smith *forma inerme* Beetle (1)]

This form occurs intermixed with the awned form of bluebunch wheatgrass in greater proportions in higher precipitation areas of the intermountain region. It retains most of the same characteristics and adaptations of the species except for having rhizomes, an open sod-forming habit, strongly involute leaves, and awnless lemmas or sometimes very short, straight awns on a small proportion of plants. Culture is the same as for bluebunch wheatgrass but hammermilling of seed is unnecessary. Seedling vigor may be slightly superior to 'common' bearded bluebunch wheatgrass, but is still much weaker than crested wheatgrass. Beardless wheatgrass is much more widely seeded than the bearded form.

## IMPROVED VARIETY

'Whitmar' is a cultivar selected and developed in Washington from an intermediate awnless strain that has broad adaptation in the Pacific Northwest and Great Basin States. It is almost the only planting seedstock of either form of the species generally available and used for revegetation in the West today.

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Figure 6. Bluebunch wheatgrass (*Agropyron spicatum*). Plant x 1/2; spikelet x 3.

**REDTOP**  
*Agrostis alba* L.  
[= *Agrostis stolonifera* L. (1)]

**ORIGIN**

Native to Europe. Naturalized in more humid areas of the U.S. See map for distribution in the U.S.

**SPECIES CHARACTERISTICS**

Cool season, open sod-former of the C-3 type.

Spreading rhizomatous or stoloniferous perennial with decumbent to semierect culms 1 to 4 feet tall. Leaf blades coarse, flat, and pointed. Thin, membranous ligule about 1/4 inch long and pointed. Inflorescence a semiopen, conical-shaped, red panicle, often closing and bleaching brownish after flowering. Spikelets one-flowered, borne on whorled branches. Glumes purplish and lance-shaped; lemmas awnless with minute bearded base (1).

Species starts growth in early to midspring, varying with latitude and altitude; matures in mid to late summer and makes fair volume of fall regrowth in wet sites. Good palatability to livestock in spring and early summer, fair palatability after headed but poor in winter (2).

**ENVIRONMENTAL RELATIONSHIPS**

Mesic to semihydric in moisture requirements; widely adapted in the humid 20 to over 40 inches MAP zones where moisture accumulates. Thrives best on moist to semiwet soils. No marked soil texture limitation when moisture abundant; otherwise best on clay loam and loam soils. Tolerant of moderately acidic and nutritionally poor soils low in calcium, phosphorus, and potassium. Not suited for planting on limey soils or on limestone sites. Tolerant of poorly drained wetlands and subirrigated sites, submergence, and frequent flooding. Fair tolerance to soil salinity and moderate to fair drought tolerance compared to grasses seeded on humid and semiarid areas, respectively. Good grazing resistance among humid pasture grasses due to semiprostrate form, rhizomes, and lower palatability, often increasing in cover in grazed pasture mixtures. Dense sodded stands become unproductive without nitrogen fertilization or legumes. Good cold tolerance; species seeded or naturalized from near sea level on east and west coasts to subalpine elevations in mountains. Tolerant of semishaded environments. Moderately competitive; slightly too aggressive for weaker turf species and sometimes weedy (3). Only fair tolerance to fire (4).

**CULTURE**

Planting Depth, Rate, and Time

Small seeded; seed no deeper than 1/2 inch, preferably shallower on finer textured and moist soils. Cover broadcasted seed to similar depth; seed may be pressed into soil with a cultipacker. Rates for drill seeding only need to be about 4 to 5 pounds PLS per acre. Commonly used rates of 8 to 10 pounds per acre liberal and adequate for broadcasting and for poorer seedbeds and harsh sites. Seed before the 2-month period that has the most favorable conditions for rapid germination and seedling growth; best times are usually early spring, late fall, early fall, or in June or July, latter dates for higher mountain areas. (5).

Seed Cleaning and Quality

Combine in hard dough stage; also can be harvested by swathing or binding first. Clean in fanning mill equipped with 28 x 28 mesh and 50 x 50 mesh upper and lower screens. Seed quality: at least 92 percent purity; 90 percent germination; 83 percent PLS; and 4,990,000 seed per pound.

Germination and Seedling Characteristics

Seed germinates rapidly in 10 days in lab tests. Good seedling vigor; sometimes planted at greatly reduced

rates as a fast-developing "nurse crop" with slower developing lawn grasses. Develops into full stand by second season when seeded at full rate; sometimes nearly full cover at end of first season.

## MANAGEMENT

Species seeded for pastures, meadows, hay, lawns, golf courses, wet waterways, ditchbank cover, soil conservation in burned or cut-over timberlands, to retard weed invasion in wet lowlands or irrigation projects, and to revegetate acid mine spoils in humid eastern States (6). Usually used in mixtures at reduced rates of seeding for temporary lawns, rough landscaping, or low maintenance cover; but used where species uniquely fits wetter habitats better than timothy (*Phleum pratense*) and lower fertility sites better than other species, like smooth brome (*Bromus inermis*) or Kentucky bluegrass (*Poa pratensis*). More commonly used for forage or turf in humid zones. Redtop pasture mixtures need to be grazed rather closely in a rotation grazing system to keep plants producing palatable new regrowth all season on wet and subirrigated sites (7). Hay must be cut in early flowering stage to maintain acceptable quality. Weed control needed in first-year stands and fertility management or renovation in older sod-bound stands.

## ASSOCIATED SPECIES

Sometimes seeded in mixtures with other turfgrasses with or without legumes. May dominate such mixtures unless managed to control competition. Makes a rather coarse sod and unattractive in amenity turfs. Redtop and alsike clover (*Trifolium hybridum*) make a good mixture for wet meadows and subirrigated sites. Also used as quick cover-developing species in game range restoration and disturbed land seeding mixtures.

## PESTS AND DISEASES

Susceptible to leaf rusts and spotting and snow mold; usually not serious.

## IMPROVED VARIETIES

None.

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Figure 7. Redtop (*Agrostis alba*). Plant x 1/2; spikelet, floret x 5.

## BIG BLUESTEM

*Andropogon gerardii* Vitman

### ORIGIN

Native to most areas east of Rocky Mountains. Primary species of tallgrass prairie of Midwest. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Tall, long-lived, warm season, bunchy sod-former of C-4 type; a decreaser in most native grassland habitats.

Culms 3 to 6 feet tall, reddish-purple at maturity. Rhizomes thick, 3 to 6 inches long. Numerous long basal and stem leaves green to dark green, often tinged with purple; blades flat to V-shaped, broad, rough-edged, upper surface pimply hairy on basal leaves. Ligule short, membranous, irregular, split margined. Inflorescence a two to six-branched raceme shaped like a turkey foot, source of another common name. Spikelets borne in pairs along raceme axis; one stalkless, plump, awned, and fertile and other stalked, slender, awnless, and usually sterile. Sterile florets add to chaffy seed quality and low purity (1).

Freely interbreeds, and is being artificially bred, with sand bluestem (*A. halli*), which is distinguished by longer rhizomes, fuzzier seedheads, shorter awns, lighter blue-green foliage, and sandy soil habitats. Starts growth in mid to late spring and matures in September and October. Makes good summer regrowth but very little fall regrowth. Highly palatable to cattle from late spring until fall; only fair winter palatability. Preferred over other species by elk in early growth stages (1).

### ENVIRONMENTAL RELATIONSHIPS

Thrives on deep, fertile silt and clay loam soils of lowlands, draws, and ravines, including overflow and subirrigated sites in the 20 to 30 inches MAP zones of central U.S.; also common on the calcareous blackland soils from east Texas to Georgia. Occurs less commonly in sandy draws, on shallow, gravelly ridges, and near limestone ledges in wet years. Moderate salinity tolerance; common on basic reacting soils (1,2). Moderate fertility requirements. Moderate tolerance to high water tables and short term submergence and flooding. More productive with water tables below the surface and fairly good drainage (1,2,3). Moderate shade tolerance. Good winter hardiness of local native seed sources or strains; some stand losses with seed from distant southern sources and reduced yield with seed from distant northern sources. Very tolerant to fire in dormant or earliest growth states; late spring burning results in earlier growth, more uniform grazing use, greater steer weight gains, increased species' cover, and greater seed stalk production (4). Only fair grazing resistance when actively growing; good when grazed after mature in winter. Fairly good compatibility with other warm season grasses and legumes. Tends to increase with management in warm season grass mixtures.

### CULTURE

#### Planting Depth, Rate, and Time

Drill 1/4 to 1 inch deep on fine to moderately coarse soils to 1 1/2 inches deep in sands on prepacked seedbed. Cover broadcasted seed shallowly with soil. Plant 15 to 25 PLS per square foot (5 to 8 pounds PLS per acre) for minimal satisfactory rangeland stands (5); 50 to 100 percent more seed on erosive sites and when broadcasting. Seed in nonvolunteering crop stubble for better stands on erosive sites; topsoil, fertilizers, and supplemental mulch may be needed on critical sites. Seed-hay method of reseeding sometimes most feasible. Same density of established plants obtained at Mandan, North Dakota using 5, 10, and 15 pounds of high quality seed (3). Species sometimes sod-transplanted for critical sites; e.g., terrace outlets. Plant seed March-April in southern Great Plains and April-May in central and northern Great Plains (4,5). Good seedling emergence from winter dates of planting but erratic stand establishment.

### Seed Cleaning and Quality

Combine seed after past the hard dough stage. Carefully control or regulate wind blast, tractor speed, swath width, and speed and spacing of cylinder. Process combined seed in hammermill and reclean in fanning mill to commercial quality (2). Seed quality: 60 percent purity; 60 percent germination; 36 percent PLS; and 130,000 pure seed per pound. Seedheads containing 20 percent fill of potentially fertile florets considered commercially harvestable.

### Germination and Seedling Characteristics

Germinates in 28 days, most by 10 days, under ideal laboratory conditions with prechilling. Seedling vigor is fairly good; growth is usually as rapid or more rapid than common warm season associates. Stands develop slowly and usually are not established until second year.

### MANAGEMENT

Species seeded for pasture, hay, native landscaping, prairie chicken cover, waterways, and stabilization of disturbed areas. Also used for warm season irrigated pastures. Native and improved seed sources and strains from less than 200 miles south of seeding area usually produce more forage than local seed. Herbicides, repeated mowing, or carefully controlled grazing needed to control weeds in new seedings. Kansas Agriculture Experiment Station recommends grazing for weed control (4). Graze established stands moderately, usually not closer than a 6-inch stubble in summer (1). Continuous grazing of stands in good condition and rotational deferment of bluestem pastures in poor condition advocated by some authors (4); others advocate rotational grazing. Late spring burning will remove ungrazed surplus herbage that interferes with uniform grazing and early growth. Fertilization with nitrogen sometimes profitable on meadows; not essential to maintain cover.

### ASSOCIATED SPECIES

Native stands occur mixed with little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), yellow Indiangrass (*Sorghastrum nutans*) and other native forbs and shrubs. Seedings of native grass species often are made in mixtures approximating the climax vegetation composition of each site (6).

### PESTS AND DISEASES

Grasshopper infestations can destroy stands. Seedling diseases may justify fungicidal seed treatment. Leaf spots, rusts, other foliage diseases, head smut, and ergot may occur in wet years.

### IMPROVED VARIETIES

'Pawnee', released in Nebraska, and 'Kaw', from Kansas, are late maturing cultivars recommended for central Nebraska south to Oklahoma and through Oklahoma, respectively. 'Champ', developed by interbreeding divergent types including big and sand bluestem, is an early cultivar recommended from Nebraska south into Kansas and eastward on favorable sites (3).

#### Sand bluestem *Andropogon hallii*

Shorter awned, raceme hairier, foliage often bluer, and more strongly rhizomatous native grass of sandhills and sand prairies in the Great Plains; often seeded in mixtures to revegetate and reclaim disturbed sandy soil sites, including "blowouts" in dunes. 'Cherry', 'Elida', 'Garden', and 'Woodward' are improved cultivars. Consider seed-hay and sod transplant methods of establishment for critically disturbed sites.

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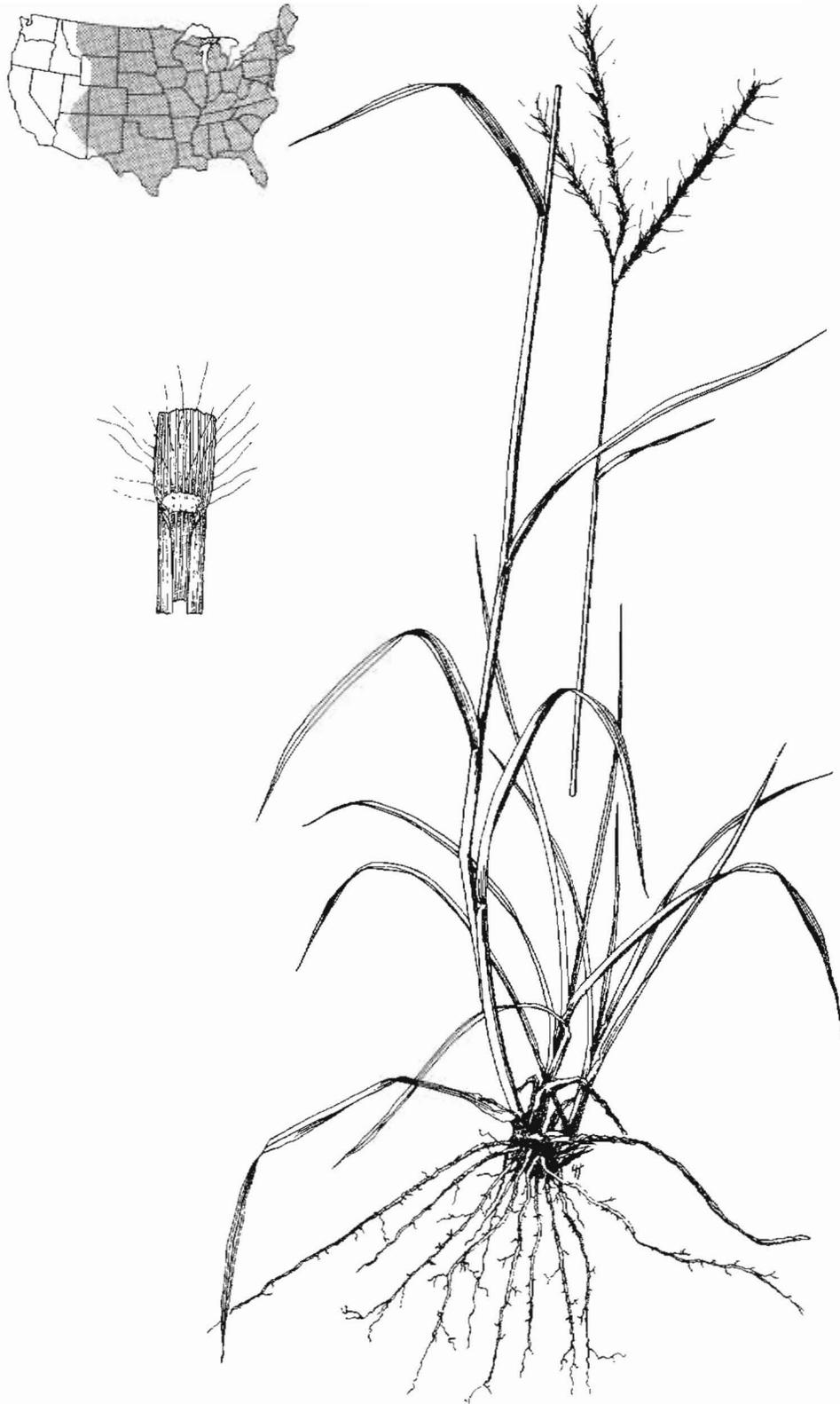


Figure 8. Big bluestem (*Andropogon gerardii*). Plant x 1/4; ligule x 2.

## LITTLE BLUESTEM

*Schizachyrium scoparium* (Michx.) Nash (1)

### ORIGIN

Native; primary species of midwestern prairies; widely distributed except in Pacific Coast States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, long-lived, perennial bunchgrass of the C-4 type.

Culms 1 to 4 feet tall, erect and large-tufted, having occasional short rhizomes. Basal stems and sheaths flattened. Leaf blades hairless, V-shaped in cross-section, keeled, light blue-green when young, reddish brown mature. Ligule 1/16 inch, membranous, fringe-margined. Inflorescence several unbranched racemes, one on end of each seed stalk branch. Spikelets paired along raceme axis; fertile one plump, awned, and stalkless; sterile one stalked, awnless or awn-tipped. Deep fibrous root system. Semisod-forming in subhumid zones and sites (2).

Plants resume growth in spring, head out in late summer, and mature in fall. Fair amount of early summer regrowth, negligible regrowth in fall. Good palatability to cattle in early summer; fair palatability in late summer and fall; poor palatability in winter. Fair palatability to elk and deer (2).

### ECOLOGICAL RELATIONSHIPS

Tolerant to wide range of sandy to clayey soils with adequate soil moisture; silty soils optimal. Common on stabilized sandy and sands range sites; not adapted to wetlands and saline subirrigated sites. Best stands occur on limy uplands and thin loess range sites in Nebraska and on calcareous soils derived from limestone in Southern States. Low to fair fertility requirements; survives in infertile sands. Optimal growth in over 20 inches MAP zones, good in 15 to 20 inches zone on sands, but species grows in 10 to 40 inches MAP zones. Good winter hardiness and cold tolerance of local strains sown within 200 miles north and 100 miles south of origin. Species occurs from about 1,000 feet in elevation on lower plains sites to about 7,500 feet in eastside Rocky Mountain woodlands. Moderate drought tolerance (more than big bluestem) and moderate shade tolerance. Good fire tolerance in the dormant state; fire results in earlier growth and greater seedstalk production, steer gains, and uniformity of forage use. Species reacts as decreaser under summer use, increaser with winter grazing. Moderately compatible in prairie plant seeded mixtures; may increase in cover when mixed with more palatable or taller species (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 inch deep on finer textured soils and 3/4 inch deep on coarse soils, preferably on prepacked seedbeds. Cover broadcasted seed shallowly. Topsoil and supplemental mulches sometimes needed for bare, erosive, and disturbed sites (5). Use 15 to 25 PLS per square foot (2.5 to 4.5 PLS pounds per acre) for drill rates on rangelands; double the rate when broadcasting or for harsh and erosive sites. Seed in March or April in southern Great Plains and April or May in central and higher western Great Plains areas.

#### Seed Cleaning and Quality

Combine seed by adjusting air blast and equipment settings and speed. Chaff and straw may be removed either by running combined material through a scalper or through a fanning mill. Processing seed in a hammermill will improve it to better commercial grade and make it usable in drills. Seed quality: 50 percent purity; 60 percent germination; 30 percent PLS; and 225,000 pure seed per pound (6).

### Germination and Seedling Characteristics

Seed germinates in 28 days under lab conditions after prechilling. Seedling vigor rather weak. Full stands often not attained before third season. Mature plants reproduce well from seed and spread moderately fast in absence of drought.

### MANAGEMENT

Species used for pasture and hay and for game bird cover. Seeded on disturbed, eroding lands, including abandoned croplands, roadsides, gullies, and prairie restorations. Also seeded in rangeland mixtures for sandy, silty, and clayey sites in 16 to 20 inches and over 20 inches MAP zones in central and southern Great Plains. Sometimes used in mixtures with prairie species in so-called prairie restoration projects. Weeds in new seedings require control; options are skillful management of grazing, use of herbicides, or repeated mowing (4). Native ranges in satisfactory condition can be moderately grazed season-long; use deferred rotation or winter grazing to improve ranges in unsatisfactory condition. Similar harvest management needed on established stands. Late spring burning with damp soil beneficial when rough or unused herbage develops. Take wildlife habitat needs into consideration in total management plan.

### ASSOCIATED SPECIES

Species associated with big bluestem (*Andropogon gerardii*), sideoats grama (*Bouteloua curtipendula*), porcupine needlegrass (*Stipa spartea*), and prairie dropseed (*Sporobolus heterolepis*) on uplands and as a secondary component with prairie sandreed (*Calamovilfa longifolia*) and sand bluestem (*Andropogon hallii*) on sandy sites. Species seeded in mixtures approximating climax composition of each site and as a part of seeding mixtures for sandy areas. Legumes and forbs sometimes added; shrubs less frequently. Plant strongly competitive species, such as legumes or grain "companion crop", in alternate rows with grass.

### PESTS AND DISEASES

Grasshoppers a hazard first season. Fungicidal seed treatment helps to control seed-borne diseases of the slower developing warm season species.

### IMPROVED VARIETIES

'Aldous' is a moderately late maturing selection, from Flint Hills of Kansas, adapted to parts of Kansas and Nebraska. 'Blaze' is late maturing cultivar which matures deep red and is valued for range seedings, critical area stabilization, and native landscaping in parts of Nebraska. 'Camper' is moderately late maturing and adapted throughout Nebraska. 'Cimarron', developed from several sites in southwestern Kansas and panhandle of Oklahoma, is adapted to those areas and portions of adjacent Colorado and New Mexico. 'Pastura' was developed from a higher elevation New Mexico site and is adapted to eastern New Mexico, portions of the Texas and Oklahoma panhandles, and southeastern Colorado (3).

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Figure 9. Little bluestem (*Schizachyrium scoparium*). Plant x 1/2; ligule x 12; two pairs of spikelets x 6.

## CAUCASIAN BLUESTEM

*Bothriochloa caucasica* (Trin.) C. E. Hubbard

### ORIGIN

Introduced from Tiflis, Georgia, U.S.S.R. Endemic of limited range; not what Soviet botanists call *B. caucasica* (1). See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium-sized, warm season bunchgrass of the C-4 type.

Mostly erect, 2 to 4 feet tall, without rhizomes or stolons. Light green narrow leafblades up to 1 foot long, smooth except hairy about ligule; ligule short and membranous. Inflorescence a reddish panicle, 3 to 6 inches long with numerous slender branches shorter than the central axis. Hairy panicle branches and pedicel internodes. Spikelets paired; stalkless one awned and fertile; stalked one similar but staminate (2).

Foliage turns bright reddish-brown when mature; popularly called red bluestem; contrastingly different from yellowish foliage and purple panicles of East Indies sourgrass (*B. ischaemum*). Species about 2 weeks later in spring development than native and seeded warm season grasses in Kansas (3). Poorer palatability than other Old World and better native bluestem grasses (*Bothriochloa intermedia* and *Andropogon* spp., respectively).

### ECOLOGICAL RELATIONSHIPS

Well adapted to moderately fertile loamy and clayey textured soils but grows less productively on sandy, clayey, and eroded soils. Winter hardy and persistent from east-central Colorado and northern Kansas throughout the southern Great Plains on suitable sites to South Texas. Adapted in the 16 to 30 inches MAP zones, 20 inch zone more optimal. Good drought tolerance; stays green through seasonal drought. Tolerant of weak salinity and grown on weakly basic and weakly acid soils. Moderate grazing tolerance; close summer use prevents seed production. Little evidence of shade tolerance. Good fire tolerance in dormant state. Not very compatible in seeding mixtures due to lower palatability (3,4,5,6).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 to 1/2 inch deep or broadcast and cover shallowly. Cultipacker can be used to press broadcast seed into soil. Plant March 15 to May 15. Use 1 to 2 pounds PLS per acre for drill-seeding on nonirrigated areas; more seed needed for broadcasting, harsh sites, and where dense or immediate cover desired (5). Drilling into nonvolunteering crop stubble or using supplemental mulch improves stand establishment on erosive sites. Researchers advocate intensive row crop culture, fertilization, and management similar to weeping lovegrass (7).

#### Seed Cleaning and Quality

Combine harvesting possible with a canvas-type combine. Grass stripper also used. Species irregular in seed production and maturation. Scalping or light hammermilling makes seed recleanable in a fanning mill. Seed quality: 50 percent purity; 60 percent germination; 30 percent pure live seed; and 860,000 pure seed per pound.

#### Germination and Seedling Characteristics

Seed germinate in 28 days under ideal laboratory conditions after prechilling. Good seedling vigor. May mature a short seed crop first season under favorable conditions; ready for grazing second season. Seedlings sensitive to fertility level and show response to fertilizers on eroded soils. Species spreads moderately fast by natural reseeding. Not as aggressive in seedling stages as East Indies sourgrass.

## MANAGEMENT

Species seeded to limited extent in central and southern Great Plains for range and pasture and for soil stabilization of eroding fields and roadsides. Dense foliage provides good upland bird cover. Seed shortage, seed handling, and management problems make use of this species secondary or minor despite some good characteristics. Moderately close grazing use needed of established stands to maintain usable herbage quality and good livestock performance. Good livestock and herbage production responses to fertilization. Species requires intensive management inputs for sustained high production.

## ASSOCIATED SPECIES

Optimal management possible when seeded in pure stands. Dense stands very effective in preventing weed invasion, sometimes even during establishment year.

## PESTS AND INSECTS

Grasshoppers a hazard in seedling year. Thrips affect seed yields. Tolerant of certain parasitic nematodes. Little evidence of seed and foliage diseases.

## IMPROVED VARIETIES

None.

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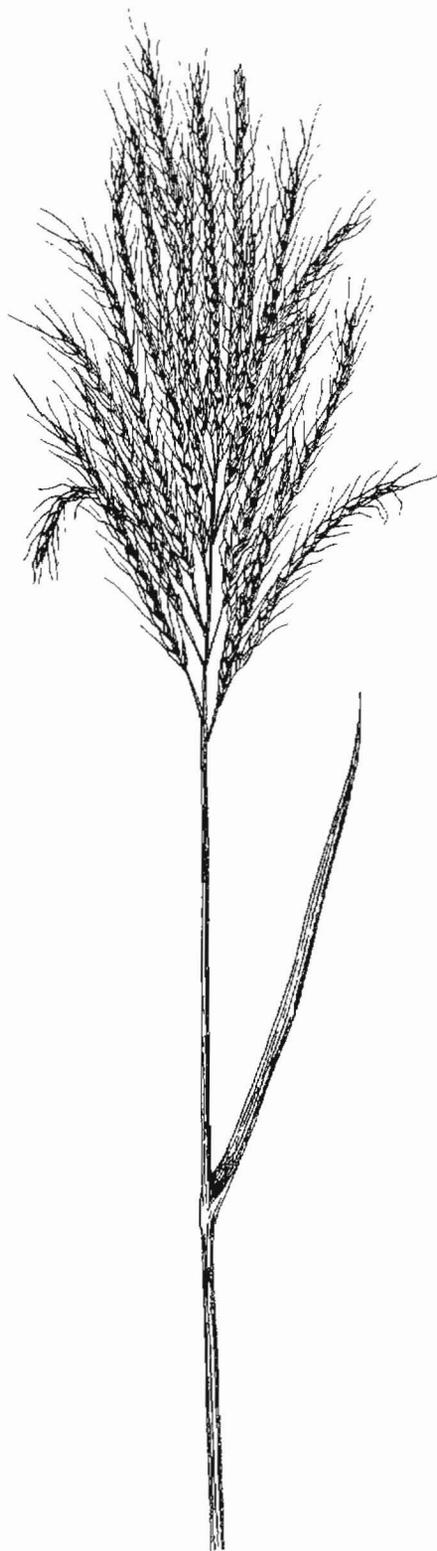


Figure 10. Causasian bluestem (*Bothriochloa caucasica*). Inflorescence x 2/3.

## SIDEOATS GRAMA

*Bouteloua curtipendula* (Michx.) Torr.

### ORIGIN

Native. Widespread distribution eastward from Rocky Mountains. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, bunchy, sod-forming grass of the C-4 type.

Culms 1 to 3 feet tall, erect from dense tufts or sod patches, usually with short scaley rhizomes. Leaves mostly basal, grey to bluish-green, and drying brown. Medium width, flat or loosely rolled leaf blades with swollen based hairs along margins. Ligule collar-shaped, fringe-margined. Inflorescence an upright, slender raceme with 25 to 50 drooping spicate branches (or spike-like racemes), each with 1 to 12 spikelets dangling from one side of the rachis. Glumes and lemmas purplish when young, latter with bright orange anthers. Spikelets fall off after maturity (1).

Largest, most widely distributed grama grass, with abundant seedstalks, suitable for domestication. Starts growth in midspring, makes vigorous vegetative growth in summer and matures usually between July and September, varying with latitude, altitude, moisture, and strain. High palatability to livestock during late spring and summer; fair forage value when mature. Moderate compatibility with grasses and legumes and not weedy (2).

### ENVIRONMENTAL RELATIONSHIPS

Adapted to broad spectrum of sandy to clayey textured soils; least tolerant to loose sands and dense clays. Species shows varying tolerance to soil salinity from weak to moderate. Best stand development on medium to fine-textured soils of uplands and in the 17 to 20 inches MAP zones in the central Great Plains; as good development may be found in the 12 to 16 inches MAP zones in the Southwest. Moderate drought resistance; less tolerant than blue grama (*B. gracilis*); more tolerant than big bluestem (*Andropogon gerardii*). Good winter hardiness only in well adapted strains and seed sources. Species responds to daylength with distinct long, intermediate, and short day plants. Adapted southern strains or seed sources of native plants usually produce more forage; be cautious about using untested strains or sources, especially those from more than 200 miles south or from great differences in elevation. Species occurs up to about 8,000 feet in elevation in southern Rocky Mountains. Moderately tolerant of spring flooding. Tolerant of semishaded sites and occurs in open woodlands. Generally damaged by wildfires, especially during drought and with dry soil conditions, but fair tolerance of planned burning in dormant state. Moderate grazing tolerance, less so than blue grama. Generally a decreaser on upland sites in the below 20 inches MAP zones but an increaser in tallgrass prairies. Nitrogen fertilization stimulates greater seed production and better quality (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed no deeper than 1/4 inch on fine-textured soils and 3/4 inch on coarser textured soils. Cultipacking previously prepared seedbed provides adequate covering after broadcasting. Seeding in nonvolunteering crop stubble or supplemental mulch needed on erosive sites. Light, timely irrigations and mulch needed to ensure seeding success on surface mined soils. Drill 15 to 25 PLS per square foot (3.5 to 5.5 pounds PLS per acre) to obtain 1 to 2 established plants per square foot, minimal satisfactory rangeland stand. Use 50 to 100 percent more seed for broadcasting, bare areas, harsh sites, or denser, early stands. Suitable seeding dates: April 1 to May 15 in northern and high, western Great Plains; March 15 to May 15 in central Great Plains; January to April in southern Great Plains, and June 15 to July 15 for Transpecos and southwestern areas. Pitting to concentrate moisture aids seedling establishment in drier areas (3,4).

### Seed Cleaning and Quality

Seed satisfactorily combined by adjusting sickle set, cylinder speed, wind, and sievers. Can be recleaned in ordinary fanning mill, scalper, or by rethreshing. Processing in hammermill not essential. Seed quality: 60 percent purity; 70 percent germination; 42 percent PLS; and 191,000 seed per pound.

### Germination and Seedling Characteristics

Germinates in 28 days under standardized lab conditions; most seed germinates in first 7 days with ideal field conditions. Seedling vigor is fair in comparison to all grasses but good when compared to native warm season grasses. Under unusually favorable conditions may produce a forage crop the first season, usually not until second season. Established plants spread slowly by tillering and mostly by rhizomes. Field germination, emergence, and establishment better than with blue grama (5).

### MANAGEMENT

Native stands used for pasture, less commonly for hay. Often used in mixtures for seeding abandoned and eroding fields, depleted ranges, and bare, eroding, and disturbed soils in northern, central, and southern Great Plains and Southwest. Recommended for seeding silty, clayey, and sandy upland sites in the 12 to 25 inches MAP zones in the central Great Plains; also on overflow and subirrigated sites in drier zones. Used somewhat for seeding intermittently flooded waterways. New seedings require weed control by grazing, herbicides, or repeated mowing. Graze stands moderately to maintain production; leave a 3 to 6-inch stubble on better condition ranges; use a deferred rotation grazing plan to improve stands in unsatisfactory range condition. Seeds eaten by songbirds; small mammals consume seedheads and plants.

### ASSOCIATED SPECIES

Species occurs somewhere mixed with most of the major grasses of the Great Plains and Southwest; most commonly with blue grama (*B. gracilis*) and little bluestem (*Schizachyrium scoparium*). Variety of forbs and shrubs also occurs in such mixtures. Commonly seeded in warm season mixtures with bluestems (*Andropogon spp.*) and grama grasses; less commonly with cool season grasses, forbs, and shrubs. Few legumes persistent on sites where species is used. Plant legumes or nurse crops, when recommended, in alternate rows to minimize competition.

### PESTS AND DISEASES

Grasshoppers destructive, especially of seedling stands. Some leaf and stem rust in wet years, somewhat reduced in improved varieties.

### IMPROVED VARIETIES

'Butte', from Nebraska, is relatively early maturing and is recommended in portions of Colorado, Nebraska, and Kansas, and the Dakotas. 'Coronado' was developed from eastern New Mexico collections and is recommended in portions of New Mexico, Texas, Oklahoma, and Kansas. 'Pierre' is winter-hardy in the central Dakotas and southeastern Montana and was developed by increase of a South Dakota collection. 'Premier', from Mexico, is recommended for portions of west-central Texas. 'Trailway', developed from Nebraska collections, is recommended for portions of central Nebraska and Kansas. 'Tucson', from Arizona, is recommended for portions of southwestern New Mexico and southeastern Arizona. 'Uvalde' is recommended for portions of southcentral and the Big Bend regions of Texas. 'Vaughn', from New Mexico, is widely recommended for portions of west Texas, New Mexico, western Oklahoma, southwestern Kansas, eastern Colorado, and southeastern Wyoming. Consult with plant materials specialists for local variety and strain adaptations to sites and for specific purposes.

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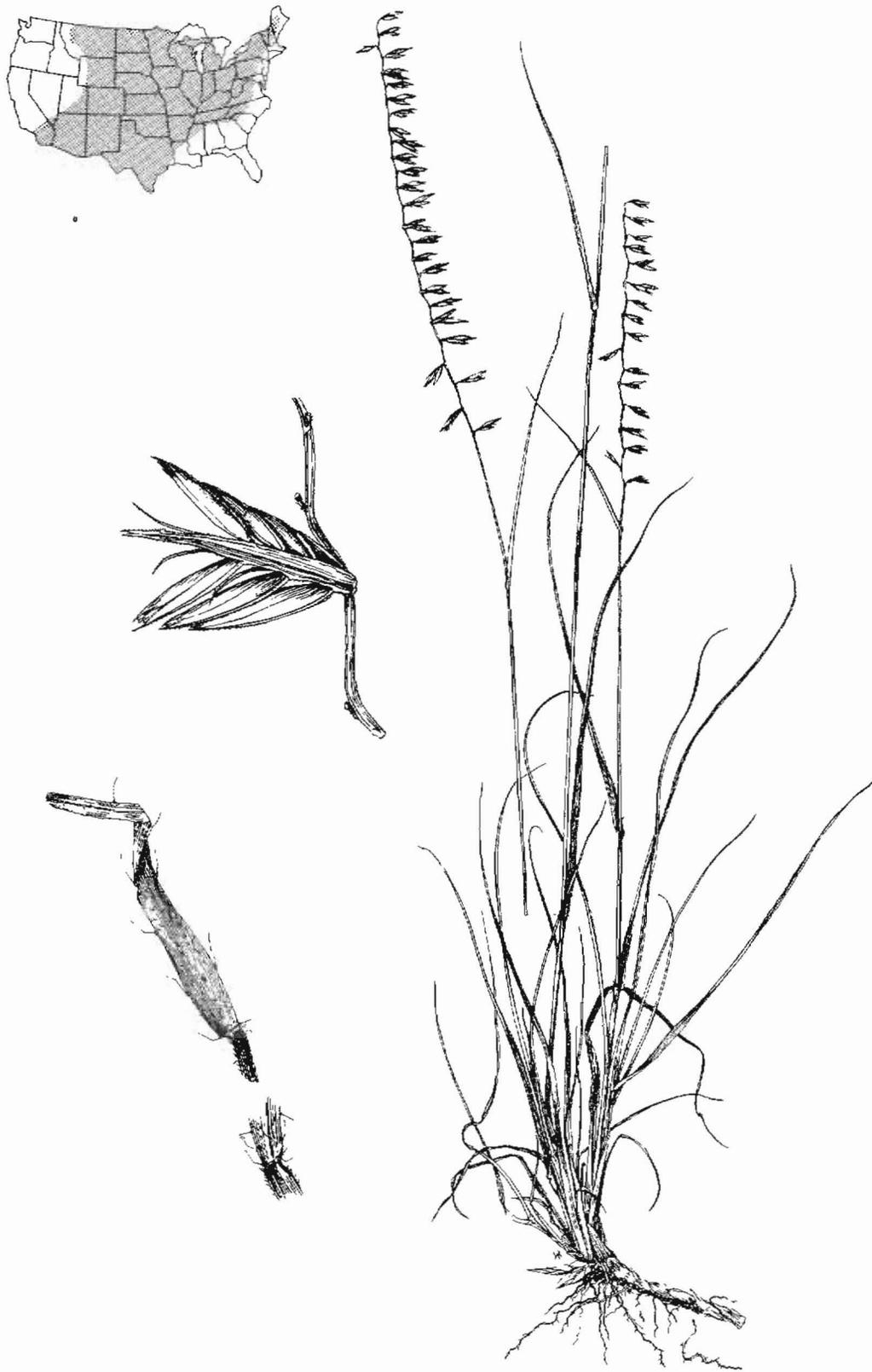


Figure 11. Sideoats grama (*Bouteloua curtipendula*). Plant x 1/2; leafblade, ligule x 2; "spike" or spicate branch x 6.

## BLUE GRAMA

*Bouteloua gracilis* (H.B.K.) Lab. ex Steud.

### ORIGIN

Native. Major species of the western Great Plains and Southwest. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, open, sod-forming shortgrass of the C-4 type. Bunch growth form in South; sod-former in North, higher elevations, and when closely grazed.

Dense tufted, commonly 6 to 24 inches tall with grey-green basal leaves. Leaf blades flat to loosely inrolled, narrow and short. Ligule a hairy semicircle. Inflorescence of one to three spike-like, comb-shaped spicate branches, bluish-purple when young, straw-colored after maturity. Spikelets small and in two rows on underside of axis (1).

Highly palatable to livestock yearlong; used sparingly by antelope. Starts growth midspring, matures intermittently summer to fall, makes good summer regrowth but little regrowth in fall. Nutritious herbage and cures on stem at higher nutritive level than most grasses.

### ECOLOGICAL CHARACTERISTICS

Thrives on soils varying from sandy to clayey textured; grows less vigorously on sands and clays. Tolerant of moderate soil salinity and commonly present on alkaline, but rarely on weakly acid, soils. Rather low level of fertility demand; some reports of favorable responses to nitrogen but usually more response to nitrogen by associated cool season or weedy competitors. Intolerant of frequent flooding or much submergence. Not shade-tolerant. Variable fire tolerance: fair when dormant; some damage during active growth, especially during drought. Most drought-tolerant of major grasses on Great Plains rangelands; also most grazing tolerant, except for buffalograss (*Buchloe dactyloides*). Unique ability to become semidormant with increasing drought; renews growth quickly with available moisture. Produces flowers and seed in 60 days after growth renewal in central Great Plains (2). May produce two or, rarely, a third crop of seedstalks with intermittent moisture. Good winter hardiness of local strains; some stand losses from distant southern seed sources. Seeds from sources up to 200 miles south of planting site usually produce more forage than local sources but seeds from northern and western sources more than 100 miles distant are less vigorous and mature earlier (3). Only fair compatibility in seeding mixtures due to greater palatability, shorter stature, and weak seedling vigor (3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed with special grass drill 1/4 to 1/2 inch deep or broadcast and cover with soil to similar depths. Better establishment obtained in wind erosion areas when seeded in protective nonvolunteering crop stubble. Light irrigations and mulching essential to seeding success on harsh, erosive sites and surface-mined soils. Drill-seed 25 to 40 pure live seed per square foot (1 to 3 pounds PLS per acre) to obtain 1 to 3 established seedlings per square foot, the minimum satisfactory stand on rangelands. Increase rates 50 to 100 percent or more for broadcasting, harsh sites, south and west exposures, and where earlier or denser cover needed (4). Suitable planting dates are April to mid-May in Central Great Plains, slightly earlier in Southern Great Plains, and June 15 to July 15 in Southwest. Seed before or very early in the 1 to 2-month period most favorable for rapid germination and seedling establishment (5).

#### Seed Cleaning and Quality

Seed can be combine harvested satisfactorily by making necessary adjustments in equipment settings and speed. Seed may be processed to acceptable quality using a scalper, hammermill, or rethreshing with a gentle airstream. Seed quality: 45 percent purity; 70 percent germination; 31 percent PLS; and 711,000 seed per pound.

## Germination and Seedling Characteristics

Seed germinates in about 1 week under ideal field conditions; takes 28 days in standardized lab tests. Seedling vigor is weak. Seedling lacks seminal lateral roots and crown, from which adventitious roots arise, is located next to soil surface, a precariously dry microenvironment. Plants die during first winter unless timely rains permit adventitious root development. Timely irrigation essential to seedling establishment. Seedling establishment problems make species usable only where need justifies extra economic and management inputs.

## MANAGEMENT

Native stands used for pasture, soil stabilization, and bird cover. Seeds eaten by songbirds; small mammals eat heads and plants. Seeded for revegetating abandoned croplands and disturbed areas. Weed control needed in seedling stands; may be by grazing, herbicides, or mowing (5). Native stands are grazed continuously yearlong or in summer. Optimum forage and livestock production when 300 pounds of herbage left after grazing in eastern Colorado (6). Rotation or deferred rotation grazing advocated to maintain or restore range at/to optimum cover and production. Similar management needed on seeded stands.

## ASSOCIATED SPECIES

Species commonly occurs in mixed stands, primarily with buffalograss (*Buchloe dactyloides*), needle-and-thread (*Stipa comata*), and western wheatgrass (*Agropyron smithii*) in the shortgrass prairies and with prairie sandreed (*Calamovilfa longifolia*) and sand sagebrush (*Artemisia filifolia*) on sandy sites. Species sometimes seeded alone or mixed with species native to the site being seeded. Seeding native species mixtures adapted to a site requires less management input for sustained production than seeding with exotics (7).

## PESTS AND DISEASES

Grasshoppers damage forage and stands. White grub larvae of the common green June beetle (*Cotina nitida*) feed on roots and infrequently thin stands.

## IMPROVED VARIETIES

'Lovington', released in New Mexico, was selected for outstanding vigor and forage production. Adapted to medium to fine-textured soils of uplands in eastern New Mexico, northwest Texas, and southeastern Colorado. Consult with plant materials specialists for best local strain and developing variety recommendations; e.g., a strain that will establish from greater depths of seeding is being tested in New Mexico.

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Figure 12. Blue grama (*Bouteloua gracilis*). Plant x 1; spikelet x 12.

## SMOOTH BROME

*Bromus inermis* Leyss

### ORIGIN

Native to Europe, Russia, and Siberia. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Leafy, medium-sized, cool season, long-lived, sod-former of C-3 type.

Culms 2 to 4 feet tall, leafy at base and with brown, scaly rhizomes. Leaf blades broad, smooth, flat, and lax. Ligule papery and about 1/8 inch long. Sheaths an unsplit cylinder, basal ones slightly hairy. Inflorescence an open panicle 4 to 8 inches long with numerous ascending branches. Spikelets flattened, cylindrical shaped, 5 to 10-flowered. Glumes short; lemmas flattened, brown at maturity, awnless or minutely awned from between two small apices (1).

Vigorous, uniform sod-former with dense, surface fibrous roots and rhizomes and moderately deep and extensive fibrous root system. Growth starts in early spring, makes vigorous vegetative growth during May or June (later at higher elevations and latitudes), matures during late June and July and becomes semidormant until cooler and/or rainy fall weather. Makes abundant early summer and fall regrowth. Highly palatable to livestock when green, poor palatability in winter; low palatability to elk in spring and fall and to deer in spring. Canada geese graze young plants.

### ECOLOGICAL RELATIONSHIPS

Thrives in fertile, deep, silty and clayey soils in cooler subhumid zones. Not very vigorous on sandy and dense clay soils. Better performance in 16 to over 20 inches MAP zones but useful and sometimes naturalized on overflow and subirrigated sites in lower rainfall zones. Fair salinity tolerance and grows on weakly acid to weakly alkaline soils. Fair drought tolerance; declines sharply in production but usually survives, recovers, and spreads by rhizomes. Good cold tolerance and winter-hardiness. Adapted and persisting at subalpine elevations about 11,000 feet in elevation with management in central and southern Rocky Mountains; not persisting above 9,000 feet in elevation in northern Rocky Mountains. Somewhat intolerant of prolonged summer heat and generally not adapted to nonirrigated sites much below 5,000 feet in elevation in Arizona, New Mexico, and Texas. Moderate tolerance to early spring flooding but not tolerant of high water tables in surface foot of soil. Optimal growth on well-drained soils. Moderate shade tolerance. Responds well to irrigation and nitrogen fertilization. Dense stands become sod-bound in 3 to 5 years without a perennial legume in stand or nitrogen fertilization (2,3). Fair tolerance of fire when dormant and in early spring (4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 to 1 inch deep on finer to coarser textured soils, respectively. Better stands obtained on prepacked seedbeds. Cover broadcast seed with soil to same depths. Drill 15 to 20 PLS per square foot (5 to 7 pounds PLS per acre) for pasture purposes in drier, subhumid zones. Increase seeding rate 50 to 100 percent for broadcasting; on harsher, erosive, and south and west exposures; humid zones; and where quicker and denser cover is desired. Supplemental mulching results in better stand establishment on steep and erosive slopes. Plant before or very early during the most favorable 2-month period for rapid germination and seedling establishment; early spring, late fall, early fall before October, June 15 to July 15 in southwestern pine and adjacent zones, or June or as early as possible in summer at higher mountain elevations (3,5).

#### Seed Cleaning and Quality

General preference is to either combine harvest seed when fully mature or to use a swather first. One experimental test yielded 694, 584, and 394 pounds per acre of 'Manchar' seed by binding and threshing, swath, and combining direct, respectively (6). Seed quality: 92 percent purity; 85 percent germination; 78 percent PLS; and 140,000 to 145,000 seed per pound.

## Germination and Seedling Characteristics

Seed germinates rapidly in 14 days and is aided by a short prechilling treatment. Strong seedling vigor. Ready for grazing by end of second growing season with good moisture conditions.

## MANAGEMENT

Species used for nonirrigated pasture; for soil conservation and stabilization in grass waterways, terrace outlets, drainage ditches, and on roadsides; also seeded for irrigated pasture and hay, with or without alfalfa (*Medicago sativa*) and other species. Widely used in game range restoration and mined land stabilization. Provides fair cover for small game and upland birds but low diversity of cover due to competitiveness. Seeds eaten by birds and rodents. Control weeds when necessary in seedling year. Graze moderately spring and fall to complement native range grazed in summer. More uniform grazing use by rotation grazing system; more vigorous stands obtained by resting periodically during active growing season. Fertilization program necessary to maintain sustained high levels of production; conservative fertilization may be needed to maintain moderate volumes of cover.

## ASSOCIATED SPECIES

Commonly seeded with alfalfa (*Medicago sativa*) in Northcentral and Midwestern States and under irrigation in West. Commonly used in meadow and rangeland seeding mixtures with other cool season species and legumes for higher elevation zones. Soon becomes sodbound when grown alone.

## PESTS AND DISEASES

Grasshoppers, gophers, and other rodents may damage stands and/or forage. Fungicidal seed treatment aids in control of seed-borne seedling diseases. Considerable leaf and stem rust, leaf spot, stripe, and occasionally head-smut affect forage and seed quality, especially in wet years.

## IMPROVED VARIETIES

Marked differences associated with northern and southern smooth brome strains, which originated in northern and central Europe, mostly in Russia and Hungary, respectively:

### Northern Type

symmetrical open panicle  
weakly rhizomatous  
better seed producer  
less rapid sod binding  
more recovery after cutting  
less drouth resistance  
less seedling vigor  
later spring grower

### Southern Type

one-sided, drooping panicle  
strongly rhizomatous  
poorer seed producer  
rapid sod binding  
less recovery after cutting  
more drouth resistance  
more seedling vigor  
earlier spring and later fall grower

### Northern-type cultivar (Origin)

'Parkland' (Canada)  
'Superior' (Canada)  
'Manchar' (Washington)  
'Carlton' (Canada)  
'Homesteader' (South Dakota)  
'Martin' (Minnesota)  
'Kuhl' (Oregon)  
'Saratoga' (New York)

### Southern-type cultivars (Origin)

'Lincoln' (Nebraska)  
'Achenbach' (Kansas)  
'Fischer' (Iowa)  
'Elsberry' (Missouri)  
'Lancaster' (Nebraska)  
'Lyons' (Nebraska)  
'Southland' (Oklahoma)

Consult plant materials specialists in each state for adaptation and best use of these and newly developed cultivars.

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Figure 13. Smooth brome (*Bromus inermis*). Plant x 2/3; spikelet x 2; two florets x 3.

**MOUNTAIN BROME**  
*Bromus marginatus* Nees  
[= *B. carinatus* Hook. & Arn. (1)]

**ORIGIN**

Native to the intermountain West. See map for distribution in the U.S.

**SPECIES CHARACTERISTICS**

Rapid developing, short-lived, medium-sized, cool season bunchgrass of the C-3 type. Tufted with fibrous, shallow roots.

Coarse culms 1 to 4 feet tall. Coarse basal and cauline leaves. Blades flat, wide, smooth to fine hairy; sheaths soft hairy; ligule membranous, 3/16 inch long. Inflorescence a narrow, open panicle, 4 to 8 inches long with erect or spreading (not nodding) branches. Spikelets flattened, seven to nine-flowered. Lemmas, enclosing seed, hairy on back, with terminal awn up to 1/4 inch long from between two teeth (1).

Freely interbreeds with California brome (*B. carinatus*) and foothill brome (*B. polyanthus*) to form a "mountain brome complex." Good palatability to livestock and elk when green; only fair palatability to deer in spring. Canada geese pluck young plants. Seeds relished by livestock in fall. Moderate regrowth production in summer and only fair regrowth amount in fall (2).

**ECOLOGICAL RELATIONSHIPS**

Thrives on moderately deep, fertile, moist, medium to fine-textured soils but moderately vigorous on thin, infertile, coarser, fairly dry soils, especially of open communities and disturbed sites. Tolerant of fair salinity but intolerant of high water tables and early spring flooding. Vigorous native stands occur in 18 inches or more MAP zones. Weakly moderate drought tolerance. Good winter-hardiness; common in foothills to abundant at mountain elevations of about 10,000 feet in central Rocky Mountains. Good shade tolerance and grows in moderately dense aspen stands. Only fair tolerance of wildfires; survives chiefly by seed. Weak stand longevity of 3 to 5 years partially compensated by good self-seeding habits. Weaker responder to irrigation; moderate growth response to fertilization (2,3).

**CULTURE**

Planting Depth, Rate, and Time

Drill seed about 1/2 inch deep on finer textured soils, 1 inch deep on medium, and 1 1/2 inches deep on coarse-textured soils. Species commonly seeded at 8 to 12 pounds PLS per acre for rangeland purposes; rate may be increased on disturbed soils and on harsh or eroding surfaces. Supplemental mulch aids soil stabilization and stand establishment on steep and erosive sites. Seed in late fall or as early in summer as possible in higher mountains. (4).

Seed Cleaning and Quality

Seed shatters quickly. Harvest with binder in dough stage, shock and dry, then thresh. Use hammermill to remove awns for drill seeding. Reclean to commercial quality in a fanning mill. Seed quality: 98 percent purity; 85 percent germination; 83 percent PLS; and 70,000 to 90,000 seed per pound (5).

Germination and Seedling Characteristics

Seed germinates in 14 days after prechilling. Excellent seedling vigor. Commonly heads out first growing season.

## MANAGEMENT

Sometimes seeded with yellow sweetclover (*Melilotus officinalis*) for crop rotations to improve soil organic matter and tilth in Pacific Northwest. Used in seeding mixtures to revegetate livestock and big game ranges, to protect road cuts and fills, mined lands, and burned-over forestlands. Control weeds in seedling stands when abundant. Rotation grazing of native stands best management for species. Encourage self-seeding to improve stand longevity. Nitrogen fertilization program benefits commercial seed production. Seeds are eaten by songbirds and rodents.

## ASSOCIATED SPECIES

Native stands occur mixed with needlegrasses (*Stipa spp.*), fescues (*Festuca spp.*), wheatgrasses (*Agropyron spp.*), bluegrasses (*Poa spp.*), forbs, and shrubs in mountain shrub, aspen, grassland, and dry-meadow types. Commonly seeded with shade-tolerant species (e.g., orchardgrass (*Dactylis glomerata*) and tall oatgrass (*Arrhenatherum elatius*)), in shaded tall mountain shrub types and with these and other mesic grasses and adapted legumes in aspen and open subalpine sites on intermountain livestock and big game rangelands. Separating mountain brome from other grass by drilling seeds in alternate rows may improve stand establishment of the weaker, longer-lived grasses.

## PESTS AND DISEASES

Seed-eating rodents and gophers troublesome on wooded and forb-populated ranges. Aphids affect seed production. Litter removal from seed production fields may reduce insect damage. Head and seed smut sometimes problems; fungicidal seed treatment beneficial in seed industry, unnecessary for forage production.

## IMPROVED VARIETIES

'Bromar', only variety, was selected and released from Washington primarily for its high production potential in crop rotations when mixed with yellow sweetclover (*Melilotus officinalis*) (5).

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Figure 14. Mountain brome (*Bromus marginatus*). Plant x 1/2; floret, glumes x 2.

## PRAIRIE SANDREED

*Calamovilfa longifolia* (Hook.) Scribn.

### ORIGIN

Native of Great Plains and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Coarse, stemmy, warm season, open-sod former of the C-4 type.

Culms 2 to 5 feet tall, arising singly and attached to stout, scaly, spreading rhizomes. Leaves mostly cauline, pale green to straw colored. Blades rigid, flat to rolled, hairless, 1 foot long or longer, tapering to drawn-out tip. Ligule short hairy and collar hairy inside. Panicle 6 to 14 inches long, semiopen and wider at middle. Spikelets pale, shiny, and one-flowered; lemmas awnless and densely hairy at base (1).

Effective sand-binding, coarsely fibrous root system augmented by rhizomes. Growth starts in late spring and flowering occurs between July and September in the Nebraska sandhills. Fair volume of regrowth made in summer and poor amount in fall. Uniformly fair palatability to livestock summer and winter and to elk summer and fall (1,2).

### ECOLOGICAL CHARACTERISTICS

Optimal performance on sandy-textured soils in the 16 to 20 inches MAP zones, common in the 12 to 16 inches zone, and occurs on medium-textured soils in overflow, silty, and limey upland range sites. Tolerant of weakly acidic, alkaline, and saline-nonsodic soils. Strong drought resistance, occurring in the 10 to 12 inch MAP zone, and replacing bluestem grasses (*Andropogon spp.*) during the protracted drought periods. Intolerant of high water tables and early spring flooding. Good cold tolerance but native seed from distant southern or far lower elevational sources may lack good winter-hardiness. Species common from about 2,000 feet in elevation or lower in Great Plains to about 6,000 feet in elevation in Rocky Mountain river valleys or on the intermountain desertic plains. Intolerant of shade at all growth stages. Wildfire damages sites but species fire-tolerant when dormant. Good tolerance of grazing. Increaser in mixtures with bluestems (*Andropogon spp.*); decreaser with commonly associated shortgrasses. Can be largely displaced by shortgrasses by prolonged close and frequent use. Strong competitor when well established (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1 inch deep in sandy soils and shallower in medium-textured soils. Need special grass drills to handle hairy, unprocessed seed. Cover broadcasted seed with soil to similar depths. Drilling in nonvolunteering crop stubble or using seed-hay method of seeding improves stand establishment on erosive sites. Irrigation essential to successful seeding of mined lands and critical habitats. Species may be sprigged in sand dunes and erosive sites; e.g., in "blowouts." Drill 25 to 40 PLS per square foot (4 to 7 pounds PLS per acre) for rangeland purposes. Double rate for broadcasting and for harsh, erosive, and south- and west-facing sites. Better seeding times: early spring, mid-spring, or before the 2-month period most favorable for good germination and seedling establishment. Irrigated seedings may be seeded spring or early enough in summer that seedlings become well rooted before winter (2,4).

#### Seed Cleaning and Quality

Difficult to harvest in quantity due to late maturity, seed shattering, and hairy seed. Combine seed in dough stage. Process in hammermill and reclean in fanning mill. Seed quality: 85 percent purity; 75 percent germination; 64 percent PLS; and 274,000 seed per pound (2).

### Germination and Seedling Characteristics

Seed germinates in 28 days after 2-week prechilling period. Seedling vigor is only fair. Stands develop slowly and may require 3 years or longer for fully developed stand.

### MANAGEMENT

Native stands used for grazing and hay. Occasionally seeded in warm season grass mixtures on sandy-textured soils; less commonly drilled or seeded by seed-hay method for stabilizing unstable sandy lands, including "blowouts" and sand dunes. Rangeland and seeded stands managed by moderate continuous or rotation grazing in summer or yearlong. Poor stands and range condition improved by winter grazing or deferred rotation grazing. Weedy new seedlings and established stands improved by herbicides (5).

### ASSOCIATED SPECIES

Occurs mixed in native stands with sand bluestem (*Andropogon hallii*), little bluestem (*Schizachyrium scoparium*), and sand lovegrass (*Eragrostis trichodes*) on choppy sand range sites and with sand bluestem, needlegrasses (*Stipa spp.*), and grama grasses (*Bouteloua spp.*) on sand range sites in the central Great Plains. Several shrubs, including soapweed yucca (*Yucca glauca*) and sand sagebrush (*Artemisia filifolia*), and a variety of forbs occur intermixed on these sites. Species is seeded in warm season mixtures on sandy lands; more commonly mixed with bluestem grasses. Sometimes seeded in mixtures which approximate the climax composition of a range site. May be seeded alone on harsher sites and for optimal management.

### PESTS AND DISEASES

Grasshopper infestations damage new seedlings. Gophers undercut, smother, and use forage. Diseases seldom of economic importance.

### IMPROVED VARIETIES

'Goshen', only variety, developed from Wyoming collection; adapted for seeding in portions of Wyoming, Montana, western Dakotas, and Nebraska.

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Figure 15. Prairie sandreed (*Calamovilfa longifolia*). Plant x 1/2; two spikelets, floret x 6.

## BASIN WILDRYE

*Elymus cinereus* Scribn. and Merr.

### ORIGIN

Native to intermountain region and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Tall, coarse, cool season bunchgrass of the C-3 type.

Robust, forming clumps 3 feet across with erect culms 3 to 6 feet or taller, typically without, but often with, short rhizomes. Leaf blades wide, long, and flat with raised veins; conspicuous papery ligule and pointed auricles. Inflorescence a stout, stiffly erect spike; sometimes branched; with three to six spikelets clustered at each axis joint; slender bristle-tipped glumes and several larger, pointed, seed-bearing lemmas, rarely short-awned (1).

Extensive soil-binding, coarse, fibrous root system. Earlier spring growth and ready for grazing 3 weeks earlier than tall wheatgrass (*Agropyron elongatum*). Fair palatability to cattle, horses, and elk spring and fall; better palatability early in season; good winter forage and cover above snow. Fair volume of summer and fall regrowth where subirrigated (1).

### ECOLOGICAL RELATIONSHIPS

Adapted to same soils as tall wheatgrass in intermountain region: optimal in silty and clayey soils; somewhat tolerant of sandy and clay-textured soils. Various ecotypes tolerant of strongly saline-nonsodic and saline-sodic soils. Better adapted to winter-wet and summer-dry climates than summer-wet and winter-dry climates. Adapted to below 10 inches to over 20 inches MAP zones, optimal in overflow and subirrigated range sites of over 15 inches MAP zones. Moisture concentrating site more controlling than MAP. Tolerant of fair soil drainage, short term winter flooding, and water table intermittently in top foot of soil. Better tolerance of prolonged summer drought than tall wheatgrass. Local strains/ecotypes winter-hardy, but be cautious about using seed from markedly different latitudes, elevations, and habitats. Grows at 1,000 feet to 2,000 feet in elevation in drainage basins and up to 8,000 or 9,000 feet in mountains. Tolerant of partial shade of shrublands and woodlands. Generally fire-tolerant but may be damaged by wildfire with dry soil conditions. Moderate grazing resistance but susceptible to damage from intense grazing of early spring and fall regrowth. Very strong competitor, suppressing associates and herbaceous weeds (1,2).

### CULTURE

#### Planting Depth, Rate, and Time

Use similar culture to tall wheatgrass: seed at 1 inch depth, drill seed 20 PLS per square foot (5 pounds PLS per acre) for dense pasture swards or use half as much seed when drilled early spring in furrows or corrugations on spring-flooded sites. Seed late fall or as early as possible in summer in mountain sites (3).

#### Seed Cleaning and Quality

Combine seed directly or collect by hand, chop, and fan for small projects. Seed quality: 80 percent purity; 85 percent germination; 67 percent PLS; and 95,000 to 166,000 (median 130,500) seed per pound.

#### Germination and Seedling Characteristics

Germinates in 21 days with alternating temperatures in lab tests. Fair seedling vigor. Stands establish by second or third season.

## MANAGEMENT

Native stands used for spring and fall pasture and hay; species seeded on subirrigated and flooded sites for similar purposes and standing winter hay; potentially useful for soil stabilization of drainage ditches and disturbed soils. Excellent upland game bird cover and emergency winter big game forage (4). Potentially useful as fence row plantings and field and windbreak borders. Management of stands similar to tall wheatgrass; withhold grazing in spring until 10 inches high, leave at least 6-inch stubble; rest while enough soil moisture remains for growth to restore root reserves; follow same stubble-height guides in using fall regrowth; and rest from grazing before winter dormancy. Dense stands without legumes require a fertilization program for sustained high production.

## ASSOCIATED SPECIES

Commonly occurs mixed with big sagebrush (*Artemisia tridentata*), black greasewood (*Sarcobatus vermiculatus*), wheatgrasses (*Agropyron spp.*), and narrow-leaved cottonwood (*Populus angustifolia*). Not often seeded in mixtures.

## PESTS AND DISEASES

Sometimes severely infested with leaf rusts, damaging forage quality. Some ergot occurs in wet years.

## IMPROVED VARIETIES

'Magnar' is used for soil stabilization in southern Idaho, northern Utah, and northern Nevada.

Russian wildrye  
*Elymus junceus* Fischer

Introduced into northern Great Plains, intermountain, and Rocky Mountain regions. Densely tufted, basal-leaved, cool season bunchgrass superficially resembling crested wheatgrass (*Agropyron cristatum*). Short, dense, flat-cylindric spike with two or more short-awned spikelets clustered at axis joints. Lemmas containing seeds, short-awned and fine fuzzy on backs. Resumes spring growth and matures earlier than crested wheatgrass; makes much more regrowth, stays green all summer with moisture, and regrowth stays green later in fall. Weak seedling vigor and less drought resistance in seedling stage, partly due to few lateral seminal roots. Strong competitor when well established, self-thins into open stands and better planted alone in 18 inch or wider rows on semiarid sites; intensively managed and fertilized where economic. More palatable and nutritious than crested wheatgrass. Better adapted on silty and clayey soils of high fertility with good balance in precipitation or more summer than winter precipitation. More tolerant of summer heat in summer rainfall areas than crested wheatgrass. Seeded exclusively for pasture; wide plant spacings ineffective in controlling soil erosion or stabilizing soils on slopes. Culture similar to crested wheatgrass except for wide row spacing and incompatibility in seeding mixtures. Stands more difficult to establish than crested wheatgrass and plants more sensitive to nitrogen. Optimally used spring and fall or summer and fall to complement other forage resources. Provides some winter grazing in Southern Plateau region. Longevity 25 years or longer in northern Great Plains; shorter in certain areas of Great Basin. Varieties: 'Mayak' and 'Sawki' in Canada; 'Vinall', selected in U.S. for more consistent and greater seed production (5).

Canada wildrye  
*Elymus canadensis* L.

Native, stemmy, short-lived, perennial bunchgrass 2 to 4 feet tall with broad, rough basal and stem leaves having large auricles. Tufted with shallow, coarse, fibrous roots; not strongly competitive. Nodding coarse spikes with two or more awned spikelets per axis joint, bearing two to five seed-containing lemmas with 1-inch long curled awns. Secondary species in midwestern prairies where reacts as a decreaser; sparser and more commonly found in disturbed sites in western Great Plains and intermountain West. Very strong seedling vigor, forming stands first year, reaching peak production second and third year, then thinning rapidly. Sometimes used as rapid developer and site stabilizer in seeding mixtures, where better seeded in alternate rows with other species; rarely seeded alone or with sweetclover (*Melilotus spp.*) as a short term pasture in place of annual cereal grains, and partly for crop rotation benefits. Potentially greater longevity as a replacement for cereal grains now seeded in some alternate row plantings with long-lived perennial

mixtures for disturbed soil stabilization. Seeds can be hammermilled for drill seeding. Plants occasionally infested with leaf and stem rust and ergot. Fair palatability before heading. Moderately drought resistant and winter-hardy, but avoid distant southern and low altitude sources of seed. Seed supplies scarce.

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Figure 16. Canada wildrye (*Elymus canadensis*). Plant x 1/2; floret, two rachis internodes with spikelets x 2.

## WEeping LOVEGRASS

*Eragrostis curvula* (Schrader) Nees

### ORIGIN

Introduced into Southern Great Plains and Southwest from South and East Africa. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium-sized, coarse-leaved, warm season, perennial bunchgrass of the C-4 type.

Densely tufted with culms 2 to 4 feet tall, purple at nodes when young, and sometimes branched, with abundant long, drooping, basal leaves 1 to 2 feet long. Leaf blades inrolled and tapering to brown threadlike tips. Basal sheaths hairy on back; ligule hairy. Elongated, semiopen, panicle-type inflorescence, 10 to 16 inches long, with slender, ascending branches borne singly or in pairs, weakly hairy in axils. Spikelets compressed, 7 to 11-flowered, narrowly lance-shaped and gray-green to lead colored. Lemmas small, overlapping, pointed, and unawned (1).

Extensive fibrous root system effective in stabilizing soil. Growth starts earlier in spring and maturity occurs earlier than for native grasses. Flowers in late spring and again in late summer or fall; flowers with pleasing aroma. Fair palatability to livestock, better when herbage grazed before 40-days old. Good volume of summer and early fall regrowth with adequate soil moisture and soil fertility (1,2).

### ECOLOGICAL RELATIONSHIPS

Thrives on fertile sandy to silty-texture soils in warm temperate to subtropical subhumid climates, but grows on coarse sands and clayey soils of lower fertility. Outstanding ability to become established on land classed as poor for crop production. Better performance in the 20 to 40 inches MAP zones, but grows well in the 15 to 20 inches zone and even in the 10 to 15 inches zone with intensive culture, especially on water accumulation sites or with irrigation. Tolerant to strongly alkaline and highly acid soils. Sensitive to cold, only adapted to areas with mean minimum temperatures above -5° F. Grows between sea level in East and about 7,000 feet in elevation in Southwest. Moderate shade tolerance; performs well in partial shade of woodlands. Tolerant of annual burning in dormant state or at start of growth in early spring. Moderately tolerant of grazing; grazed or mowed plants more thrifty than unharvested plants, except some winterkill from fall grazing before fall dormancy near northern limits of adaptation. Strong competitive ability; not easily managed or compatible in mixtures. May become somewhat weedy without management. (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Regulate drill seeder to have seed covered 1/2 inch deep on loam soils or no more than 1/4 inch deeper or shallower in drier or windier areas and/or seasons or in coarser soils or wetter and finer soils, respectively. Better stand establishment when drilled in harvested, close-drilled sorghum or sudan stubble in areas of high wind erosion in southern Great Plains and in pits, basins, or furrows in arid Southwest. Irrigation and supplemental mulching may be necessary to establish good stands on surface mined lands. Recommended rates: 20 PLS per foot of row planted in 12-inch rows for rangeland; but preferably in 36 to 42-inch rows for intensively managed pastures (2). Forty to fifty drilled PLS per square foot or 60 broadcasted PLS per square foot recommended for critical area stabilization and mined land revegetation. Time seeding to precede the 2-month period most favorable for rapid germination and seedling establishment; better dates are as early as late February in South, as late as June in the northern limits of adaptation, March 15 to May 15 at Woodward, Oklahoma, and just prior to, or early after, start of uncertain rainy periods of more arid Southwest. (2,4).

### Seed Cleaning and Quality

Seed ready to harvest when 25 percent of grains are amber colored. Harvest seed directly by combining; by binding, shocking, and threshing; or use double reel seed stripper at 10-day intervals to collect irregularly maturing seed. Clean in fanning mill equipped with upper screen having 1/25-inch holes and 40 x 40 mesh lower screen. Seed quality: 95 percent purity; 80 percent germination; 76 percent PLS; and 1.5 million grains per pound.

### Germination and Seedling Characteristics

Completes germination in 14 days under controlled laboratory conditions. Most seeds germinate in 7 days in field. After-ripening seed dormancy broken in storage after 5 to 6 months. Year-old seed results in best field germination. Strong seedling vigor. Makes good cover first year and some plants head out with good moisture conditions.

### MANAGEMENT

Species primarily useful for soil conservation purposes: ground cover on bare, disturbed, and burned-over areas; drainageways and siltation control; erosion control on man-made bare areas, such as roadsides, drainage ditches, dikes, areas around airports and landing strips; and alone or less commonly in mixtures for pasture and hay. New seedings may need weed and insect control first season. Intensive management advocated for seeded stands at Woodward, Oklahoma: (1) remove old growth; (2) fertilize conservatively; (3) withhold grazing in spring until plants are 6 inches high; (4) rotate grazing, using each unit 1 week and resting for 5 weeks; (5) mow or graze to a 4-inch stubble; (6) rest Sept. 1 to Dec. 1, then graze in winter with supplements; and (7) optimize use with other seasonal forages and native rangelands (5).

### ASSOCIATED SPECIES

Some favorable associations with self-seeding or persistent legumes reported in literature, but generally optimal production and management when planted alone due to special management requirements.

### PESTS AND DISEASES

Grasshoppers, leafhoppers, and other forage-eating insects, even in light populations, are very destructive to seedlings. Rabbits and rodents are sometimes damaging. Fungicidal seed treatment gives some improvement in seedling stands by controlling seed-borne diseases.

### IMPROVED VARIETIES

'Catalina', selected for good stand establishment in Arizona, is adapted for seeding below 4,600 feet in elevation with a minimum of 12 inches MAP in southern Arizona and adjacent New Mexico. 'Ermelo', a relatively leafy cultivar, is adapted to southern Oklahoma and adjacent Texas. 'Morpa', selected for more palatability in Oklahoma, is adapted to portions of the Panhandle regions of Oklahoma and Texas and adjacent areas.

Lehmann lovegrass

*Eragrostis lehmanniana* Nees.

South African introduction, 1 to 2 feet tall, semiprostrate, stoloniferous, bunchy sod-former with fine, diffusely branched stems, short dark green leaves, short panicle with much smaller lemmas, and shallower, finely-branched fibrous root system. Easily established, thickens and spreads by self-seeding and rooting at nodes. Very efficient water user and drought-resistant. Spring and fall green forage augments native summer-green range, but aggressiveness cause for concern as is invading, unseeded, adjacent rangelands. Good soil stabilizer on road shoulders, in drainages, and on disturbed lands. Fairly good cover for upland birds. Adapted to southern plains, southern plateaus, and southwestern deserts; in Arizona below 4,500 feet in elevation in 10 to 15 inches MAP zone where temperatures rarely reach zero. Varieties 'Puhumima' and 'Kuivata' adapted to portions of southern Arizona and southern New Mexico.

Wilman lovegrass  
*Eragrostis superba* Peyr.

Large South African bunchgrass, 3 to 4 feet tall, growing in large clumps with abundant, slender, basal leaves and large, flattened, rattlesnake rattlerlike spikelets on narrow, elongated panicles. Leafblades rather flat and thin, not wiry like weeping lovegrass. Adapted in 12 to 16 inches MAP zone below 4,500 feet in elevation where temperatures do not fall below 15° F. More palatable than Lehmann lovegrass; later spring grower, provides late spring and summer forage. Difficult to establish where rabbits are abundant. 'Palar', only variety, well adapted to above conditions in southern Arizona and southern New Mexico.

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Figure 17. Weeping lovegrass (*Eragrostis curvula*). Plant x 1/3; floret x 10. (Floret after A. S. Hitchcock 1950.)

## TALL FESCUE

*Festuca arundinacea* Shreber

### ORIGIN

Native to Europe. Widely introduced and naturalized in the U.S. Area of agronomic use is centralized in humid mid-South, West Coast, and cool interior irrigated sections. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium-sized, cool season bunchgrass of the C-3 type.

Densely tufted to sod-forming with spreading, leafy base and ascending culms 1 to over 3 feet tall. Leaf blades stiff, flat, or sometimes inrolled, dark green, 1/8 to 1/2 inch wide with rough surfaces, short membranous ligule, hairy collar-edges, and short auricles. Narrow panicle up to 10 inches long, sometimes nodding, with 1/2 inch long spikelets containing five to nine florets, lance-shaped glumes and awnless to short-awned, seed-enclosing lemmas (1).

Large volume of deep, coarsely fibrous roots. Winter grower in South; mostly spring and fall grower at higher latitudes and summer grower at higher altitudes. Good early summer and late fall regrowth potential. Only fair palatability to livestock and poor palatability to elk or deer. Better livestock acceptance when seeded alone and fenced separately (1,2).

### ECOLOGICAL RELATIONSHIPS

Best performance on deep, fertile silty to clayey soils but tolerant of all soil textures with adequate moisture. Tolerant of moderate soil salinity, less tolerant than tall wheatgrass (*Agropyron elongatum*) of saline-sodic soils, moderately acid soils, and to a wide range of soil pH. Tolerant of poor drainage, winter flooding, and fairly high water tables. Mesic in moisture requirements with only fair drought tolerance, markedly less drought-tolerant than western drought-tolerant species, and intolerant of protracted drought. Good growth in over 18 inches MAP zones in cooler northern and mountainous West; optimal growth in East in over 30 inches MAP zones, but grows in parts of Oregon with 15 inches MAP. Good cold tolerance making fair winter growth in southern Missouri and mid-South. Moderate shade tolerance. Not commonly burned; fire tolerant in dormant state. Incompatible with most palatable grasses; satisfactory with vigorous legumes when intensively managed. Good tolerance to grazing and mowing to 2 to 4-inch stubble heights if not too frequent. Responsive to nitrogen fertilizers and irrigation (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 to 1 inch deep, varying according to soil and moisture conditions. Drill seeding rates vary from 2 to 18 pounds PLS per acre for extremes of sparser seedings in wide-spaced rows in subhumid areas to denser pastures for humid zones. Rates may be increased by 50 to 100 percent or more for broadcasting; harsh, erosive, and south and west-facing sites; in saline or saline-sodic soils; and when dense turf is desired quickly. Plant in late summer in lower elevation humid or irrigated areas, early spring when mixed with legumes, or late fall or as early as possible in summer in mountainous elevations. (4).

#### Seed Cleaning and Quality

Combine directly or use swather first. About one-third of seed lost by shattering. Clean seed in fanning mill using 1/22 x 1/2 and 6 x 32 (or 5 triangle) upper and lower screen sizes, respectively. Seed quality: purity 98 percent; germination 85 percent; PLS 83 percent; and 181,000 to 230,000 (median 205,500) seed per pound.

#### Germination and Seedling Characteristics

Germination occurs in 14 days after prechilling in seed testing. Seedling vigor is fair to good. Stands are somewhat slow to establish but are hardy and competitive after fully established.

## MANAGEMENT

Seeded alone or with a legume for nonirrigated and irrigated pasture, also sometimes for hay. Produces sod of good wearability. Seeded for stabilizing cuts and fills, dikes, waterways, recreational areas, and cover crops in orchards. Seeds consumed by songbirds; both seed and foliage used by small mammals. Used in eastern U.S. to stabilize surface mined soils. Control weed infestations and protect new seedlings from grazing until well rooted and headed. Continuously pastured in humid regions. Periodic close grazing to 2 to 4-inch stubble in rotational plan advocated for subhumid and irrigated areas to induce regrowth and better palatability. Annual nitrogen fertilization program needed for dense stands without legumes; starter and complete fertilization program may be needed for cut and fill material and disturbed soils (5).

## ASSOCIATED SPECIES

Occasionally seeded alone for optimal management; more commonly drilled in alternate rows with such adapted legumes as alfalfa (*Medicago sativa*), ladino clover (*Trifolium repens*), or birdsfoot trefoil (*Lotus corniculatus*). Considerable use with crownvetch (*Coronilla varia*) for stabilizing highway embankments in Midwestern and Midsouthern States.

## PESTS AND DISEASES

Cutworms, slugs, and grasshoppers reduce seedling stands and forage and seed yields. Gophers, moles, and rabbits are occasional problems. Relatively free of plant diseases. "Fescue foot-rot" sometimes causes lame cattle; alkaloids may adversely affect livestock gains. Species is a weed in finer lawn turfs.

## IMPROVED VARIETIES

'Alta', from Oregon and used in West and Northwest, is medium early and adapted to dry summers; 'Goar', from California and used in the West and Southwest, is early and adapted to alkaline soils. 'Fawn', from Oregon, has improved seedling vigor and palatability, is early, and is used in central U.S. and Northwest. 'Kentucky 31' is medium in maturing, used in Southeast and central U.S., widely adapted, and makes good winter growth. 'Kenmount', from Kentucky and Montana, is a medium maturing type, which has better midseason growth and is used in the Southeast and northern Great Plains. Consult with State and local plant materials specialists for best adapted variety for specific sites and purposes (4).

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Figure 18. Tall fescue (*Festuca arundinacea*). Plant x 1/3; spikelet x 2.

## IDAHO FESCUE

*Festuca idahoensis* Elmer

### ORIGIN

Native to intermountain and inland Pacific Northwest areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season bunchgrass of small to medium size and C-3 type.

Few upright culms 1 to 3 feet tall. Numerous fine, rough, blue-green basal leaves with narrow, inrolled leafblades. Ligule short, membranous, and swaybacked. Inflorescence a narrow panicle, 4 to 8 inches long, reddish until after maturity. Spikelets five to seven-flowered with unawned glumes and longer short-awned, seed-bearing lemmas (1).

Growth starts in March or April, matures in mid- to late-summer, varying regionally and altitudinally, then becomes semidormant until fall moisture. Makes fair fall regrowth. Scanty seed producer. Medium palatability to livestock; good palatability to elk yearlong; good palatability to deer in spring (1).

### ECOLOGICAL RELATIONSHIPS

Thrives on deep, fertile, silty and clayey soils. Less productive on lighter, rockier, and shallower soils and scarce on pumice soil material. Tolerant of weakly saline, alkaline, and acid soils. Not tolerant of flooding, high water tables, or inundation for any extended period. Grows in well-drained meadows, subhumid grasslands, and semidesert sagebrush sites. Thrives in over 15 inches MAP zones. Moderately drought-tolerant. Found growing with as little as 10 inches precipitation in some cooler or moisture-compensation sites. Seeds from local sources have excellent cold tolerance. Grows between extremes of 800 feet in the Columbia River Basin and 12,000 feet altitude in Colorado; more common between 5,000 and 8,000 feet in Montana; 7,000 to 10,000 feet in Utah and Colorado; and 3,000 to 7,000 feet in California and Pacific Northwest States. Moderately shade-tolerant and common in foothills and mountain shrublands and woodlands. Damaged by sagebrush-grassland fires; requires long recovery period. Fair tolerance of fall burning. Moderate grazing tolerance but can be injured by too intense early spring grazing. Mature plants and stands strongly competitive; seedlings weakly competitive. (1,2).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed 1/2 inch deep; 1/4 inch deeper on coarse-textured soils and 1/4 inch shallower on fine-textured soils. Better stands obtained on preformed seedbeds. Drill a minimum of 15 to 25 PLS per square foot (2 to 3 pounds PLS per acre) for minimal satisfactory stands on rangelands. Increase rate 50 to 100 percent for harsh sites; south, west, or steep exposures; poorer seedbeds; and when broadcasting. May be seeded directly in nonvolunteering grain stubble or in alternate rows with wheat or rye; supplemental mulch may be added for steep slopes and highly erosive sites. Seeding time varies regionally and altitudinally: early spring at lower altitudes with reliable moisture; late fall with uncertain moisture and at lower mountain elevations; or in spring or very early summer, as early as possible, at higher mountain elevations (3).

#### Seed Cleaning and Quality

Combine seed in hard dough stage. Clean in a fanning mill. Seed quality: 90 percent purity; 80 percent germination; 72 percent PLS; and 450,000 seed per pound.

#### Germination and Seedling Characteristics

Seed germinates in 21 days under ideal lab conditions. Seedling vigor is only fair and stands do not develop until the second or third year (3,4).

## MANAGEMENT

Limited use made of the species due to poor seed production and weak seedling vigor. Control weeds and withhold grazing during seedling year. Graze moderately; rest stands periodically for 1 to 2 months during growing season. Rest-rotation grazing may improve unsatisfactory stands (5).

## ASSOCIATED SPECIES

Species intermixed in native stands with bluebunch wheatgrass (*Agropyron spicatum*), big sagebrush (*Artemisia tridentata*), and ponderosa pine (*Pinus ponderosa*); greatly invaded by cheatgrass brome (*Bromus tectorum*) in past half century.

## PESTS AND DISEASES

Seedling stands reduced by grasshoppers and rodents. "Damping-off" seedling diseases sometimes affect stand success.

## IMPROVED VARIETIES

None.

Arizona fescue  
*Festuca arizonica* Vasey

Native, common in ponderosa pine zone from Colorado south to west Texas, Mexico, and Nevada. Similar to Idaho fescue; larger plants having lemmas with shorter awn-tips. Moderately shade and drought-tolerant. Cool season growth habits, but making reduced spring growth due to being dry season. Matures late summer with little fall regrowth. Dense, coarse, fibrous root system. Moderately palatable; moderate grazing tolerance; only fair tolerance of wildfires. Limited seedlings made in native habitats when required to revegetate disturbed lands with natives. 'Redondo', developed from northern New Mexico collection, is adapted for revegetating and stabilizing disturbed soils.

Sheep fescue  
*Festuca ovina* L.

Native, dwarfed, small-tufted, circumboreal bunchgrass very similar to Idaho fescue; and more common at higher subalpine and alpine elevations in Rocky Mountains and Cascade-Sierra Nevada Mountains. Tolerant of shallow, gravelly, and dry, exposed sites. 'Covar', developed from Turkish introduction, adapted to many exposed high altitude northern Rocky Mountain and northern intermountain sites with over 8 inches MAP. Culture similar to Idaho fescue.

Hard fescue  
*Festuca ovina duriuscula* (1) Koch

Larger European form of sheep fescue, more widely used for revegetation and soil conservation purposes in suitable sites having over 15 inches MAP in montane to subalpine zones of Rocky Mountain, intermountain, and Pacific Northwest regions.

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Figure 19. Idaho fescue (*Festuca idahoensis*). Plant x 1/3; spikelet, floret x 6.

## GALLETA

*Hilaria jamesii* (Torr.) Benth.

### ORIGIN

Native to the southwestern U.S. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Short to medium-sized, warm season, bunchy sod-former of C-4 type.

Culms 1 to 2 feet tall, leafy based, hairy at nodes, with stout roots and short, scaly and woody rhizomes. Leaf blades short, rigid, pointed, flat or involute, and pale blue-green before maturity. Ligule short, membranous, truncate and fringe-margined; collar pilose hairy. Inflorescence an erect spike 1 to 3 inches long, purplish before maturity. Spikelets clustered in groups of three at each node, falling entirely after maturity, exposing zig-zag axis. Spikelet clusters villous at base; central spikelet fertile; lateral two spikelets staminate (1).

Facultative warm season species; may start growth with available moisture in spring; matures one seed crop in June like cool season species and a second seed crop from summer rains in August to October. Good palatability to livestock when growing alone during growing season; only fair palatability when mixed with grama grasses. Moderate summer regrowth volume with good summer rainfall; only fair volume produced in fall and very little after frost (2).

### ECOLOGICAL RELATIONSHIPS

Thrives on silty and clayey soils in southwestern Great Plains and on certain sites dominated by shadscale saltbush (*Atriplex confertifolia*) in the southern Great Basin region; common and nearly as thrifty on certain well-drained sandy soils and fractured rockland sites in the Colorado Plateau region. Various ecotypes within species' range tolerant of moderately saline and alkaline soils, weakly saline, or nonsaline soils. Strongly drought-tolerant. Cold-tolerant and winter-hardy; naturally occurs from about 4,000 feet to over 8,000 feet in elevation and from the southern Great Basin and central New Mexico and Arizona northward into southwestern Wyoming. Seeded stands persistent into central Great Plains, well beyond natural range (e.g., Cottonwood, S.D.). Weak shade tolerance; present in open desert shrub and pinyon-juniper cover. Moderate fire tolerance; usually recovers by second year and may spread at expense of fire-injured shrubs, especially with repeat burns (3). Strong grazing resistance but great reduction in forage and rhizome production from too close and frequent defoliation. Incompatible with grama grasses (*Bouteloua* spp.) due to poorer palatability and resulting dominance, especially in southern Great Plains.

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed, in special drill equipped to handle chaffy seed, at 1/2 inch depth on fine-textured soils and moister seedbeds and up to 1 inch deep on coarser soils and drier seedbeds. May broadcast seed but cover with soil to similar depths. Seeding in furrows, basins, and pits and using deep furrow type drills contribute to better stand establishment on more arid and finer textured seedbeds. Supplemental mulching and light irrigations most reliable method of obtaining satisfactory stands. Plant 20 to 30 PLS per square foot for rangeland stands or 40 to 60 PLS per linear foot of row for disturbed land stabilization. Plant before or early during the 2-month period with most favorable conditions for rapid germination and seedling establishment; often June 15 to July 15 in northern Arizona and New Mexico (4).

#### Seed Cleaning and Quality

Combine seed direct from native stands. Clean seed by scalping or run through hammermill before fanning in mill. Seed quality not standardized: purity 20 to over 40 percent; germination 80 to 98 percent; PLS 16 to 40 percent; and seeds average about 170,000 seeds per pound.

### Germination and Seedling Characteristics

Most seeds germinate in 14 days but some continue to germinate up to 30 days. Seeds germinate well at a range of constant or alternating temperatures. Seedlings withstand drought and are winter-hardy, but stand development is rather slow and may require 2 years or longer for full stands (5).

### MANAGEMENT

Native stands grazed by cattle, sheep, and bison more uniformly during the growing season either by grazing continuously at a moderate intensity or more heavily on a rotation grazing plan. Species sometimes included in seeding mixtures for forage and for soil stabilization purposes where it naturally occurs as a primary species. New seedings may require weed control where infestations of weeds are heavy; grazing should be withheld for at least the first growing season (2,4).

### ASSOCIATED SPECIES

Occurs in native stands mixed with blue grama (*Bouteloua gracilis*) and alkali sacaton (*Sporobolus airoides*) in southwestern Great Plains; more commonly with big sagebrush (*Artemisia tridentata*), pinyons (*Pinus* spp.), oneseed juniper (*Juniperus monosperma*), blue grama, sand dropseed (*Sporobolus cryptandrus*), western wheatgrass (*Agropyron smithii*), Indian ricegrass (*Oryzopsis hymenoides*), and alkali sacaton in the Colorado Plateau region; and with big sagebrush, shadscale saltbush, Utah juniper (*J. osteosperma*), Indian ricegrass, and sand dropseed in the southern Great Basin region. Seeded in mixtures containing the above native grasses and sideoats grama (*Bouteloua curtipendula*) and other species native to the site being seeded.

### PESTS AND DISEASES

New seedings may be affected by grasshoppers, jackrabbits, and rodents. Stands occasionally thinned by white-grub larvae of the green June bug.

### IMPROVED VARIETIES

'Viva', released in 1979 from New Mexico.

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Figure 20. *Galleta* (*Hilaria jamesii*). Plant x 1/2; spikelet cluster, staminate spikelet x 5. (Spikelet and staminate spikelet after A. S. Hitchcock 1950.)

## GREEN SPRANGLETOP

*Leptochloa dubia* (H.B.K.) Nees.

### ORIGIN

Native to southwestern U.S. and Florida. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium tall, warm season, short-lived, perennial bunchgrass of C-4 type.

Wiry erect or spreading culms 2 to 4 feet tall or sometimes taller, with numerous scabrous to sparsely hairy, blue-green to dark green, flat or folded leaf blades 6 to 18 inches long with flattened, purplish sheaths and hairy ligules. Inflorescence an open panicle up to 12 inches long composed of few to many slender, well-separated ascending to drooping racemose branches on terminal 4 to 8 inches of stems, each bearing numerous two to eight-flowered spikelets. Florets widely spreading at maturity; glumes unequal, lanceolate, and translucent with green nerves; lemmas (containing seed) broad, obtuse, and notched at apex. Considerable cleistogamous seed enclosed in sheaths (1).

Growth may start early in April or plants may remain dormant during dry periods until summer or late summer rains induce resumption of growth. May produce both late spring and fall seed crops; strong self-seeding habit. Good palatability to all kinds of livestock and fair palatability to wildlife before heading and curing; coarse and stemmy afterward (2).

### ECOLOGICAL RELATIONSHIPS

Thrives in deep, sandy soil in Florida; well adapted to rocky hills and canyons elsewhere. Rarely found on deep sandy soils and deep clays in Southwest but persistent when seeded there. Tolerant to weakly saline and moderately alkaline soils. Occurrence and seeding success in Texas suggests affinity for calcareous soils. Intolerant of poorly drained soils or high water tables. A pioneer on disturbed roadsides, drainages, and slopes. Moderately winter-hardy, slightly less than weeping lovegrass (*Eragrostis curvula*). Mostly present between 2,500 and 6,000 feet in elevation in southern Arizona. Greens up during warm spells in winter in Southern Plains. Weak shade tolerance; fair grazing tolerance. Very good drought tolerance. Good fire tolerance when dormant (3). Seedlings exhibit moderate tolerance to wind and sandblowing in experimental tests. Weakly moderate competitiveness, suitable for inclusion as quick-developing element in seeding mixtures used for disturbed land stabilization.

### CULTURE

#### Planting Depth, Rate, and Time

Drill or broadcast seed and cover with soil at 1/2 to 3/4 inch depth. Plant at rates of 0.6 pounds PLS per acre in wide-spaced rows for seed or intensively managed pastures. Use 2.0 pounds PLS per acre for broadcasting; for harsher, drier, erosive and south and west exposures; or for earlier and denser cover. Plant just before or very early during the 2-month period most favorable for rapid germination and seedling growth: March-April or August-September in Southern Plains; June 15-July 15 in southern Arizona and New Mexico. More successful stands obtained when seedings in arid and erosive sites are made in nonvolunteering crop stubble, supplementary mulched and/or lightly irrigated, or made in water-concentrating pits, basins, or furrows. Species responds well to irrigation and to nitrogen or nitrogen and phosphorus fertilization.

#### Seed Cleaning and Quality

Seeds retained well when ripe; harvest by direct combining. Careful adjusting of combine may make recleaning unnecessary. Commercial seed growers often swath first and then thresh with pickup combine. Seed may be used directly from combine or can be recleaned in fanning mill if necessary. Seed quality: 90 percent purity; 80 percent germination; 72 percent PLS; and 538,000 pure seed per pound.

## Germination and Seedling Characteristics

Seeds germinate quickly. Seedling vigor is medium to good compared to most native warm season species. Stands often head out by end of first growing season with average moisture conditions. Quicker stand establishment and greater herbage production obtained with adapted introduced grasses in tests on certain sites in South Texas (4).

## MANAGEMENT

Species usually secondary or minor in native stands and managed for sustained high production of primary species. Species recommended for inclusion in pasture mixtures used to rejuvenate depleted or cleared rangelands in Texas in zone of adaptation due to ease of establishment, aggressive volunteering, and strong drought tolerance. Species proposed by vegetation management specialists of Texas Transportation Institute for use as substitute for sorghum in seeding mixtures for highway plantings due to rapid germination, good seedling vigor, and less intense competition to slower developing, longer-lived mixture components (5). Weeds need control efforts during early seedling establishment period. Withhold grazing until plants are well established and well rooted. Graze stands moderately after establishment, using no more than 50 percent of current annual herbage production and resting stands periodically from grazing for 60 to 90 days during summer or fall to permit heading and self-seeding.

## ASSOCIATED SPECIES

Species occurs as minor associate of mesquite (*Prosopis glandulosa*), junipers (*Juniperus* spp.), grama grasses (*Bouteloua* spp.), plains bristlegrass (*Setaria macrostachya*), galleta (*Hilaria jamesii*), pricklypear cacti (*Opuntia* spp.), and various southern plains and high desert grassland shrubs and forbs. Species included in mixtures with warm season forage species, such as grama grasses, or with highway turf and cover grasses.

## PESTS AND DISEASES

Commercial seed producers may spray once for thrips control. No serious disease problems known.

## IMPROVED VARIETIES

None. Considerable variation in plant type noted from a tall, early, broadleaf form at high elevations to shorter, narrow-leaf forms of the Three-River area in Texas. Currently used commercial seed stocks came from a biotype collected by U.S. Soil Conservation Service personnel near Marfa, TX.

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Figure 21. Green sprangletop (*Leptochloa dubia*). Plant x 1/2; spikelet x 4. (Spikelet after Gould and Box 1965.)

## INDIAN RICEGRASS

*Oryzopsis hymenoides* (Roemer & Schultes) Ricker.

### ORIGIN

Native to semiarid western U.S. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium sized, cool season bunchgrass of the C-3 type.

Densely tufted perennial 1 to 2 1/2 feet tall with numerous narrow, elongated leaves almost equalling culm length. Leaf blades usually involute with paperlike, pointed ligule about 1/4 inch long. Inflorescence an open panicle with paired branches bearing one-flowered spikelets at ends of dichotomous, spreading, flexuous branchlets. Glumes broad, round-backed, taper-pointed with spreading tips, thin and papery. Lemmas hardened, broadly oval, with deciduous, short awn at tip, densely white hairy, and nearly black at maturity (1).

Highly palatable to livestock and elk when green or cured and to deer in spring. Seeds relished by game birds and rodents. Makes moderate volume of summer and fall regrowth (2).

### ECOLOGICAL RELATIONSHIPS

Thrives on loose, coarse sands; sandy and silty soils lacking much competition; and is a pioneer on thin, fractured shale and sandstone parent materials, as well as on sandy soils. Not tolerant of poorly drained, flooded, or high water table soils/sites. Drought-tolerant and common in deserts with 6 to 10 inches MAP. Tolerant of weak salinity and alkalinity but thrives better in near neutral soils. Moderate responder, especially with increased seed production, to light irrigation and fertilization. Better seeding success obtained in over 12 inches MAP zones. Intolerant of shade. Native seed stocks locally very winter-hardy, but avoid seed sources from areas differing much from seeding site. Species occurs in native stands between 2,000 and 10,000 feet in elevation. Good tolerance of fire when dormant. Moderate grazing resistance but killed out by too intense and prolonged spring or yearlong grazing. Not a strong competitor or very compatible with other species in seeding mixtures (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1 1/2 to 3 inches deep on medium to coarse-textured soils. Seeds emerge well from 4 inch depths in sand. Similar soil coverings needed for broadcast seedings. Drill 20 to 25 PLS per square foot for rangeland purposes; double the seeding rate when broadcasting and for critical area stabilization purposes. Seed into nonvolunteering crop stubble seeded in 18-inch drill rows or closer in semiarid or wind-erosion areas. Still higher rates of seeding, supplemental mulching, and light irrigation may be necessary for good soil stabilization of disturbed sites. Generally seed before the 2-month period with most favorable conditions for rapid germination and seedling growth: late fall with high dormancy seed; early spring, early fall, or June 15 to July 15, according to regionally reliable moisture, with low dormancy seed. Dormancy overcome by using older seed, acid-bleached seed, or planting seed in fall to overwinter in soil (5,6).

#### Seed Cleaning and Quality

Combine seed directly from planted fields or harvest by hand-stripping from native stands. Use hammermill to remove hairs for drill seeding. Rectean product in fanning mill. Seed quality: 95 percent purity; 11 percent germination; 10 percent PLS; and 235,000 seed per pound.

## Germination and Seedling Characteristics

Seeds germinate in 56 days in standard seed testing. Slow and poor germination due to seed dormancy. Seedling vigor fair to moderate. Stands develop somewhat slowly and may require 3 to 5 years with dormant seed. Hardy and persistent after well established.

## MANAGEMENT

Native stands occur mostly on sandy or porous, fractured rockland sites in drier areas of the Great Plains, Great Basin, and Pacific Northwest but spottedly in the mountains, especially in the Southwestern pinyon-juniper woodlands. These rangelands are grazed at various seasons or yearlong. The species is seeded sparingly due to seed shortages, dormancy problems, and high cost of seed. Greater availability of low dormancy seed supplies should increase use of species for food and cover for livestock and game and for soil conservation purposes in former native habitats. New seedings need weed control; grazing should be withheld until plants are well rooted and head out. Graze native and seeded stands moderately in spring; periodically remove stock in late spring or summer when enough soil moisture is left to permit heading. Stands sometimes short-lived unless occasionally permitted to self-seed. Moderate winter grazing promotes range recovery (6).

## ASSOCIATED SPECIES

Species commonly associated with prairie sandreed (*Calamovilfa longifolia*), sand bluestem (*Andropogon hallii*), sand sagebrush (*Artemisia filifolia*), sideoats grama (*Bouteloua curtipendula*), sand dropseed (*Sporobolus cryptandrus*), needle-and-thread (*Stipa comata*), big sagebrush (*Artemisia tridentata*), junipers (*Juniperus* spp.), pinyons (*Pinus* spp.), and green Mormon-tea (*Ephedra viridis*) in the West. Usually seeded alone for optimal management but may be used in seeding mixtures with other species native to a site or with other soil-stabilizing species for soil conservation purposes.

## PESTS AND DISEASES

Grasshoppers, jackrabbits, and rodents may damage stands. Less rodent damage to seeds when planted at 3 to 4 inch depths. Minor stand or forage losses due to variety of seed and root rotting, seedling blight, stem rust, and smut organisms.

## IMPROVED VARIETIES

'Nezpar', released from the Aberdeen, Idaho plant materials center, is well adapted to the intermountain area. 'Paloma' is recommended for range seedings and soil stabilization in Arizona, New Mexico, and Colorado.

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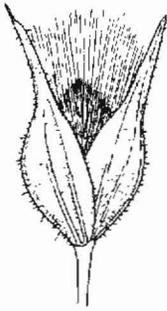


Figure 22. Indian ricegrass (*Oryzopsis hymenoides*). Plant x 1/2; spikelet, floret x 4.

## SWITCHGRASS

*Panicum virgatum* L.

### ORIGIN

Native to all of the U.S. except California and Pacific Northwest. Primary species of midwestern tallgrass prairies. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Tall, warm season, patchy sod-former of the C-4 type.

Strongly rhizomatous with scaly, stout rhizomes. Culms smooth, 2 to 5 feet tall, with abundant leaves up to 2 feet in length. Leaf blades often blue-green, wide, flat or folded, with pilose hairs at base of upper surface. Foliage cures to a rich orangish color in fall. Ligule short hairy. Inflorescence an open extended panicle 6 to 18 inches long with numerous small, egg-shaped, pointed spikelets borne toward ends of spreading branches. First floret sterile, resembling second glume; second floret fertile, smooth, shiny, and fused to seed (1).

Growth resumes in late spring; plants mature in mid to late summer or early fall, making fair regrowth with available moisture; little fall regrowth after frost. Good palatability to livestock until heads; poor palatability in fall and winter. Seeds provide food for song and game birds (1).

### ECOLOGICAL RELATIONSHIPS

Mesic grass; well adapted to all soil textures with adequate moisture. Thrives on fertile, lowland, subirrigated and overflow sites, especially on silty and clayey soils. Weakly moderate drought tolerance. Considerably reduced forage production and cover with moderately acute drought, but present and seeded on upland sandy sites. Better performance in over 16 inches MAP zones, especially on moisture accumulating sites. Tolerant of early spring flooding and of imperfect drainage but rather intolerant of high water tables. Tolerant of moderate soil salinity and acidity; lower pH limit 4.0 to 4.5. Good winter-hardiness and cold tolerance of local native and improved strains developed from local stock. Avoid using seed grown or collected more than 200 miles southward or 100 miles northward. Southern material up to 200 miles distant usually more productive of forage. Species grows from near sea level up to 7,000 feet in elevation in Rocky Mountains. Weakly moderate shade tolerance, occurring in open woodlands. Good tolerance to controlled burning. Moderately grazing tolerant. Somewhat vulnerable to close grazing in spring and early summer due to early elevation of shoot apices. A decreaser in most Great Plains grassland, except when winter-grazed. Good responder to irrigation and fertilization. Moderately compatible in native warm season grass mixtures (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed between 1/4 and 3/4 inch deep on prefirmed seedbeds. Commercial seed is clean and easily drilled. Better stands obtained by planting into nonvolunteering crop stubble or by adding supplemental mulch and light irrigation in critical and erosive sites, including surface mined soils. Topsoil and/or fertilizers needed for good stands on exposed subsoils, parent materials, and spoils. Seeding rate varies with methods, costs, and purposes of seedings and site and seedbed conditions. Satisfactory pasture generally results by end of second season after drilling 15 to 25 PLS per square foot (2 to 3 pounds PLS per acre). Use 50 to 100 percent higher rates for broadcasting and for hay, also for dry, hot, and rough sites or seedbeds. Plant prior to 2-month period most favorable for rapid germination and seedling regrowth; usually March to April in southern Great Plains and April to May in northern Great Plains (4,5,6).

#### Seed Cleaning and Quality

Combine seed directly or use binder first. Dry combined seed before sacking to avoid damage from

heating. Hammermill at 800 rpm to obtain smooth florets for planting. Reclean in fanning mill fitted with 1/14 and 1/22 sized upper and lower screens. Seed quality: 95 percent purity; 70 percent germination; 66 percent PLS; and 389,000 seed per pound.

### Germination and Seedling Characteristics

Seeds germinate in 28 days in seed lab testing after prechilling. Considerable seed dormancy; fresh seed sometimes planted in winter; using year-old seed preferable. Species only shows fair to medium vigor; some improvement in new varieties. Stands usually develop by second or third season; possible to use certain herbicide-tolerant strains and produce fair first year cover and forage with good moisture conditions or irrigation.

### MANAGEMENT

Native stands useful for grazing and hay; good for wildlife food and cover. Species seeded for those purposes, for grass waterways, terrace outlets, and, sometimes, for irrigated pasture and hay. Also used for mine soil stabilization and in mixtures with bluestems (*Andropogon* spp.) and yellow Indiangrass (*Sorghastrum nutans*) for prairie restoration. New seedings require weed control. Strains being developed at Nebraska Agricultural Experiment Station are moderately atrazine resistant. Grazing considered acceptable weed control method at Kansas Agricultural Experiment Station. Moderate continuous summer grazing or an early rotation system for steers advocated for good condition ranges. Some form of deferred or rotation grazing usually prescribed for poorer condition ranges or seeded pastures. Annual fertilization needed on pure stands of high density. Combining seeded cool season with native or seeded warm season switchgrass or bluestem pastures provides longer, more productive pasturage in subhumid tallgrass prairie regions.

### ASSOCIATED SPECIES

Species very commonly occurs with big bluestem (*Andropogon gerardii*) and yellow Indiangrass (*Sorghastrum nutans*) and a variety of forbs and few shrubs on midwestern lowland prairies. It is seeded with these associates and other species on subirrigated, overflow, sandy, and even sands range sites, often somewhat in proportion to their natural occurrence on site being revegetated.

### PESTS AND DISEASES

Grasshoppers and leafhoppers hazardous in new seedings. Some stand losses from damping off and seedling blight. Rusts occasionally affect forage quality.

### IMPROVED VARIETIES

'Alamo' (Texas); 'Blackwell' (Oklahoma); 'Caddo' (Oklahoma); 'Grenville' (New Mexico); 'Kanlow' (Kansas); 'Nebraska 28'; 'Pathfinder' (Nebraska); and 'Summer' (South Dakota) are recognized varieties. Consult with plant materials specialists about these and developing varieties for specific sites and purposes.

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Figure 23. Switchgrass (*Panicum virgatum*). Plant x 1/3; spikelet x 8. (Spikelet after Gould and Box 1965.)

## DALLISGRASS

*Paspalum dilatatum* Poir.

### ORIGIN

Introduced into southern U.S. from South America; widely used and naturalized in southern and Pacific Coast States; also in the milder irrigated sections of the Southwest. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season bunch to open sod-former of C-4 type.

Culms leafy at base, erect, 1 to 4 feet tall, from a decumbent, knotted base of short rhizomes. Nodes often hairy. Leaf blades flat, 1/4 to 1/2 inch wide, elongated, rough edged, and long hairy near collar. Ligule a rounded membrane. Inflorescence a panicle of 3 to 8 ascending or drooping, racemose branches 2 to 3 inches long. Spikelets small, compressed, ovate, and pointed, borne in overlapping pairs and hairy fringed. Fertile lemma, enveloping seed, elliptic, pale and unawned (1).

Strongly fibrous rooted, with weak rhizomes forming incomplete sod, not fully effective in resisting erosion of steep slopes. Growth starts earlier in spring than for most warm season grasses; growth continues throughout summer with moisture; remains green in winter at southern locations, sufficient for winter grazing on clayey blacklands. Makes quick recovery and abundant regrowth until frost. Produces seed intermittently; two crops possible. Palatable and nutritious to all kinds of livestock when green. Provides food and cover for birds and small mammals (1).

### ECOLOGICAL RELATIONSHIPS

Thrives on moist, fertile, clayey and loamy lowlands; tolerant of most soil textural groups except sandy. Endures extremes of drought and moisture on heavy clays better than most humid zone grasses. Generally adapted to over 35 inches MAP zones in southeastern U.S. and to irrigation in southwestern U.S. Tolerant of moderately saline and acidic soils. More productive in near neutral soils. Only fair drought resistance compared to western native grasses. Tolerates moderate frost. Weakly moderate shade tolerance and good fire tolerance when dormant. Moderately tolerant to grazing. Some defoliation benefits production and persistence because species has determinate type of growth. Responds well to irrigation: fertility demanding for good performance. Becomes sodbound without legumes or nitrogen fertilization. Good compatibility with legumes and other grasses due to weak rhizomes.

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 to 3/4 inches deep; use shallower depth on moister or finer textured soils and deeper depth on drier or coarser soils. Species requires a firm, well prepared seedbed for good establishment. Cover broadcasted seed shallowly with soil or use a cultipacker and press seed into soil. Need 25 to 40 PLS per square foot to produce satisfactory pasture stands in drier edges of humid zones or in coarser upland soils. Double seeding rate for denser stands in moister humid zones, and for broadcasting, poor seedbeds, and erosive sites. Late fall (Oct. to Nov.), late winter, or spring are preferred seasons for seeding in South; late fall more commonly used in rice-growing areas.

#### Seed Cleaning and Quality

Combine standing crop directly or mow, windrow, and combine out of windrow. Combined seed needs to be dried thoroughly. Hairy bracts can be hulled in a hammermill. Use a gravity cleaner rather than a fanning mill. Seed quality: 70 percent purity; 70 percent germination; 49 percent PLS; and 220,000 seed per pound.

### Germination and Seedling Characteristics

Seed germinates in 21 days in seed lab tests. Has considerable dormancy. Seedling vigor only fair. Careful management required to obtain good stands. Hardy and persistent, even escaping from cultivation after well established.

### MANAGEMENT

Species makes better pasture than hay due to lodging. Sod-forming habits with defoliation and persistent spreading make it potentially useful for soil conservation purposes. Topsoil replacement and/or heavy initial fertilization, supplemental mulch, and sometimes irrigation are needed for good establishment in reclamation of disturbed soils. Control weeds in seedling stands and withhold grazing until well established. Graze in continuous or rotation plan, not letting growth exceed 12 inches or stubble become shorter than 2 inches; resting periodically in late summer or fall to restore vigor and production. Annual nitrogen fertilization and other soil amendments needed, according to legume composition and soil tests.

### ASSOCIATED SPECIES

Seed species with a legume, usually either white clover (*Trifolium repens*) or a lespedeza (*Lespedeza* spp.). Species a valuable addition to other warm season grass mixtures, including bermudagrass (*Cynodon dactylon*) and carpetgrass (*Axonopus affinis*).

### PESTS AND DISEASES

Ergot fungus commonly replaces seed embryos in wet seasons; ergot is poisonous to animals. Anthracnose and leaf blights occur. Sugar cane borers reduce seed production.

### IMPROVED VARIETIES

'Prostrate', developed in Georgia, reported to be better adapted to light, poorly drained soils than "common."

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Figure 24. Dallisgrass (*Paspalum dilatatum*). Plant x 1/2; spikelet x 10. (Spikelet after A. S. Hitchcock 1950.)

## REED CANARYGRASS

*Phalaris arundinacea* L.

### ORIGIN

Native to northern U.S. and circumboreal. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Large, moderately coarse, cool season, sod-forming grass of C-3 type.

Culms thick, 3 to 6 feet tall, arising from large leafy sod clumps, having shallow, stout, spreading rhizomes. Leaf blades flat, thick, and rigid, up to 1 inch wide. Ligule large, obtuse, and membranous. Inflorescence a narrow, dense panicle 3 to 7 inches long with short appressed branches lobed at base. Glumes with narrow-winged midnerves; fertile lemma ovate, unawned, appressed hairy and brownish at maturity, flanked by a pair of hairy, scale-like sterile lemmas (1).

Growth starts in early spring and continues until frost with adequate moisture and fertility; little regrowth after frost. Medium palatability to livestock when actively growing. Poor to fair palatability in fall and winter; less palatable than tall fescue. One of the highest forage-yielding grasses in its semihydric habitat (2,3).

### ECOLOGICAL RELATIONSHIPS

Thrives on poorly drained, wetland areas that are frequently flooded or subirrigated, especially in silty or clayey textured soils. Moderately tolerant of coarser sandy soils; thrives on uplands under irrigation. Excellent tolerance to high water tables, flooding, and submergence. Only moderate drought tolerance; may winterkill on uplands without adequate moisture or snow cover. Moderate tolerance of saline, alkaline, and acidic soils but not sodic soils. Species occurs in brackish tidelands along northwest coast. Moderate cold tolerance and winter-hardiness, but less hardy than smooth bromegrass (*Bromus inermis*). Seedlings more frost sensitive than most cool season species. Species occurs from near sea level to about 9,000 feet in elevation in Rocky Mountains. Not shade-tolerant. Sites seldom burned by wildfires; some tolerance to controlled burning due to rhizomes. Strong tolerance to grazing except in early growth stages. Alkaloidal content and increasing fiber content with advancing maturity associated with declining palatability. Competitive species, rapidly spreading by seeds and rhizomes on adapted sites. Incompatible with most species but possible to retain in legume mixtures with intensive culture and management (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 to 3/4 inch deep in fine to medium coarse-textured soils or broadcast seed and cover with soil to similar depths. Drill 40 to 50 PLS per square foot for pasture purposes. Increase rate 50 to 100 percent for denser stands for hay or soil stabilization and when broadcasting. Use only fresh seed which has been tested quite recently because seeds rapidly lose viability in storage. Spring, late summer, or late fall on poorly drained areas are more successful seeding dates. Stands easily established by pushing sod-pieces or jointed stems into wet soil; plant cuts with joints superior to sodpieces in very wet soils. Also established by spreading sod-pieces and jointed stem segments with manure spreader followed by disking (1,2,4).

#### Seed Cleaning and Quality

Harvest seed by binding, heading, or windrowing first and/or combining. Combined seed needs careful drying to avoid germination losses from heating. Seed recleaned in fanning mill equipped with 1/12 and 6 x 20 upper and lower screen sizes. Seed quality: 96 percent purity; 80 percent germination; 77 percent PLS; and 506,000 seed per pound.

## Germination and Seedling Characteristics

Germination completed in 21 days in standard seed lab testing. Seeds germinate slowly and irregularly in the field. Moderate seedling vigor; seedlings may reach 10 to 20 inch heights in first season. Usually does not head out until summer of second year. Full stands may not be attained until third season.

## MANAGEMENT

Species widely used, especially in Northcentral and Pacific Northwest for seeding humid, wet, and irrigated lands for pasture, hay, and silage. Valuable in soil conservation programs for gully control and maintenance of grassed waterways, stream channel banks, edges of farm ponds, silting basins; especially useful as a cover in which to dispose and use sewage effluents. A potential weed and silt-accumulator to be avoided along slow-running ditches and shallow streams. Considered usable only on mined lands which are wet or receive additional moisture. New seedings need weed control and protection from grazing during first growing season. Graze established stands at the 6 to 24-inch vegetative stages, using an intense stocking and short rotation plan; always leave at least a 4-inch stubble. Possible to use with alfalfa (*Medicago sativa*) in subhumid and humid (not wetland) zones by careful grazing management. Alfalfa replaces nitrogen fertilization otherwise needed to prevent sodbinding (1,2,5).

## ASSOCIATED SPECIES

Naturally occurs with a variety of semihydric graminoids; e.g., sedges (*Carex* spp.), rushes (*Juncus* spp.), and bulrushes (*Scirpus* spp.). Usually seeded alone for optimal stands, management, and production. May be maintained with alfalfa (*Medicago sativa*) and ladino clover (*Trifolium repens*) by planting in alternate rows and managing carefully.

## PESTS AND DISEASES

Grasshoppers and cutworms cause minor damage; leaves occasionally infected by *Hefminthosporium giganteum* and damaged by a frit fly (*Oscinefla frit*) (3).

## IMPROVED VARIETIES

Numerous cultivars developed by experiment stations and commercial seed companies. Consult with State and local plant materials specialists for superior varieties for specific sites and purposes.

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Figure 25. Reed canarygrass (*Phalaris arundinacea*). Plant x 1/2; spikelet, floret x 10.

## TIMOTHY

*Phleum pratense* L.

### ORIGIN

Eurasian meadow grass widely used and naturalized in northern U.S. and mountainous West. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small-tufted, cool season, short-lived, perennial grass of C-3 type.

Culms erect. 2 to 3.5 feet tall, uniformly leafy, with swollen bulblike bases. Leaf blades soft, flat, rough-edged, up to 1 foot long. Ligule membranous, irregular-margined, rounded or pointed and sometimes split. Inflorescence a dense, narrowly cylindrical, spikelike panicle. Spikelets one-flowered; small floret containing seed flanked by a pair of distinctive short awn-tipped and hairy-fringed, keeled glumes (1).

Moderately shallow and fibrous root system. Growth resumes in early to late spring; matures in early to late summer, varying with altitude and latitude. Produces moderate amount of cool season regrowth in early summer and fall with adequate moisture and fertility. Good palatability to livestock spring through fall; to elk, spring and summer; and to deer in spring. Some use made by white-tailed deer and moose (1,2).

### ECOLOGICAL CHARACTERISTICS

Thrives in deep, fertile, loamy, silty, and clayey soils of humid zones. Adapted to thin, gravelly, and rocky soils if adequately moist. Moderately demanding and responsive to nitrogen fertilization; responds well to irrigation. Tolerant of several weeks of winter flooding but only few days during growing season. Best performance with water table 6 inches or deeper. Generally requires at least 20 inches MAP or irrigation with lower amounts for economic production. Tolerant of soils that are weakly acidic to weakly basic in reaction. Excellent cold tolerance and winter-hardiness. Grown from sea level to alpine elevations. Variable growth habit responses to day length, requires selection of adapted strains. Good shade tolerance. Fair tolerance to fire in dormant state but sites seldom burnable. Good compatibility with legumes and cool season grasses (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed at 1/2 inch depth in moist soil; 1/4 inch deeper or shallower in drier or coarser textured soil or in moister or finer textured soils, respectively. Cover broadcasted seed shallowly with soil or press them into soil by cultipacking. Drill 40 to 50 PLS per square foot (about 2 pounds PLS per acre) for pasture-type stands. Increase seeding rate 50 to 100 percent for broadcasting, harsh sites, poor seedbed conditions, and wet meadows or for hay crops. Use similar or greater rates for critically erosive sites and surface mined soils. Latter sites may require supplemental mulching for good stand establishment; do not hydromulch because seedlings must root in mineral soil. Plant before or early during the 2-month period most favorable for rapid germination and seedling growth: late summer, early spring, or late fall most regions; June or early July in high mountains. Irrigated plantings commonly made in August or from spring until midsummer at mountainous elevations; should be sown at optimum date for seeding legumes when used in mixtures (2,3,4).

#### Seed Cleaning and Quality

Combine seed when well matured. Carefully adjust combine's threshing equipment for optimum yield. Clean seed in fanning mill fitted with 1/19 or 1/20 sized top screen and 6 x 32 or 6 x 34 sized bottom screen. Seed quality: 99 percent purity; 90 percent germination; 89 percent PLS; and 1,230,000 seed per pound (5).

### Germination and Seedling Characteristics

Seed germinates rapidly in 10 days in seed lab testing aided by prechilling. Moderate seedling vigor. Usually well established by second season, sometimes by end of first season with more favorable conditions and longer growing season.

### MANAGEMENT

Species traditionally prized for horse hay and as a dominant in irrigated mountain meadow mixtures. More commonly planted for hay than pasture, but usually aftermath is grazed. Species sometimes used in seeding mixtures for stabilizing roadsides and disturbed soils from industrial or mining activities. New seedlings planted alone need weed control; when seeded with companion crop, companion crop should be harvested as early as possible. Do not graze until new seedlings head out. Maximum dry matter hay yields obtained by harvesting in post-bloom stage; more digestible protein and metabolizable energy obtained from early cut hay. Legumes in mixture maintain higher soil nitrogen and dietary protein. Split nitrogen applications stimulate greater production. Graze meadows in a rotation plan. In humid zones, graze until jointing stage, then mow for hay at bloom stage; repeat two or more times under favorable growing conditions. Harrow or drag meadows and fertilize annually. Clover composition of meadows improved by feeding late cut hay containing clover on areas lacking such (1,4).

### ASSOCIATED SPECIES

Sometimes seeded alone or in mixtures with grasses and without legumes for horse hay. More commonly seeded in mixtures with other meadow grasses [tall oatgrass (*Arrhenatherum elatius*), meadow fescue (*Festuca elatior*), orchardgrass (*Dactylis glomerata*), meadow foxtail (*Alopecurus pratensis*), and creeping foxtail (*A. arundinaceus*)] and adapted legumes (4,5).

### IMPROVED VARIETIES

There were 25 varieties on the National list in 1972. Consult with regional, State, and local plant material specialists for materials adapted and suited to specific sites and purposes.

#### Alpine Timothy *Phleum alpinum*

Shorter native grass; occurs in alpine/subalpine elevations and higher latitudes worldwide. Shorter spikelike panicles wider at base, glumes longer awned, swollen upper sheath, and lack of bulblike bases distinguish alpine timothy from common timothy. Naturally revegetates somewhat in open or disturbed sites in western mountains; good performance in reclamation tests in Montana alpine mine wastes (6). Seed supplies limited.

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Figure 26. Timothy (*Phleum pratense*). Plant x 1/2; glumes, floret x 10. (Glumes and floret after A.S. Hitchcock 1950.)

## BIG BLUEGRASS

*Poa ampla* Merr.

### ORIGIN

Native to the intermountain West. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium-sized, basal-leaved, cool season bunchgrass of the C-3 type.

Culms 2 to 4 feet tall with green to blue-green, smooth, basal leaves 8 to 16 inches long. Leaf blades narrow, folded, elongated with boat-shaped tips and short, thick, rounded ligule; those of culm leaves with conspicuous hard auricles. Inflorescence a narrow, elongated panicle, up to 8 inches long. Spikelets three to five-flowered, narrow, subcylindric with narrow-tipped glumes and round-backed and pointed lemmas, keeled above and yellowish green to brown (1).

Sometimes with short rhizomes, probably due to interbreeding with rhizomatous *Poa* spp.; typically densely tufted. Strong fibrous root system when fully established; immature plants and seedlings easily uprooted on wet and loose soils. Growth resumes very early in spring, earlier than crested wheatgrass; matures in early summer at lower elevations with moisture exhaustion or later in summer with continuous vegetative growth from abundant moisture at higher elevations. Makes good early summer and late fall regrowth, usually latest green herbage of any cool season species. Good palatability to livestock spring and fall; also in summer at higher elevations; excellent palatability to elk yearlong and to deer in spring (1,2).

### ECOLOGICAL RELATIONSHIPS

Thrives on moderately coarse sandy to fine clayey soils; fair tolerance to coarse sands and dense clay soils. Intolerant of saline soils but tolerant of weakly alkaline and acid soils. Weak tolerance of early spring flooding, high water tables, and poor drainage. Thrives in 15 to 20 inches MAP zone but nearly equal performance in better moisture sites of 12 to 15 inches MAP zone. Moderate drought tolerance compared to cool season species commonly seeded in its native habitat. Excellent cold tolerance of local ecotypes; species occurs from foothill to subalpine elevations. Moderate shade and grazing tolerance. Intolerant of dry season wildfires; fair tolerance when dormant. Weak yield responder to irrigation; moderate responder to nitrogen fertilization. Species weakly compatible with other cool season species; better compatibility when seeded in alternate rows with stronger competitors (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed about 1/2 inch deep for medium-textured soils with average moisture conditions or 1/4 inch shallower or deeper for finer and moister or coarser and drier soils, respectively. Cover broadcasted seed with soil to a similar depth. Drill 3 to 5 pounds PLS per acre for minimal to moderate stand densities on semiarid to average moisture range sites seeded for pasturage and cover. Increase seeding rates 50 to 100 percent for broadcasting; for harsher, drier, and erosive sites; and for quicker and denser cover. Seed before or very early during the 2-month period with most favorable conditions for rapid germination and seedling growth: early spring; late summer; late fall; or as early as possible in summer for higher mountain sites (2,3,4).

#### Seed Cleaning and Quality

Better seed yields obtained by binding, shocking and threshing or windrowing and then combining. Seed readily cleaned in a fanning mill. Seed quality: 90 percent purity; 70 percent germination; 63 percent PLS; and 917,000 seed per pound.

## Germination and Seedling Characteristics

Seed germinates in 28 days under standardized lab conditions after a short prechilling treatment; two-thirds germinate in the first 10 days (4). Seedling vigor is moderate among cool season species and rather good for a bluegrass. Stands may be ready for grazing by the second fall with moderately good moisture conditions. Seedlings and immature plants are easily pulled up by grazing.

## MANAGEMENT

Species is seeded alone or in mixtures with alfalfa and sometimes with other species for pasture and hay; the early green cover and long leaves provide excellent nesting cover and shade for pheasants and other birds and small mammals. Seeds eaten by songbirds, and the seed heads and foliage eaten by small mammals. New seedlings require weed control during first season. Usually grazing must be withheld for two growing seasons to avoid stand losses from pull-up. Species is amenable to spring and fall grazing. Where spring pull-up from grazing occurs, fall grazing may be safer if plants are seeded in close-drilled rows in high population densities to maximize vegetative shoot development and minimize proportion of culms developing because latter most easily pulled up by grazing (5). 'Sherman' big bluegrass most advantageously used in late fall to early winter in ponderosa pine parks and abandoned fields in central Colorado (4).

## ASSOCIATED SPECIES

Species occurs naturally in the big sagebrush and Palouse prairie vegetation associations and in minor amounts in subalpine grassland and open-forest communities. Species seeded alone most commonly but also in mixtures with alfalfa (*Medicago sativa*) for hay on both dryland and irrigated areas. It may be seeded in mixtures with other simple grass or more complex grass, legume, forb, and shrub mixtures for game range restoration or improvement. Plant species in alternate rows with stronger competitors for better stand establishment.

## PESTS AND DISEASES

Grasshoppers, jackrabbits, and rodents affect newly seeded stands. Leaf and stem rusts sometimes lower forage quality and stem maggots cause sterile culms in seed fields.

## IMPROVED VARIETIES

'Sherman', a high producing utility type selected from Oregon materials, is widely used in the pine zones of Pacific Northwest and Rocky Mountain West (3,6).

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Figure 27. Big bluegrass (*Poa ampla*). Plant x 1/2; floret x 8. (Floret after A. S. Hitchcock 1950.)

## KENTUCKY BLUEGRASS

*Poa pratensis* L.

### ORIGIN

European meadow grass widely introduced and naturalized in U.S. in Colonial and Homesteading eras. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Short to medium height, cool season, dense sod-forming perennial grass of the C-3 type.

Densely-tufted and turf-forming with shallow, fibrous root and abundant, widely spreading rhizomes. Leaves mostly basal; blades narrow, glabrous, V-shape in cross section with boat-shaped tips. Membranous, short, blunt ligule. Inflorescence an open panicle, pyramidal or conical-shaped, with whorls or branches in fives or threes. Spikelets small with keeled glumes and lemmas. Lemmas with a web of fine hairs at their base (1).

Growth starts in early spring, usually March or early April; vegetative growth rapid until late July and August when becomes semidormant with summer heat and inadequate moisture. Abundant fall regrowth made until mean daily temperatures drop to near freezing level. Highly palatable to most grass consumers in rapid growth phases; palatability greatly reduced during semidormancy of late summer and winter (2).

### ECOLOGICAL RELATIONSHIPS

Thrives on moist, fertile sandy to clayey alluvial soils high in organic matter in cool temperate climates. Survives, but makes less growth, on sands; dense clays; and thin, rocky soils with adequate moisture. Tolerant of weakly basic, acid, and salty soils. Nitrogen-demanding for good production. Intolerant of prolonged flooding, high water tables, or poor drainage. Good cold and winter hardiness. Naturalized from near sea level to the alpine edge of the Rocky Mountains. Rather moisture demanding and only fairly drought tolerant. Requires about 18 inches MAP or irrigation for good performance. Moderate shade tolerance; common in aspen groves; not as tolerant as orchard grass (*Dactylis glomerata*) or red fescue (*Festuca rubra*). Intolerant of burning in active growth stages; almost eradicated by late spring burning of midwestern bluestem pastures; retained for desirable ruffed grouse drumming ground cover by burning when dormant with damp soil. Excellent grazing tolerance; increases or invades in intensely grazed pastures within its zone of adaptation. Poor compatibility with most pasture or hay species but fairly good with turf grasses and clovers (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill no deeper than 1/4 inch on heavier soils or 1/2 inch on lighter textured soils. Often broadcasted and rolled or cultipacked to press seed into surface soil. Supplemental mulch improves stand establishment. Seeding 50 to 150 PLS per square foot (about 1 to 3 pounds PLS per acre) will produce an adequate nucleus for full stands within 2 or 3 years on subhumid rangelands (3); as much as 8 pounds of quality seed per acre are used for pastures in the Northeastern States; 1 to 2 pounds of quality seed per 1,000 square feet are recommended for lawns (4). Heavier rates needed for erosive soil and steeper slopes, especially south and west exposures: 5 pounds PLS per acre adequate with good management. Early fall (August to September) for humid lowland elevations; early spring, especially when a legume is included in mixture; or late fall (October to November) for mountain elevations are preferred dates for seeding Kentucky bluegrass or mixtures containing it (4). Species now commonly seeded for amenity grassland purposes.

#### Seed Cleaning and Quality

Harvested either by swathing before combining, combining the standing crop directly, or by using strippers. Seed processed by rubbing equipment to remove the hairy web. Clean defuzzed seed in fanning mill using 26 x 26-mesh top screen and 6 x 40-mesh bottom screen. Seed quality: 90 percent purity; 80 percent germination; 72 percent PLS; and 2,156,000 to 2,200,000 seed per pound.

## Germination and Seedling Characteristics

Seed germinates in 28 days in laboratory tests. Weak seedling vigor. Stands develop slowly even with considerable care. Stands seldom fully developed before third growing season. Consider sod transplanting where early cover needed.

## MANAGEMENT

Species naturalized in cooler, moist sites across the country. Seldom seeded in West due to low yield and natural invasion into overused and disturbed pastures. Useful for amenity grasslands or landscaping around industrial sites; also used or naturalized in mountain, northern Great Plains, and cornbelt waterways. Control weeds especially during seedling year. Planting with legume improves production and quality of forage. Liming required on acid soils; nitrogen fertilization needed at least annually when grown without legume; use soil test information to determine other deficient nutrients that need to be included in fertilizer program. Graze continuously at moderate intensity or rotate grazing with periodic resting during growing season to leave 2 to 3-inch stubble. Mowing or grazing to a 1 to 3-inch stubble is essential for maintaining clover in seeding mixtures (5). A fertilization program is needed for good forage production and where quality and esthetic turf is desired.

## ASSOCIATED SPECIES

Most commonly associated with white clover (*Trifolium repens*), red top (*Agrostis alba*), Canada bluegrass (*Poa compressa*), timothy (*Phleum pratense*), tall fescue (*Festuca arundinacea*), and a host of weeds in naturalized stands. Commonly seeded alone or in mixtures with bentgrasses (*Agrostis* spp.) and clovers (*Trifolium* spp.) in amenity grasslands and for landscaping or soil stabilizing turf.

## PESTS AND DISEASES

Stand, quality of turf, and forage affected by white grub larvae of May and green June beetles, sod webworms, leafhoppers, moles, and gophers. Leaf and stem rusts, powdery mildew, and other fungal and bacterial diseases affect seed crop in northwestern States (5). Infectious turfgrass diseases, including seedling blight, melting-out, fading-out, brown patch, dollar spot, snow mold, and fairy ring, cause extensive damage to lawns and golf courses.

## IMPROVED VARIETIES

There were 33 strains or cultivars in 1972 National listing. Consult with State or local plant materials specialists for varieties best adapted to specific sites and purposes.

Canada bluegrass  
*Poa compressa*

Introduced from Eurasia and naturalized in disturbed places in Kentucky bluegrass range; has distinctly flat stems, short blue-green leaves, shorter condensed panicles, and mostly nonwebbed lemmas. Grows in more open, bunchy sods; tolerates moderately acid, infertile, drouthy, thin-soil sites in over 15 inches MAP in northern and western mountain areas. Sometimes used for low maintenance landscaping, stabilization of disturbed land surfaces, and in pasture mixtures on poorer sites not suited to higher producing tame pasture species. Used some in Ohio and Illinois coal districts for reclamation of coal minesoils. 'Rubens' listed as a superior cultivar (6).

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Figure 28. Kentucky bluegrass (*Poa pratensis*). Plant x 1/2; spikelet x 10.

## SANDBERG BLUEGRASS

*Poa secunda* Presl. (6)

### ORIGIN

Native to western U.S. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Short, cool season bunchgrass of C-3 type.

Small and densely tufted; culms 8 to 16 inches tall, typically under 12 inches tall. Leaves short and mostly basal; blades folded or involute and soft with boat-shaped tips. Basal leaves typically turning brown and disappearing after plants headed. Ligule membranous, long-pointed, about 1/8-inch long. Panicles yellowish, short, narrow-contracted with cylindrical spikelets, two to six-flowered and often purple-tinged. Glumes short, pointed and hyaline-margined; lemmas containing seeds terete in cross section, rounded and puberulent below, weakly keeled above and not webbed (1).

Shallow or sometimes deep, finely branched, fibrous root system. Growth starts in early spring ahead of native cool season species; matures in early summer or later at high mountain elevations; becomes dormant in summer and renews growth with fall rains. Low volume forage and seed producer; makes poor volume of summer regrowth and fair volume in fall. Good palatability to livestock while green, moderately used by elk and deer (2).

### ECOLOGICAL RELATIONSHIPS

Adapted to all soil textures; well adapted and often a dominant or primary native in shallow, rocky, and droughty soils, such as the scabrock sites of interior Pacific Northwest, where early maturity and shallow root systems are competitively advantageous. Intolerant of prolonged flooding and high water tables but occurs on imperfectly drained sites where surface soils are saturated briefly in spring. Adapted to weakly acid, alkaline, and saline soils. Species occurs spottedly from low altitude cold deserts and plains to alpine elevations. Local sources of native seed cold-tolerant and winter-hardy; avoid using seed from habitats differing greatly from seeding sites. Moderately shade tolerant and fire-tolerant when dormant. Good grazing tolerance due to short growth form and early maturity; behaves as an increaser on most rangelands and may dominate overgrazed sagebrush-grass and Palouse prairie communities. Seedlings weakly competitive but plants compatible and competitive when fully established. Often self-seeding and filling in bare spaces in bunchgrass stands and suppressing weedy cheatgrass invasion (3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed on well-prepared and firmed seedbeds at 1/4 to 1/2 inch depths. Drill 30 to 40 PLS per square foot for rangeland purposes. Double seeding rate when broadcasting; for harsh, dry, and erosive sites; and for higher density cover. Seed areas before the 2-month period most favorable for rapid germination and seedling growth. Late fall suggested for Pacific Northwest and Great Basin States.

#### Seed Cleaning and Quality

Seed not available nor grown commercially. Small stands may be harvested with hand or mechanical strippers, threshed, and cleaned in fanning mills. Seed quality: 90 percent purity; 65 percent germination; 59 percent PLS; and 925,000 seed per pound (3).

#### Germination and Seedling Characteristics

Seeds germinate slowly in 28 days in seed testing. Seedling vigor is weak. Poor stands generally reported.

## MANAGEMENT

Species behaves as an increaser except on scabrock sites; moderate grazing advocated to prevent its increase with resultant lowered production. Species rarely used as a noncompetitive, early cool season element in other mixtures or for reestablishing natives on former habitats. Species greens up before most native species and retards runoff during snowmelt, runoff period. May have place as low maintenance turf in northern Great Plains and Rocky Mountain foothills and interior valleys. New seedings require weed control and protection from grazing. Management of established stands should provide for periodic heading and self-seeding (5).

## ASSOCIATED SPECIES

Commonly a secondary species growing mixed with Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*), wheatgrasses (*Agropyron* spp.), big sagebrush (*Artemisia tridentata*), cheatgrass brome (*Bromus tectorum*), blue grama (*Bouteloua gracilis*), antelope bitterbrush (*Purshia tridentata*), and arrowleaf balsamroot (*Balsamorhiza sagittata*), and a variety of other grasses, forbs, and shrubs. Rarely seeded in mixtures with other cool season plants as an early seasonal, undercover, and/or hole-filling element.

## PESTS AND DISEASES

No serious pests recorded. Slow germination and stand development might be affected by seed and seedling molds, rots, and blight organisms.

## IMPROVED VARIETIES

None.

Canby bluegrass  
*Poa canbyi* (Scribn.) Howell

Canby bluegrass is similar to Sandberg bluegrass but is taller, more vigorous, longer leaved, later maturing, and more productive. Occurs intermixed with Sandberg bluegrass on more favorable sites in the Northern Great Plains, Rocky Mountains, and northern Intermountain and Pacific Northwest regions. At least one strain, P-851, grown for seed production and used to limited extent. Low seed yields, limited seed availability, and uncertain seeding success have made these two species of secondary importance, although Canby is distinctly superior to Sandberg bluegrass in production.

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Figure 29. Sandberg bluegrass (*Poa secunda*). Plant x 1; spikelet, floret x 4.

## YELLOW INDIANGRASS

*Sorghastrum nutans* (L.) Nash

### ORIGIN

Native to the Great Plains and eastern U.S. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Showy, warm season, bunching sod-former of the C-4 type.

Culms 3 to 5 feet tall or taller from leafy clumps, with hairy nodes and short scaly rhizomes. Leaf blades wide, flat, sometimes weakly hairy, up to 2 feet long, with prominent, rigid membranous ligules edged by teethlike vertical auricles. Inflorescence a golden bronze or yellow panicle, moderately dense, 6 to 12 inches long. Spikelets paired on ends of ascending branchlets, grey-hairy; perfect spikelet bearing fertile floret with twisted awn, sterile spikelet reduced to a fuzzy pedicel (1).

Growth resumes in mid to late spring and matures in late summer or fall; earlier than big bluestem (*Andropogon gerardii*). Good amount of summer regrowth with available moisture but little regrowth after frost. Relished by livestock in summer, only fair palatability after maturity. Grass clumps provide cover for some bird and mammal species (1).

### ECOLOGICAL CHARACTERISTICS

Thrives on deep, moist soils varying from heavy clays to coarse sands. Tolerant of moderate soil salinity and moderate acidity, as low as a pH of 4.5. Tolerant of brief or periodic flooding, water tables in second foot of soil, and imperfect drainage. Only fair drought tolerance. Good winter-hardiness of native seedstocks and of improved strains derived from such. Species occurs from near sea level to about 7,000 feet in elevation in Southwestern mountains. Avoid using seed grown in habitats differing greatly from seeding site. Moderately shade-tolerant; often found only in brushy thickets in South due to high palatability and shade tolerance. Strongly fire-tolerant; spring burning revitalizes stagnant stands having accumulations of unused herbage and litter. Fair to weakly moderate grazing tolerance to close summer grazing; tolerant of winter grazing. Species behaves as a decreaser in grasslands and is often replaced by less palatable species under prolonged close use of native and seeded mixed populations. Good responder to irrigation and fertilization, suitable for use in intensive tame pasture programs. Compatible with tall, palatable warm season grasses and adapted persistent legumes (2).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed between 1/4 and 3/4 inch deep in a firm seedbed; use former depth in moist, fine-textured soils, the latter depth with drier, looser, and coarser soil conditions. Cover broadcast seedings to similar depths with soil. Drilling directly into previous year's nonvolunteering crop stubble aids stand establishment on soils which crust and in wind erosion areas. Supplemental mulch may be needed on steep, erosive slopes and for disturbed lands. Seed mulch may be needed on steep, erosive slopes and for disturbed lands. Seed prior to the 2-month period having surface soil moisture and temperatures most favorable for germination and seedling establishment. Commonly used dates are January to April in southern Great Plains and April to May in the northern Great Plains. Irrigated plantings may be made in spring and as late in summer as seed can germinate and become established well enough to overwinter. Legume and grass seeding mixtures should be made at optimum time for seeding legumes. Exception occurs when legumes are seeded separately and usually first in an earlier season. The seed-hay method of seeding also may be used on badly eroded lands and in gullies. Sprigging of sod pieces also is possible in these situations (3).

#### Seed Cleaning and Quality

Seed can be combined directly if proper adjustments in threshing equipment are made. Seed shatters

readily and binding when the seed is in the hard dough stage is another alternative. Process harvested material in a hammermill and reclean it in a fanning mill for ease in drilling and for commercial purposes. Unprocessed seed is difficult to drill except with drills equipped to handle chaffy seed. Seed quality: 70 percent purity; 60 percent germination; 42 percent PLS; and 170,000 pure seed per pound.

### Germination and Seedling Characteristics

Seed germinate in 28 days after a prechilling treatment in standardized seed testing. Seedlings have good vigor and are superior to big and little bluestem. They form stands rather quickly, usually by the second season and sometimes by end of first season under best conditions or with irrigation.

### MANAGEMENT

Native mixed stands of midwestern and southern prairies and savannas, normally containing Indiangrass in secondary amounts, are grazed seasonally or annually or are cut for hay. Management usually is geared to the primary species, more commonly to the bluestem grasses (*Andropogon* spp.). Refer to the management discussion for big bluestem (*Andropogon gerardii*). Species sometimes is seeded in pure stands for pasture or hay, but more commonly is seeded in mixtures with bluestems and switchgrass (*Panicum virgatum*) for the same and/or watershed protection purposes; may be further mixed with partridge pea (*Cassia fasciculata*), other legumes, and showy forbs to simulate native prairie composition and for esthetics. Competitive weeds need control in seedling stands; controlled grazing an acceptable method in Kansas tests. Management must provide periodic rests from grazing during the growing season and periodic burning of accumulating litter or mulch to restore vigor and productivity to native and seeded stands. Newer, short duration grazing systems also offer promise in improving cover and productivity. Species is well suited for use with seeded cool season species in separate pastures to further extend and improve production where there is a potentially longer growing season (3,4,5).

### ASSOCIATED SPECIES

Commonly associated with big bluestem, little bluestem (*Schizachyrium scoparium*), and switchgrass in midwestern prairies. Also often seeded with these associates somewhat in proportion to their composition in original vegetation on various adapted range sites. Legumes may be added to help maintain higher soil fertility and dietary protein. Desirable to plant grasses and legumes in alternate rows to minimize competitive effects.

### IMPROVED VARIETIES

'Cheyenne' is recommended for parts of the Texas Panhandle and adjoining States. 'Holt', a fine-leafy type, is adapted to portions of western South Dakota and Nebraska and to parts of eastern Wyoming and Colorado. 'Llano', developed from a northeastern New Mexico collection, is recommended for portions of eastern New Mexico, the panhandle of Texas, and adjacent Oklahoma, southwestern Kansas, and southeastern Colorado. 'Nebraska 54' is recommended for portions of northeastern Kansas and eastern Nebraska. 'Osage' is a southern type from Kansas adapted for use in parts of central Kansas, western Oklahoma, Central Rolling Red Plains of Texas, and eastward. 'Oto', a release from Nebraska, is adapted to southwestern Nebraska and adjacent portions of Kansas and Nebraska. 'Tejas' is recommended for parts of the Central Rolling Red Plains, Edwards Plateau, and Southern High Plains of Texas (6).

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Figure 30. Yellow Indiangrass (*Sorghastrum nutans*). Plant x 1/2; spikelet x 5. (Spikelet after A. S. Hitchcock 1950.)

## ALKALI SACATON

*Sporobolus airoides* (Torr.) Torr.

### ORIGIN

Native to the western United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Stout, coarse-leaved, warm season bunchgrass of the C-4 type.

Robust with culms 1 to 3 feet tall growing from large-diameter clumps or tussocks; forming an open, hummocky sod but lacking true rhizomes. Bases surrounded by slick, shiny, cream-colored sheaths. Leaf-sheaths hairy at the summit; leaf blades extended, flat at base, and involute toward tips; with a hairy fringed ligule. Flowering branches forming an open panicle, broadly conical or pyramidal, up to 18 inches long but often shorter, and with lower branches appressed toward axis by upper sheath. Spikelets one-flowered, minute, and unawned (1).

Deep, densely fibrous root system resistant to erosion. Growth starts mid to late spring or after summer rains in the Southwest and matures from summer until fall. Fair regrowth is made with available moisture until killing frosts, especially after sites are flooded in Southwest. Medium palatability to livestock when green and fair palatability after curing in winter. Provides cover and food for birds, including waterfowl, and small mammals (1).

### ECOLOGICAL RELATIONSHIPS

Thrives on deep, moist, or subirrigated sandy to clayey textured soils in the 12 to 18 inches MAP zones. Performs well in the 8 to 12 inches MAP zone or with less precipitation on lowland sites which are occasionally flooded or receive subirrigation. Tolerant of saline, saline-sodic, and nonsaline-sodic ("alkali") soils. Maintains excellent sods on very salty soils with only two irrigations per year in Idaho. Tolerant of poor drainage, frequent flooding, shallow water tables, and moderate silt accumulations. Moderately drought-tolerant; drought reduces cover and yield but seldom kills entire turfs. Only fair shade tolerance; occasionally found under protective cover of shrubs. Moderate fire tolerance and can be burned for more uniform grazing when in dormant state. Good grazing tolerance; close use affects vigor and production. Responds well to irrigation, particularly useful in stand establishment and economic seed production. Fair compatibility in seedings with native associates of similar palatability (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed at 1/4 inch depth. Cover broadcasted seed to similar depth or cultipack to cover. Drill a minimum of 40 to 50 PLS per square foot (about 1/5 pounds PLS per acre) for rangeland pastures. Increase rate 50 to 100 percent when broadcasting and for dry, south and west exposures, and erosive sites; for hay crops; or for denser cover for conservation plantings, including disturbed land and surface mined soil stabilization. Plant seed when soil temperatures average 80-90°F and there is maximum chance for effective precipitation within 15 days. Can irrigate site first, then plant, cover site with 1/2 inch of mulch, preferably vermiculite or perlite, and irrigate every 5-day period lacking available moisture until seedlings are established in mine-land reclamation in the Southwest (4). Where uneconomical to irrigate for rangeland seedings, seeding into pits, basins, or furrows that concentrate moisture may result in better stand establishment.

#### Seed Cleaning and Quality

Seed is produced intermittently and matures irregularly within seedhead and in the field. Harvest seed by combining directly or thresh seedbearing hay. Fine, clean seed results and no further cleaning should be necessary. Seed quality (not well standardized): 85 percent purity; 80 percent germination; 68 percent PLS; 1,750,000 seed per pound; and about 1,200,000 pure, live seed per pound.

## Germination and Seedling Characteristics

Most seed germinate rapidly in 5 to 10 days under ideal conditions, but considerable dormancy results in some later germination. Seeds germinate well at constant or alternating 80-90° F temperatures. Seedling vigor is fair overall but could rate good compared to blue grama (*Bouteloua gracilis*). Stands may develop fully by end of second season under favorable conditions, more commonly not until third or later years (5).

## MANAGEMENT

Native stands are grazed seasonally or yearlong with supplements in winter and are cut for hay and the aftermath grazed. Species infrequently may be seeded in mixtures with western wheatgrass (*Agropyron smithii*) and switchgrass (*Panicum virgatum*) on saline subirrigated sites in the Great Plains for pasture and/or hay. Used alone or in native mixtures to stabilize disturbed lands, especially in Arizona and New Mexico. Competitive weed infestations may require control in seedling stands. Grazing should be withheld during seedling establishment. Mature stands are optimally grazed in late spring and summer for economic meat production. Rotation grazing with periodic deferments during the growing season and leaving a 4-inch minimum stubble at all times is advocated. Flood irrigation where feasible is best insurance against feed shortages. Improved seedings are managed better when fenced separate from other units. Hay needs to be cut in early heading stage to make fair quality hay. Usually essential to drag meadows annually to level manure and dirt mounds which accumulate in grass bunches and interfere with mowing and irrigation.

## ASSOCIATED SPECIES

Species occurs in saline bottomlands growing with inland saltgrass (*Distichlis spicata stricta*), western wheatgrass, fourwing saltbush (*Atriplex canescens*), and black greasewood (*Sarcobatus vermiculatus*). Infrequently seeded alone or in adapted grass mixtures on saline subirrigated or overflow range sites. Necessity of revegetating disturbed lands to native species has resulted in its use for these purposes, most commonly mixed with galleta (*Hilaria jamesii*), Indian ricegrass (*Oryzopsis hymenoides*), and fourwing saltbush.

## PESTS AND DISEASES

Grasshoppers, rabbits, and rodents affect both stands and forage crop. Ants tunnel in bunches and build mounds that are enlarged by silt deposits, creating characteristic hummocky microtopography.

## IMPROVED VARIETIES

None recognized Nationally. 'Willcox' is a leafy selection being increased for seeding in southern Arizona. P-15616, selected for shallow uplands, is being tested in New Mexico; PM-ND-264, from saline bottomlands in North Dakota, is being field tested.

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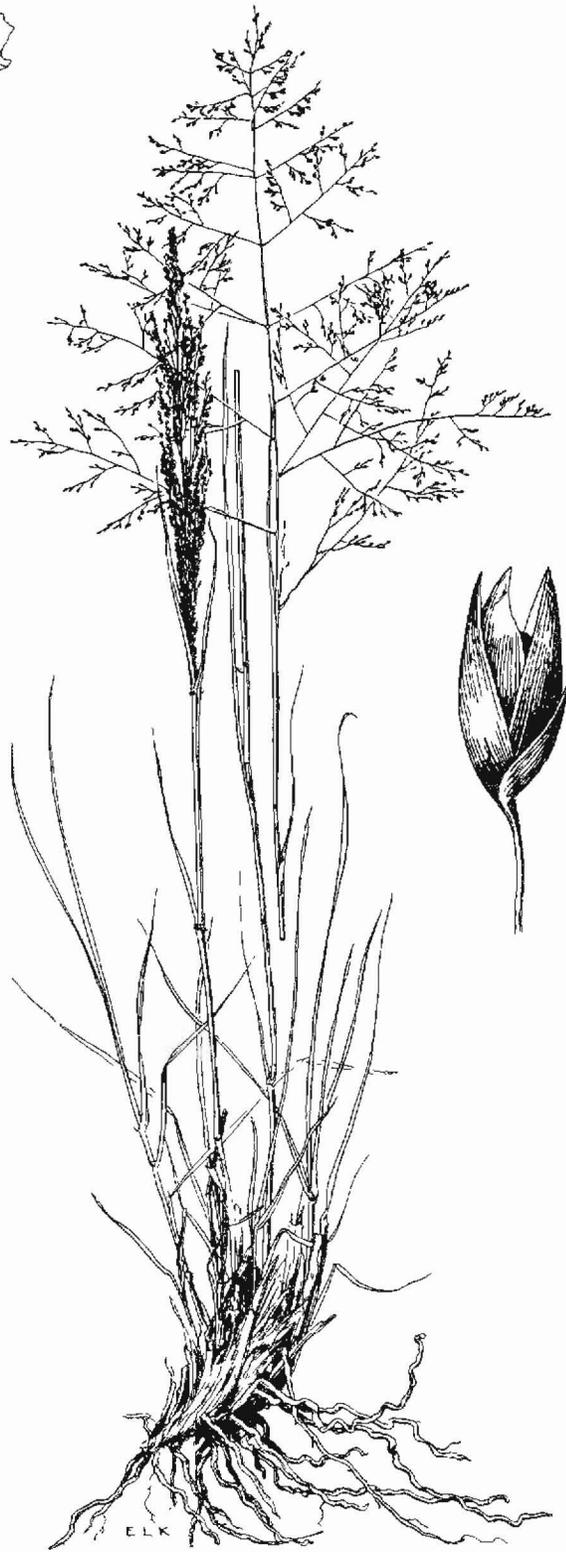


Figure 31. Alkali sacaton (*Sporobolus airoides*). Plant x 1/3; spikelet x 15.

## GREEN NEEDLEGRASS

*Stipa viridula* Trin.

### ORIGIN

Native of northern Great Plains and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Moderately tall, cool season, long-lived, perennial bunchgrass of the C-3 type.

Densely tufted. Erect culms 1 1/2 to 3 1/2 feet tall with abundant, glossy, bright-green, basal leaves. Blades flat or inrolled, 4 to 12 inches long, tapering to threadlike tips. Ligule short membranous, collarlike. Distinctive tufts of hairs at summit of sheath. Narrow, contracted panicle type of inflorescence 4 to 8 inches long. Spikelets one-flowered. Large papery glumes; soft, hairy lemma enfolding fusiform grain tipped with a bent, twisted awn about 1 inch long (1).

Has deep, extensive, fibrous root system. Starts growth in March, makes most of vegetative growth in May and June, heads in June, and matures in July. Makes good regrowth summerlong with adequate moisture; fair fall regrowth. Moderately palatable to cattle yearlong, more so when green (2).

### ECOLOGICAL RELATIONSHIPS

Thrives on clayey soils and fractured shale of bottomlands, flats, and benches. Less common on loams and sandy soils, but also thrives as pioneer successional plant on abandoned cropland and on coarser textured, disturbed soils. Grows as native on overflow, silty, and clayey sites. Moderately tolerant of flooding and short term submergence; better performance with water table a few feet below surface. Optimal growth in 12 to 20 inches MAP zone but occurs in 12 to 30 inches zones. Good drought resistance; less than blue grama (*Bouteloua gracilis*), nearly equal to western wheatgrass (*Agropyron smithii*). Thrives on moderately alkaline soils derived from calcareous shales; weakly to moderately tolerant of soil salinity. Only weak tolerance to shade of scattered shrubs and openings in woodlands. Extremely winter hardy. Occurs at elevations to 9,000 feet in Rocky Mountains. Variably tolerant of fire in dormant state, especially with a damp soil. Moderately grazing-resistant but vulnerable to intense early spring grazing or close mowing. Compatible with other cool season species when seeded in mixtures (3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill at 1 inch depth on loam; shallower depth on clayey soils and deeper on sandy soils; but not over 1 1/2 inches deep. Plant 5 PLS pounds per acre to obtain one or two plants per square foot, a satisfactory stand for rangeland purposes. Increase rate up to 100 percent for broadcasting and for erosive and harsh sites, including drier south and west exposures. No difference in productivity observed at Mandan, ND at end of fifth season from seeding 4 to 12 pounds per acre of quality seed, but heaviest rate more productive first 3 years (5). Plant fresh seed in late fall to help break dormancy; otherwise, 2 to 5-year old seed or low dormancy strains may be seeded in early spring. Best seeding dates at Mandan were September to October; late summer or early fall advocated on summer fallowed land in South Dakota. Good to excellent stands reported from September seedings on surface disturbed soils in the Piceance Basin in western Colorado (6).

#### Seed Cleaning and Quality

Seed matures irregularly and shatters quickly. Harvest with a binder and thresh after thoroughly dried. May also be harvested with a swather and combined or combined directly. Hammermill seed to remove awns and fuzz. Clean to commercial quality in a fanning mill. Attempt to remove yellow-green seed and retain mature gray seed which has greater potential germination (6). Seed quality: 90-95 percent purity, 25 percent germination; 22-24 percent PLS; 181,000 pure seed per pound.

### Germination and Seedling Characteristics

Germinates slowly in 21 days in official seed testing after prechilling in KNO<sub>3</sub> substrate. Optimum germination at constant 68°F or alternating 68°-55°F temperatures (7). Good seedling vigor but slow to develop full stands, often not until third growing season.

### MANAGEMENT

Green needlegrass used for seeding rangelands, pastures, hay, and to stabilize erosive sandy to clayey soils in northern Great Plains. Seeds are eaten by small mammals and songbirds. One of few native cool season species with wide range of soil adaptations; especially tolerant of dense clays. More commonly seeded in mixtures with western wheatgrass and/or other cool season grasses or legumes because it tends to thin out with time in pure stands. Control weeds, especially first 30 to 60 days after seedlings emerge; withhold grazing first season. Graze stands moderately, resting a different unit each year for 2 months during growing season. Where warm season grass pastures or rangelands exist, graze seeded stands spring and fall or in winter in complementary plan.

### ASSOCIATED SPECIES

Most commonly associated with western wheatgrass in native stands; occurs less commonly with silver sagebrush (*Artemisia cana*), blue grama, and needle-and-thread (*Stipa comata*). Seeded in mixtures with western wheatgrass or with desert wheatgrass (*A. desertorum*), intermediate wheatgrass (*A. intermedium*), and pubescent wheatgrass (*A. trichophorum*), with or without legumes, such as alfalfa (*Medicago sativa*) or yellow sweetclover (*Melilotus officinalis*).

### PESTS AND DISEASES

Grasshopper resistant. No major diseases; occasionally leaf-rust infested.

### IMPROVED VARIETIES

'Green stipagrass', superior to common green needlegrass in forage and seed production, seedling vigor, and regrowth ability. 'Lodorm', green needlegrass, is a selection for low seed dormancy. Both are adapted to same area as the species (8). Sleepygrass (*Stipa robusta*), closely related unpalatable species, naturally occurs on disturbed sites in the Southwest and may be useful on such sites, particularly on those subject to intense grazing.

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Figure 32. Green needlegrass (*Stipa viridula*). Plant x 1/2; glumes, floret x 2.

# COMMON YARROW

*Achillea millefolium* L.

## ORIGIN

Native of Eurasia; widely escaped throughout much of U.S. See map for distribution in the U.S.

## SPECIES CHARACTERISTICS

Herbaceous, cool season, perennial forb.

Stems aromatic, hairy, 1 to 3 feet tall with shallow, fibrous roots and extensive, slender rhizomes. Sometimes turf-forming. Basal leaves in rosettes before stems elongate. Leaves alternate, lanceolate in outline, finely dissected into narrow ovate to linear divisions, grey-green to green, and variably hairy. Inflorescence a flat to round-topped panicle with numerous, small composite-type flowerheads, each subtended by several rows of bracts. Outer flowers of heads white, radiating, and strap-shaped; inner disk flowers tubular and whitish; both bear tiny oblong, flat, white or gray achenes (1).

Plants have offensive odor and bitter taste. Growth resumes in early spring or later at higher latitudes and altitudes; flowering occurs from late spring or later throughout most of the summer; seeds mature during summer and fall, some not maturing regularly in subalpine and alpine areas. Fair palatability to sheep; usually poor palatability to cattle but occasionally better; some use made by game birds, rabbits, small mammals, deer, and bighorn sheep (1,2).

## ECOLOGICAL RELATIONSHIPS

Thrives in loamy soils of moist sites, especially in cool temperate climates, from prairie and plains to high mountain elevations. Weedy and rapidly occupying open and disturbed communities in lawns, roadsides, drainages, and gullies. Fair tolerance to sites having imperfect drainage and subjected to infrequent flooding. More abundant and vigorous in over 18 inches MAP zones but growing in moisture accumulating or disturbed sites with considerably less. Weakly moderate drought tolerance, persisting by rhizomes and seed. Tolerant of weakly basic to weakly acidic soils, adapting to somewhat greater extremes, and to some salinity. Strongly moderate tolerance to shade; thrives in fairly dense aspen groves. Good winter-hardiness, but avoid planting material from habitats differing much from seeding environment. Good fire tolerance in dormant state. Good tolerance to grazing; generally thrives when associated species are overgrazed. Not very compatible in seeding mixtures; less palatable and more aggressive than most associates. Strongly competitive when established (2,3).

## CULTURE

### Planting Depth, Rate, and Time

Drill about 1/4 inch deep or broadcast and cover to similar depth with soil or cultipack. Drill 40 to 60 PLS per square foot (1/2 pounds PLS per acre) for pure stands under ideal moisture and soil conditions; double the rate when broadcasting and for harsh, erosive, and south- or west-facing sites. Reduce rate to proportion desired in mixtures. Seed at optimum date for primary species when in mixtures; preferably before the moistest growing season; usually early spring, late summer, or late fall. Species can be transplanted by sodpieces for critical area stabilization, such as gullies.

### Seed Cleaning and Quality

Hand collect heads, dry, and fan material. No seed quality standards exist. Acceptable purity 50 percent, germination 80 percent (up to 98 percent with alternate wetting and drying), PLS 40 percent, and 4,124,000 seed per pound (4).

### Germination and Seedling Characteristics

Satisfactory germination occurs with continuous exposure to moisture at 72° F to 84° F. Most germination occurs in 2 to 8 days. Benefit of moist prechilling questionable due to conflicting evidence. Vigor of seedlings rated good in intermountain region; 2 or 3 years needed for plants to flower and reproduce (5).

### MANAGEMENT

Considered to have high potential for alpine and subalpine revegetation and for stabilization and beautification of roadsides and critical sites; moderate potential for use in revegetation in coal mined lands and stabilization of heavy use areas in western Colorado and adjacent intermountain sites. Species rarely used except experimentally. Might be used advantageously for stabilizing disturbed lands because yarrow naturally invades and revegetates such areas. Species useful for game birds, rabbits, small mammals, and big game. New seedlings may need some weed control and protection from trampling during establishment. After establishment, moderately heavy grazing or defoliation of associates at times which tend to suppress their spread should aid yarrow vigor, esthetics, and stand-persistence.

### ASSOCIATED SPECIES

Host of weedy and successional species occur with yarrow, like common dandelion (*Taraxacum officinale*) and cinquefoils (*Potentilla* spp.). Western yarrow (*A. millefolium lanulosa*) commonly associated with the perennial weed stage of retrogressive plant succession on western mountain rangelands. Sparse plants also occur intermixed in good condition rangelands, hence presence of the species is not always a reliable indicator of a disturbed environment.

### PESTS AND DISEASES

No serious pest or disease problems documented. Mild infections by rusts, root and stem rots, root knot nematodes, and powdery mildew noted. Sometimes a host to pale bastard toadflax (*Commandra pallida*) (6).

### IMPROVED VARIETIES

None.

Western yarrow

*Achillea millefolium lanulosa* (Nutt.) Piper

Very similar to common yarrow but having linear leaf segments and densely hairy leaves and stems. A native plant not so commonly found in lawns, around buildings, and in fields. Western yarrow, rather than common yarrow, occurs as a weedy component of western rangelands. Many authors consider both yarrows to be one species. Strains of the latter subspecies should be tested for western land reclamation. *A. m. roseum* may have a place in beautification projects where adapted.

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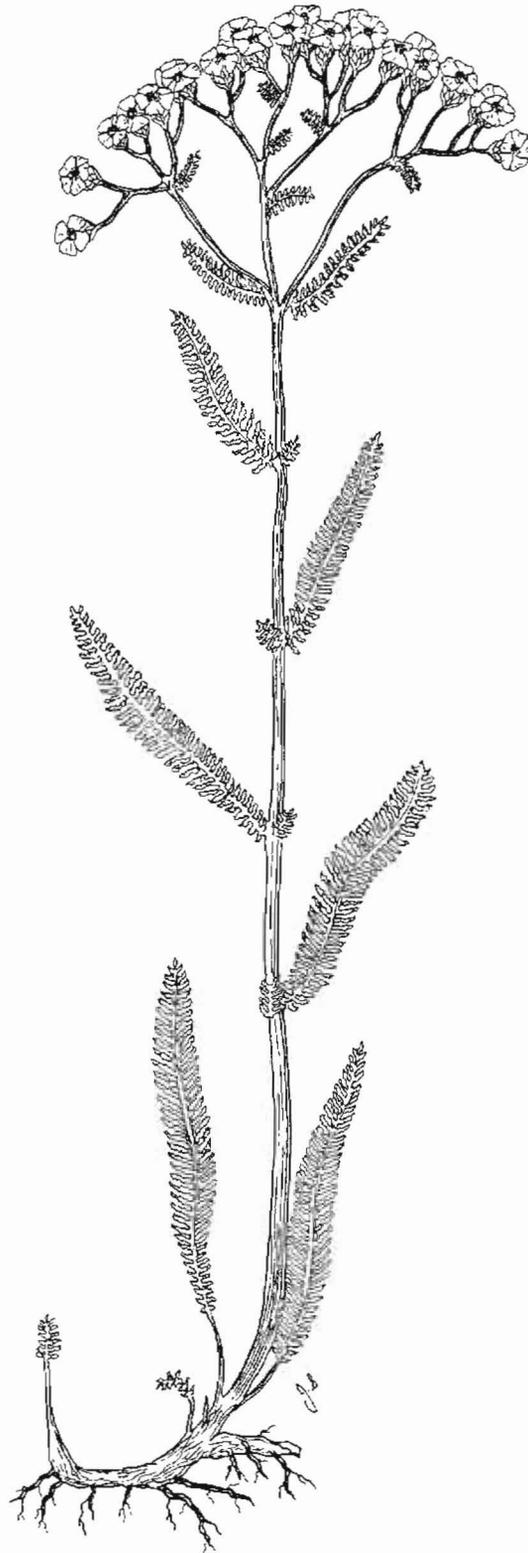


Figure 33. Common yarrow (*Achillea millefolium*). Plant x3/5; leaf closeup x1; flowerhead x2. (Flowerhead and leaf after C. L. Hitchcock et al. 1969.)

## CICER MILKVETCH

*Astragalus cicer* L.

### ORIGIN

Native to Eurasia where it grows in moist grasslands, open woodlands, flooded drainages, and meadows. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Spreading, warm season, herbaceous, leguminous perennial forb.

Stems of large diameter, succulent, decumbent, usually less than 3 feet tall, and spreading up to 10 feet with vigorous, creeping rhizomes and a short tap root. Leaves 4 to 8 inches long, odd-pinnate, with 21 to 27 light green leaflets, about 1 to 2 inches long, and sparsely hairy. Inflorescence a contracted raceme with 15 to 60 pealike pale yellow to white flowers which mature into inflated, bladder-shaped, leathery, hairy reddish-green to green pods, turning black at maturity and containing numerous seeds that detach and rattle inside pods. Seeds bright yellow to pale green, flattened, and egg-shaped (1).

Growth resumes about 2 weeks later in spring and matures about 2 weeks later in summer than alfalfa. Good summer regrowth potential and fair amount of regrowth in fall with available moisture. Palatable to livestock, elk, deer, and antelope; somewhat less palatable than alfalfa but nonbloating and nontoxic. May form nearly total cover from underground rhizomes and foliar spread under favorable conditions. Disintegrates to little or no cover in winter (2).

### ECOLOGICAL RELATIONSHIPS

Well adapted to all soil textures from clays to sands but best performance on loams and sandy loams and on soil derived from limestone. Better performance than alfalfa on thin foothill soils and on wet and higher altitude sites. Tolerant of soils ranging from weakly acidic to strongly alkaline in reaction; also tolerant of moderate soil salinity. Some stand establishment reported in wet site with pH of 9.8. Performs satisfactorily on poor, infertile soils, such as critically disturbed sites. Optimum performance with moisture equivalent to 18 to over 20 inches MAP. Tolerant of subirrigation with water tables within 3 feet of surface. Established stands show good drought tolerance but seedlings are more sensitive. Satisfactory stands generally obtained with over 14 inches MAP in cooler climates and more favorable sites. Good winter hardiness; species thrives at higher altitudes with less than 30 frostfree days; can be used to replace alfalfa in high elevation meadows. Generally grown in Rocky Mountains between 2,000 and 8,000 feet in elevation; only recommended above 4,000 feet in Pacific Northwest and Great Basin States. Good performance in association with shrubs; more useful in mountain shrub zone but seeded from upper sagebrush zone into openings in aspen and subalpine forests. Succulence and rhizomes suggest fire resistance when green and tolerance when dormant. Well established stands strongly competitive and only compatible with certain specific grasses (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 to 3/4 inch deep in a well prepared, firm seedbed. Use 8 pounds PLS per acre for drill seedings, 5 pounds PLS per acre for mixtures with grass, and 3.0 to 3.5 pounds per acre in wide rows for seed production. Double the rate for critical area stabilization and for harsh and south- and west-facing sites, especially when seeding at other than optimum time. Double the solid seeding rate when broadcasting and double it again on critical sites. Critical sites need to receive over 15 inches MAP or light irrigations for satisfactory stand establishment. Plant prior to the moistest growing season, usually during April or May; can plant later with irrigation (2).

### Seed Cleaning and Quality

Seed crops mature in late summer or early fall at lower elevations of the Rocky Mountains. Seed is retained well in the pods for several weeks after maturity. Windrow the seed crop and allow it to dry until pods are brittle; defer threshing until pods dry during the day. Rethreshing tailings increases seed recovery. Seed quality: 95 percent purity; germination, 20 percent unscarified, 50 percent scarified (excluding hard seed), and 75 percent including hard seed; PLS, 19 percent unscarified, 43 percent scarified, and 71 percent with hard seed; and 130,000 seed per pound. Scarify seed in mechanical huller or scarifier several times just before planting, until 30 to 50 percent of seeds swell to double-size in 24 hours in water or test about 57 percent germination in standard germination test. Scarified seeds lose viability quickly in storage. Inoculate seed with specific inoculum just before seeding to induce N-fixation (4,5).

### Germination and Seedling Characteristics

Seed emerges in field in 10 to 14 days under favorable conditions. Majority are hard seeds impermeable to water unless scarified. Seedling vigor rates good with irrigation but only fair under dryland conditions due to slow rate of growth. Irrigated stands make a short hay crop first season and may attain full stand by end of second year; dryland seedings may take 3 years to develop full stands (2,4).

### MANAGEMENT

Currently used to limited extent due to seed shortages and special seed treatment required. Species recommended for high elevation meadows, irrigated pastures at lower elevations, and dryland areas receiving 16 inches MAP. Recommended for use in grass mixtures for stabilizing critical areas (pond or canal banks, spillways, road cuts and fills, mine spoils) and as erosion control cover crop in orchards, windbreaks, and stream overflow areas. Well-rated potential for use in restoring big game range in intermountain West. Control weeds and withhold grazing on seedling stands. Allow no grazing on critical stabilization sites. Take only two hay crops for sustained hay production under irrigation. Graze pastures moderately in a rotation plan using crop when 8 to 12 inches tall and leaving about a 4-inch stubble. Fertilize according to soil test (2,4).

### ASSOCIATED SPECIES

Species recommended in grass-legume seedings with grasses about equally competitive and especially with creeping foxtail (*Alopecurus arundinaceus*), smooth brome (*Bromus inermis*), orchardgrass (*Dactylis glomerata*), and tall fescue (*Festuca arundinacea*). Plant grasses and legumes in alternate rows to minimize competition and increase stand longevity. Species composition recommended at 50 percent in such stands.

### PESTS AND DISEASES

Grasshoppers reduce seed crops but do little damage to foliage. Aphids, thrips, seed chalcids, and a seed-eating vetch bruchid reported to occur in plants. Stands and forage crop somewhat affected by root, crown, and stem rots, and a root rot has been noted on the tap roots.

### IMPROVED VARIETIES

'Lutana' was released in Wyoming and Montana in 1970 and has most of the characteristics described above. 'Monarch' was released in 1980 from Colorado and was bred for superior seedling emergence. It is recommended for the same areas in which 'Lutana' is adapted.

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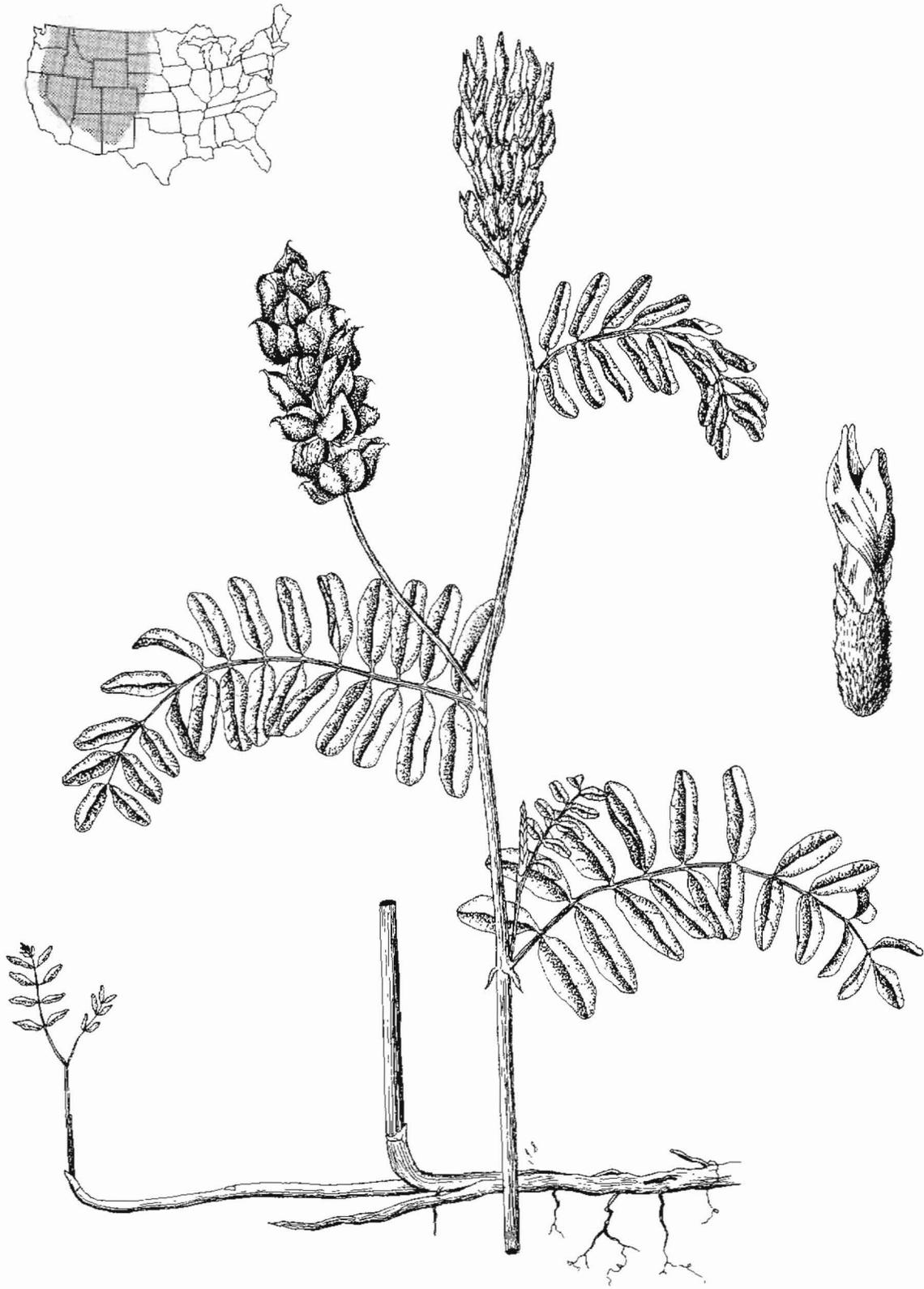


Figure 34. Cicer milkvetch (*Astragalus cicer*). Plant x 1/2; flower x 1. (Flower after Stroh et al. 1972.)

## ARROWLEAF BALSAMROOT

*Balsamorhiza sagittata* (Pursh) Nutt.

### ORIGIN

Native chiefly of the Intermountain West. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, herbaceous, perennial forb.

Leaves mostly basal, large arrowhead shaped or triangular heartshaped, silvery-grey to white woolly pubescent, entire, long stalked up to 1 foot long or longer. Stems scapose, 1 to 2 feet tall, bearing sunflower-like flowerheads singly, having fuzzy basal bracts, yellow strap-shaped ray-flowers 1 to 2 inches long, and yellow tubular disk flowers bearing smooth four-angled and three-angled achene-type seeds, respectively (1).

Thick, resinous, fleshy taproot with turpentinelike odor, moderately deep and resisting trampling. Growth renews very early in spring, flowering from late spring to midsummer, and maturing in early to late summer, varying with regional environmental conditions. Little summer and fall regrowth except when moisture remains abundant. Fair palatability to livestock, especially to sheep, when foliage tender, usually before heading; some acceptance by big game. Very poor herbage acceptance in fall and winter (1).

### ECOLOGICAL RELATIONSHIPS

Thrives in well drained silty and loamy soils of the Palouse prairies and adjacent sagebrush-grass and open juniper and ponderosa pine zones of the northern intermountain region. Tolerant of moderately alkaline to weakly acidic and also weakly saline soils. Intolerant of shallow water tables but tolerant of briefly saturated soil conditions on imperfectly drained soils; e.g., on some deep planosols. Strongly drought-resistant. Thrives in 16 to 20 inches MAP zone; almost equally vigorous in the 10 to 15 inches zones on favorable sites, but usually less abundant. Locally winter hardy, but likely to vary regionally; do not use plant materials from habitats differing much from planned seeding site. Naturally occurs between about 1,000 and 9,000 feet in elevation. Tolerant of semishade of woodlands and shrublands. Moderately compatible with other species and competitive when fully established. Strongly tolerant of grazing. Good fire tolerance when dormant (1,2).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 to 1 inch deep on medium and coarse-textured soils, respectively; vary depths similarly for moist and drier soil conditions, respectively. Drill in either desired or original species composition percentages of a full stand rate of 20 PLS per square foot (10 to 20 percent recommended), using seed subjected to 2 months cold-moist stratification where 3 months continuous snow cover not assured on site after late fall seedings. These stratified seeds can be seeded very early, or as early as possible, in spring (2,3,4).

#### Seed Cleaning and Quality

Harvest seed by hand-collecting heads or using combine where feasible. Withhold stock from collection areas until after seed harvest. Dry heads, mechanically flail or macerate-chop them, and clean material in fanning mill. Seed quality not standardized: 95 percent purity; germination about 4 percent unstratified, 67 percent stratified in gibberellic acid and kinetin, and up to 86 percent after 4 to 12 weeks stratification at 2 to 5°C (3,5).

### Germination and Seedling Characteristics

Germination occurs slowly over an 8 week period. Maximum germination attained by 12 weeks moist prechilling at 0 to 5°C, but temperatures for germination and stratification are same, resulting in some germination during stratification unless seed removed after 8 weeks. Very poor and erratic germination without seed development; dry storage ineffective in breaking dormancy. Seedling vigor rather weak and stands develop slowly.

### MANAGEMENT

Species used in seeding mixtures for game range restoration in Utah. Rated high potential for oil shale restoration, coal mined land revegetation, and roadside and critical site stabilization and beautification; medium potential for revegetation of surface disturbed lands in intermountain region. Showy flower heads add diversity and aesthetics to monotonous landscapes. Management needed to effectively stratify seed; better stands possible by planting balsamroot and other slow developing species in alternate rows with quicker developing or more competitive species. Reduce or withhold stocking and control weeds in seedling stands where feasible, and practice good range management after establishment (6).

### ASSOCIATED SPECIES

Commonly associated in native stands with Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), big sagebrush (*Artemisia tridentata*), western and Utah junipers (*Juniperus occidentalis* and *J. osteosperma*), ponderosa pine (*Pinus ponderosa*), and the mountain shrub complex of the northern intermountain and interior Pacific Northwest regions. Recommended at 1/4 to 1 pound per acre rates in mixtures with native and exotic wheatgrasses, Russian wildrye (*Elymus junceus*), smooth brome (*Bromus inermis*), orchardgrass (*Dactylis glomerata*); alfalfa (*Medicago sativa*) and other forbs; and rabbitbrush (*Chrysothamnus* spp.) and other shrubs for seeding big sagebrush, mountain shrub, and juniper-pinyon type game ranges in Utah.

### PESTS AND DISEASES

Some insect damage reported to seedheads; livestock and big game selectively graze flowerheads before maturity. Heavy insect infestations require control when seed crops affected.

### IMPROVED VARIETIES

None.

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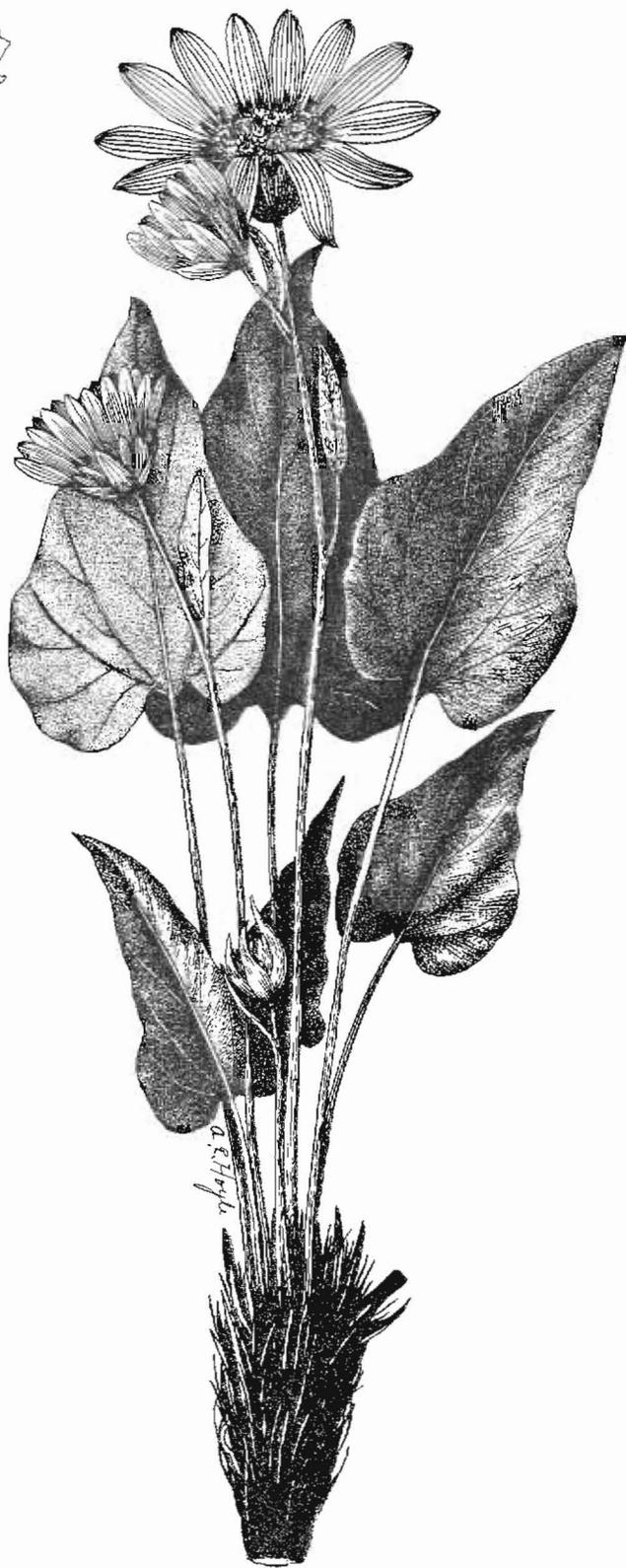


Figure 35. Arrowleaf balsamroot (*Balsamorhiza sagittata*). Plant x 1/3.

## CROWNVETCH

*Coronilla varia* L.

### ORIGIN

Native to Mediterranean regions of Europe, southwest Asia, and Africa. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Rhizomatous, cool season, herbaceous, perennial, leguminous forb.

Stems angular, decumbent to ascending, 1 to 4 feet tall, with a deep taproot and numerous laterals from a branched root crown. Leaves alternate, stipulate, and pinnately compound, typically with 9 to 25 leaflets. Pealike, variegated white to purple flowers, borne in an umbel resembling a crown. Seeds borne in segmented, cylindrical, fingerlike pods breaking into sections on drying, each segment containing one rod-shaped seed, yellowish to mahogany brown (1).

Adventitious buds on roots produce stems or rhizomes by which plants produce a nearly total cover effective in preventing erosion. Flowers esthetic and bloom over long period. Good palatability to livestock and big game; not known to cause bloat (1).

### ECOLOGICAL RELATIONSHIPS

Best adapted to fertile, well drained soils with a pH of 6 or above, particularly on calcareous soils; tolerates some infertility and acidity when well established. Lower pH limit of 5.0; sometime spreading into areas with a pH of 4.5 after established. Well adapted north of 35° N. latitude and east of 97th meridian. Intolerant of high water tables or prolonged flooding. Thriving in over 30 inches MAP zones but good performance in over 20 inches zone. Weakly moderate tolerance to drought due to surviving rhizomes and seed; some tolerance of burning for same reason. Moderate shade tolerance; seeded in western mountain shrublands and woodlands. Moderate tolerance of grazing, but overgrazing or mowing more than once per year reduces vigor and thins stands. Strongly competitive when fully established, suppressing weeds and also desirable associates and developing a monoculture (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 to 1 inch in depth on moister or finer textured soils and on drier and coarser soils, respectively. Seed 10 to 20 pounds PLS per acre, the lower rate when drilling and in semiarid zones and the higher rate in humid zones, when broadcasting, and on harsh, steeply sloping, and south and west-facing sites. Plant before the 2-month growing season which has the most favorable moisture conditions for rapid germination and seedling establishment; usually best times are either early spring or late summer to early fall. Seed must be inoculated with the specific type of legume bacteria before sowing. Plant crowns effectively transplanted in spring to early summer (1,4).

#### Seed Cleaning and Quality

Combine harvesting practical with proper adjustment of equipment. Swathing or windrowing unsatisfactory due to loss of seed. Material from combine consists of pod segments covering seed. Use scarifier to break up these pieces and reclean product in fanning mill. Seed quality: 98 percent purity; 90 percent germination; 88 percent PLS; and 110,000 seed per pound (5).

#### Germination and Seedling Characteristics

Most seed germinate moderately fast in 14 days under ideal conditions; some delayed germination from dormant seeds. Seedling vigor only fair; stands develop slowly, taking 3 or 4 years, in part due to slow or poor germination. Once established, species slowly spreads until it develops total cover.

## MANAGEMENT

Chiefly useful for watershed protection of poor, erosive, and sloping lands; limited use in restoring big game ranges and for pasture and hay. Also used for stabilization of highway embankments, mine soils, and disturbed lands. Species well suited for improving bluegrass pastures by sod seeding. Control weeds in new seedings by mowing above seedlings and/or seeding with quick developing companion grass, such as weeping lovegrass (*Eragrostis curvula*), mountain brome (*Bromus marginatus*), or slender wheatgrass (*Agropyron trachycaulum*) where moisture will support both crops. Clipping studies indicate rotation grazing to 6-inch stubble at 8-week intervals gives optimum dry matter production. Do not mow more than once per year. More research needed on seed production, stand establishment, and forage uses before more widely used (4).

## ASSOCIATED SPECIES

Species may be seeded or transplanted by itself. Commonly used with tall fescue (*Festuca arundinacea*) in Midwestern and Midsouthern States to stabilize highway embankments.

## IMPROVED VARIETIES

'Emerald', 'Penngift', and 'Chemung' are cultivars released from Iowa, Pennsylvania, and New York, respectively. 'Emerald' recommended for use in Interior Coal Provinces; 'Chemung' and 'Penngift' in the Appalachian Region.

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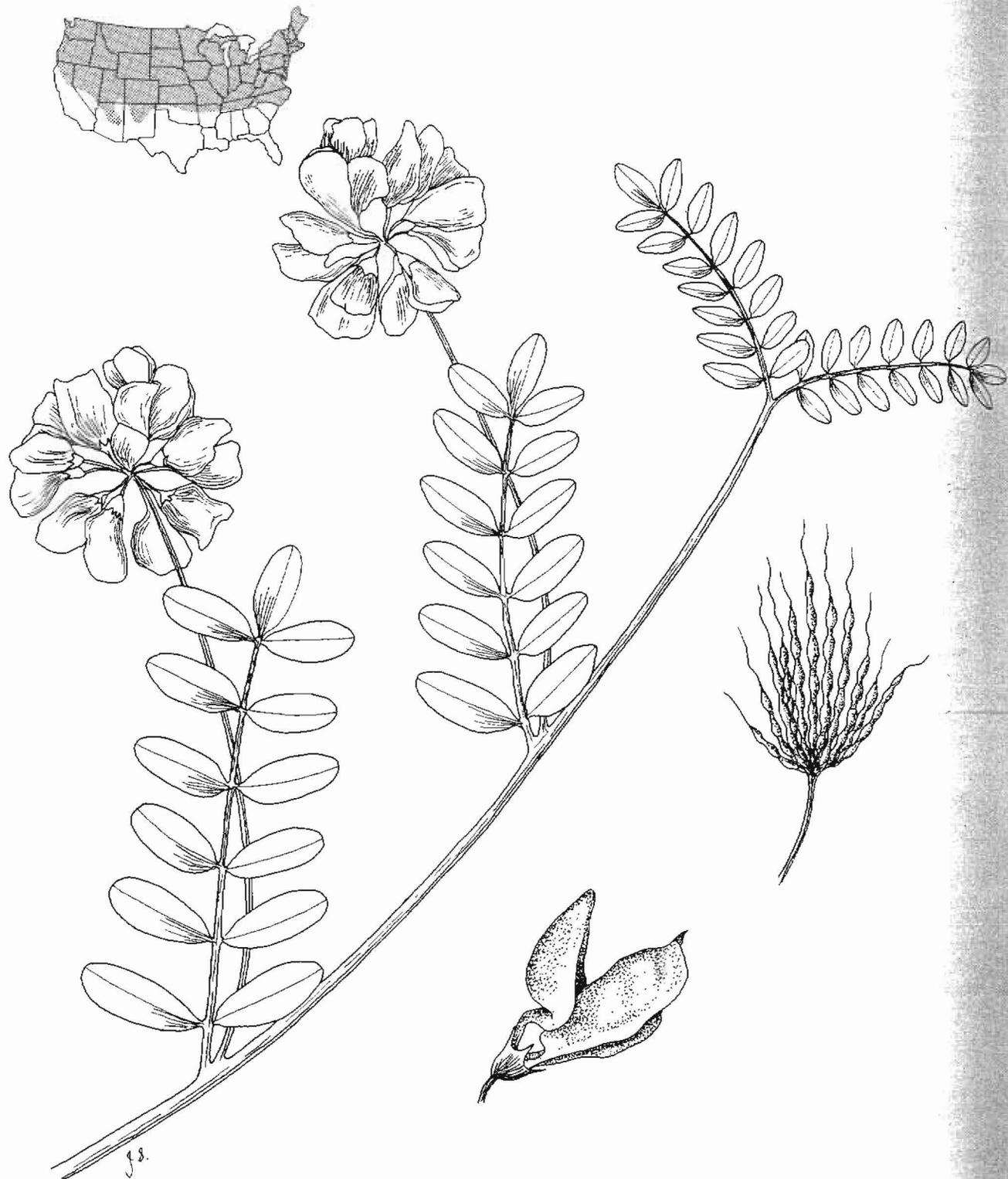


Figure 36. Crownvetch (*Coronilla varia*). Plant x 1; flower x 4; pods x 1. (Flower after C. L. Hitchcock et al. 1961, pods after Graham 1941.)

## ILLINOIS BUNDLEFLOWER

*Desmanthus illinoensis* (Michx.) MacM.

### ORIGIN

Native to southcentral United States, extending into Northern Great Plains and Southwest. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, herbaceous, perennial, leguminous forb.

Stems glabrous, angled, longitudinally grooved, erect, 2 to 4 feet tall. Leaves alternate; about 4 inches long, bipinnate with 6 to 15 pairs of pinnae (main divisions), each with 20 to 30 pairs of small linear leaflets, and bristlelike basal stipules, smooth or hairy. Leaves sensitive to stimuli, infolding in bright sunlight and when touched. Flowers five-parted, borne in white "powder-puff" globose heads producing clustered flat scythe-shaped pods slightly spirally twisted, each about 1 to 1 1/2 inches long and containing two to six beans which "explode" from pods at maturity (1).

Semiwoody stem bases; deep, woody roots and developing rootstocks in favorable environments. Growth resumes in later spring than for cool season species, flowering June or July until September, maturing about a month later, making summer and fall regrowth with available moisture but none after frost. Good palatability and nutritious to livestock and big game; seeds used by birds (2).

### ECOLOGICAL RELATIONSHIPS

Thrives on medium-textured soils and tolerant of all except coarse sands and dense clays. More frequent and vigorous in 16 to over 20 inches MAP zones. Most commonly occurring in moist depressions and tolerant of some flooding. Fairly common in open communities and on semibare and disturbed sites along roads, slopes, and river banks. Tolerant of moderately acidic (lower pH limit is 5.0) and somewhat alkaline soils. Good drought tolerance, especially in open communities without full competition. Species of subtropical stock winter hardy in about 200 to 300 mile latitudinal bands; apt to be somewhat cold sensitive if imported from distant southern sources. Less vigorous but tolerant of partial shade. Fair tolerance of burning in dormant state; hard seeds may be stimulated to germinate. Species responds to grazing as a decreaser, rapidly declining under too intense defoliation. Compatible with climax dominants of tallgrass prairie; adequate evidence of competitiveness (3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

When seeded alone, drill seed 1/2 to 1 inch deep on clayey or moister and sandy or drier soils, respectively. Drill 5 to 10 pounds PLS per acre, using former rate in grass-legume mixtures and latter rate when seeded alone for minesoil stabilization in humid zones. Increase rate 50 to 100 percent when broadcasting. Seeding in prepared, dead crop stubble or adding supplemental mulch and irrigating when feasible may aid establishment on minesoils and critical areas. Use only about 1 pound per acre in rangeland and critical area seeding mixtures. Drill-seed mixtures before the moistest growing season: usually early to midspring in southern to midlatitudes optimal for both primary species and legumes. Late fall or winter seedings may prechill and stimulate better emergence of "hard" legume seed and dormant, fresh grass seeds. Consider transplanting rootstocks for critical area stabilization; good rootstock production occurs under nursery conditions and may be duplicated in favored habitats (2,3).

#### Seed Cleaning and Quality

Harvest small, native stands by hand-stripping pods, drying under cover, and cleaning in fanning mill. Seed fields may be harvested by direct-combining and cleaning in fanning mill. Seed quality not standardized:

acceptable purity 95 percent or better; germination 70 percent (including hard, dormant seed), requiring scarification for good germination; PLS 66 percent or better; and 85,000 seed per pound or up to 151,000 seed per pure pound of seed (6).

#### Germination and Seedling Characteristics

Nonhard seed germinate in 7 to 14 days, most within 5 days, with much delayed germination from unscarified seed. Seedling vigor very good, may flower and produce seed first season with favorable growing conditions, but more fully established and productive second season.

#### MANAGEMENT

Generally recommended in the following seeding mixture for mined land reclamation and to simulate tallgrass prairie composition on suitable sites in eastern Kansas, western Missouri, and eastern Oklahoma (3):

<u>Species</u>	<u>Rate - pounds PLS per acre</u>
Switchgrass ( <i>Panicum virgatum</i> )	2
Big bluestem ( <i>Andropogon gerardii</i> )	3
Little bluestem ( <i>Schizachyrium scoparium</i> )	3
Yellow Indiangrass ( <i>Sorghastrum nutans</i> )	4
Sideoats grama ( <i>Bouteloua curtipendula</i> )	4
Illinois bundleflower ( <i>Desmanthus illinoensis</i> )	<u>5</u>
	21

Recommended for use in range seeding and for wildlife food and cover in eastern two-thirds of Texas. Liming and adding phosphates according to soil tests usually necessary on acidic soil prior to seeding. Inoculate seed with specific rhizobia strain immediately before planting. Withhold grazing and control aggressive weeds during seedling establishment. Bundleflower somewhat sensitive to phenoxy herbicides. Carefully graze or harvest and provide for periodic rests from defoliation during growing season, especially before killing frosts, and leave 6 to 10 inches of stubble after harvests to ensure perpetuation of aesthetic, soil stabilizing cover.

#### ASSOCIATED SPECIES

Chief associates of this species are the tallgrass prairie dominants listed in the above recommended seeding mixture, particularly the first four species; but the species occurs into moist sites in mixed prairie and into the woodlands of the central States and western southern States.

#### PESTS AND DISEASES

Rabbits, rodents, grasshoppers, and leafhoppers selectively attack legumes and especially seedling stands. Leaf spot and downy mildew reported on plants but probably minor in effect.

#### IMPROVED VARIETIES

None.

#### REFERENCES

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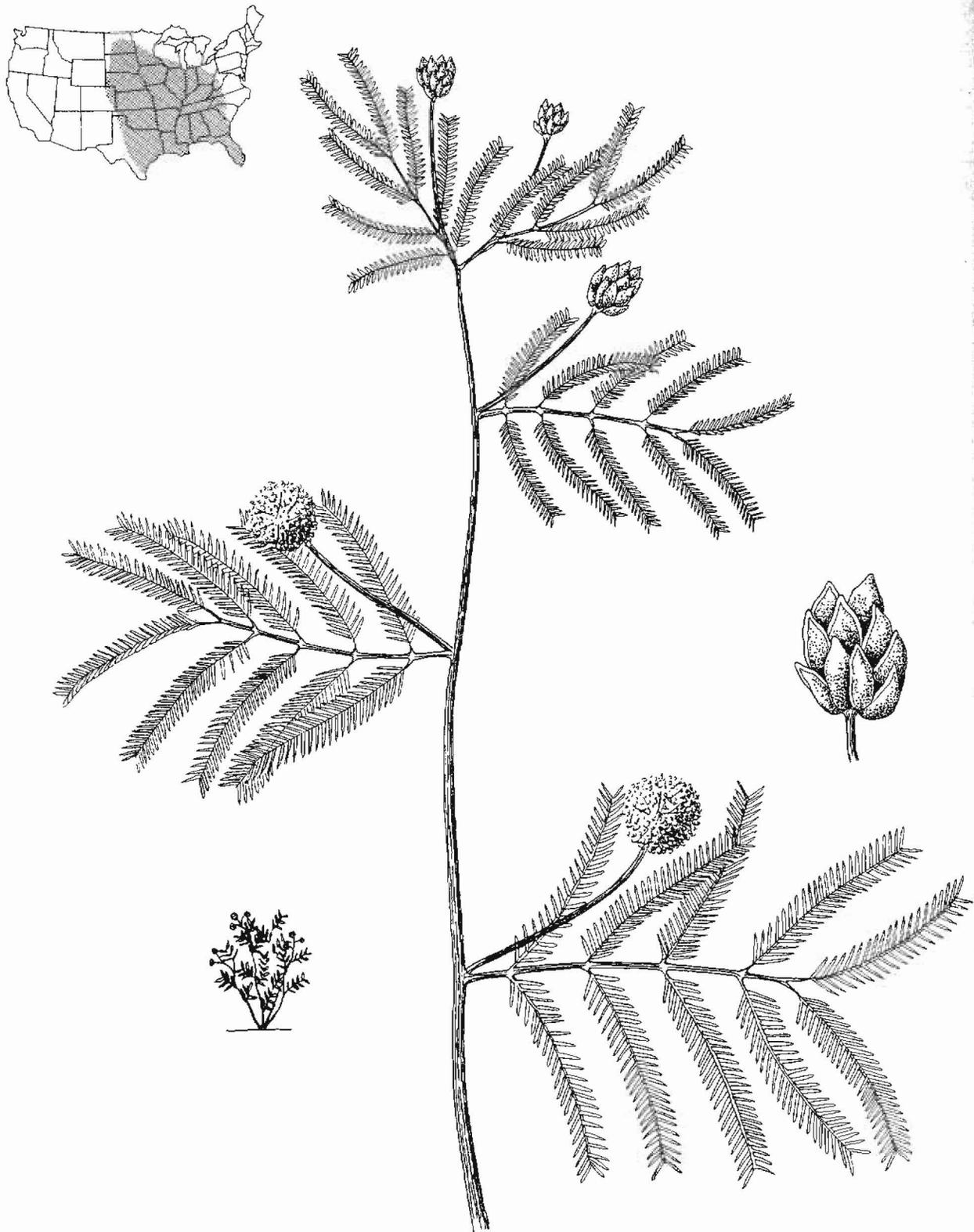


Figure 37. Illinois bundleflower (*Desmanthus illinoensis*). Plant x 1 1/2; pods x 3/4.

## NORTHERN SWEETVETCH

*Hedysarum boreale* Nutt.

### ORIGIN

Native of the intermountain and Northern Great Plains regions. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, herbaceous, perennial, leguminous forb.

Stems single to several from a woody crown, 1 to 2 feet tall. Leaves alternate; odd-pinnate, with 11 to 31 elliptic leaflets, gland-dotted and highly variable in size, shape, and hairiness; broader below and narrower above, with narrow, pointed stipules. Inflorescence an elongated, loosely arranged raceme with few to several showy white, pink, or purple flowers; having a hairy five-parted calyx and typical pealike banner, wing, and keel petals; maturing into a flattened, constricted, and reticulate several-sectioned loment-type pod, each section containing one brownish, kidney-shaped seed (1).

Plants with deep taproots and several laterals, sometimes rhizomatous. Growth resuming in early to midspring, varying with environment; flowering in May and June; and maturing in July and August. Regrowth only minimal after maturity. Herbage retains considerable succulence summerlong. Good palatability to big game and livestock; basal leaves may remain green in winter (2).

### ECOLOGICAL RELATIONSHIPS

Species grows on soils ranging from clay to sandy texture; more common on well drained sites and loamy soils, less common in drainages subject to flooding. Grows on somewhat acidic and neutral reacting soils, and often occurs naturally in habitats dominated by species indicative of moderate soil salinity and alkalinity with some exchangeable sodium. Infrequently to commonly present between 10 and 18 inches MAP, more vigorous in the 15 inches or more MAP. More commonly found in open communities and disturbed sites, suggesting better establishment and/or persistence with reduced competition. Good drought resistance and winter hardiness. Species common between 4,000 and 8,000 feet in elevation and found at even higher elevations. Fair shade tolerance but not found under dense forest canopies. Only fair or weakly moderate grazing tolerance; greatly reduced in abundance on many Utah ranges and probably elsewhere. Good fire tolerance when dormant. Fair compatibility with other species and moderate competitiveness for a native, perennial forb but much less aggressive than domesticated grasses and annuals (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 inch deep on loam soils, up to 3/4 inch deep in drier and coarser soils, and 1/4 inch deep on finer textured and moister soils. Rates of 1/2 pound per acre drilled or 1 pound per acre broadcast recommended in seeding mixtures for sandy aspects of mountain brushlands in Utah. Planting in early spring or late fall advocated, late fall planting provides natural stratification. Inoculate seed with specific *Rhizobium* strain for nitrogen-fixation just before planting. Plants experimentally stimulated in soil infested with *Glomus fasciculatus*, a mycorrhizal symbiont (5).

#### Seed Cleaning and Quality

Hand-strip or knock seed in containers, vacuum, use headcutters, or combine-harvest seed; feasibility varies with size of stands/projects and available equipment; dry material, clean in air blaster equipped with sieves, and reclean by screening or in fanning mill. Seed quality not standardized: 90 percent purity; 80 percent germination, counting hard seed; and 72 percent PLS possible with an average of 81,000 seed per pound (3,6).

### Germination and Seedling Characteristics

Germination occurs in 21 to 28 days and is better after damp prechilling or scarification and with older seed. Often major fraction of seed are hard. Seedling vigor is good to excellent and stands establish well by second year.

### MANAGEMENT

Species used as minor ingredient in seeding mixtures for game range restoration in Utah mountain shrublands. Considered potentially valuable for stabilizing disturbed lands, including oil shale mined lands, and moderately promising for range revegetation in western Colorado and adjacent intermountain States. Contributes variety to stands and improved nutrition and aesthetics. Planting weaker seedling competitors in separate or alternate rows may improve establishment. Management chiefly geared to perpetuating dominant species; reducing or withholding stocking during establishment and avoiding overuse of key forage species afterward is recommended. Periodic suppression of strongly competitive, sprouting brush species by chaining, cabling, or, where feasible and safe, burning, invigorates undercover production and improves nutrition (7).

### ASSOCIATED SPECIES

Occurs in very diverse, usually open and exposed, habitats with native species mixtures extending from black greasewood (*Sarcobatus vermiculatus*) and shadscale saltbush (*Atriplex confertifolia*) dominated Great Basin areas to big sagebrush and mountain shrublands, juniper-pinyon woodlands, and into open stands of aspen, Douglas-fir, and subalpine communities. Species considered a native legume potentially useful in rangeland and mineland mixtures containing bluebunch wheatgrass (*Agropyron spicatum*) and Idaho, rough, hard, and sheep fescue (*Festuca idahoensis*, *F. scabrella*, *F. ovina duriuscula*, and *F. ovina*, respectively).

### PESTS AND DISEASES

Rabbits and other small mammals and occasionally grasshoppers and Mormon-cricket reduce seedlings and forage quantities. Minor leaf spots and rusts noted on plants.

### IMPROVED VARIETIES

None.

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Figure 38. Northern sweetvetch (*Hedysarum boreale*). Plant x 1/2; leaflet pair x 1 1/2; pod (loment) x 2; flower x 4.

## MAXIMILIAN SUNFLOWER

*Helianthus maximiliani* Schrad.

### ORIGIN

Native to the Great Plains and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, bunching, herbaceous, perennial forb.

Stems 3 to 6 feet tall, growing singly or often clustered from short rhizomes. Leaves commonly arched, the two halves of blades often folded together forming a trough, tapering toward both ends, alternate except opposite on unelongated stems, and rough hairy with short winged petioles. Flowers in typical sunflower-type heads with bright yellow outer ray flowers, often arched over central disk flowers, and both bearing smooth four-angled achenes (1).

Plants flower July to October and make some regrowth in summer and fall with available soil moisture. Plants palatable to livestock and deer, and seeds eaten by many birds. Little use made of herbage by herbivores after frost (1).

### ECOLOGICAL RELATIONSHIPS

Adapted to deep, sandy loam to clay loam upland soils of subhumid prairies, more common on heavier soils in over 25 inches MAP zones and on lowlands with better moisture conditions in semiarid plains. Tolerant of weakly saline and weakly basic to weakly acidic reacting soils. Generally intolerant to extreme wetness in subhumid and humid zones but moderately tolerant of imperfect drainage, intermittent flooding, and water tables seasonally within few feet of surface in semiarid zones. Only fair drought tolerance, responding by reduced height growth and cover but surviving by rhizomes. Thrives in sunlight and only fair shade tolerance. Good fire tolerance in the dormant state. Local strains or improved varieties derived from them more cold-tolerant; others may be frost sensitive in rapid stem elongating stages. Not common on closely grazed ranges, indicating susceptibility to close-grazing injury. Established plants aggressive and only fairly compatible with other species in mixtures (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Generally plant seed at optimal depths for primary species in mixtures. Species emerges best when planted at depths two to four times seed thickness in humid zones or with ample soil moisture under irrigation but may be seeded at variable depths up to 1 inch in semiarid regions under nonirrigated conditions. Use 3 pounds PLS per acre in mixtures and 6 pounds per acre for stabilizing minesoils in Kansas and adjacent subhumid to humid zones. Due to aggressive spreading, only about 0.10 to 0.25 pounds per acre should be sown in prairie grass mixtures. One pound PLS per acre recommended for strip or block plantings for wildlife purposes. Optimal time for seeding is November to May in central Great Plains and January to March in Southern Great Plains; the earlier dates may aid in breaking seed dormancy. Plants also can be started by transplanting fleshy roots during early spring or earlier in southern latitudes. Plants spread by rhizomes and form large colonies. Softwood cuttings also can be rooted in the greenhouse (4,5).

#### Seed Cleaning and Quality

Seed growing in wild stands may be harvested by gathering heads, drying them, either mechanically flailing or hammermilling, and recleaning in a fanning mill. Widely spaced row plantings can be combined directly and cleaned in a fanning mill after hammermilling when necessary. Seed quality not widely standardized: 90 percent purity; 60 percent germination; 54 percent PLS; and about 225,000 seed per pound.

### Germination and Seedling Characteristics

Seeds germinate rather quickly in 7 to 14 days, but nearly half may be dormant. Good seedling vigor and stands develop rather rapidly with some flowering possible by end of first growing season in South; usually not fully developed until second year. Plants continue to spread.

### MANAGEMENT

Used with grasses and other species to provide diversity in mixtures and for landscape beautification, wildlife food, and both watershed and wildlife cover. Limited use also made for revegetating coal mine soils in Kansas and perhaps adjacent States. Protect seedling stands from close use and trampling and control weeds before they become a problem. Moderate grazing and periodic deferment from grazing during the growing season should ensure better thrift and persistence of this species.

### ASSOCIATED SPECIES

Species naturally grows in mixtures with big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), and yellow Indiangrass (*Sorghastrum nutans*) of the true prairies and also a variety of species in mixed prairies and adjacent areas. Purple prairieclover (*Petalostemum purpureum*), scurfpeas (*Psoralea* spp.), gayfeathers (*Liatris* spp.) and many other forbs also are intermixed in such stands (1,3).

### PESTS AND DISEASES

Nothing serious reported on this species; occasional rusts, leaf spots, and downy mildew noted.

### IMPROVED VARIETIES

'Prairie Gold', a cultivar with good competitive ability and greater cold tolerance, is adapted to the 14 inches and more MAP zones in Nebraska, Kansas, eastern Colorado, northern fourth of Oklahoma, western fourth of both Iowa and Missouri, southern fourth of South Dakota, and southeast corner of Wyoming. 'Aztec', developed from five county sources in Texas to extend flowering period, is adapted to the southern three-fourths of Oklahoma, all of Texas except the Trans-Pecos, and eastward (6).

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Figure 39. Maximilian sunflower (*Helianthus maximiliani*). Plant x 1/2.

## ROUNDHEAD LESPEDEZA

*Lespedeza capitata* Michx.

### ORIGIN

Native of central United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Herbaceous, warm season, perennial legume.

Stems leafy, stiffly erect, 1 1/2 to 4 feet tall, simple or branched, and often silvery but variably hairy. Leaves alternate, borne uniformly on stems, trifoliate (cloverlike), with short-stalked, elliptic leaflets, smooth to silky above and usually silky or velvety beneath. Inflorescence in globular heads composed of numerous flowers clustered like grapes. Flowers small, pealike, yellow to white, purplish below, and longer than the oblong one-seeded pods; seeds black (1).

Strongly and deeply rooted. Polymorphic species; usually erect but prostrate on sand dunes and varying from green to silvery and ashy gray pubescent. Grows from early or late spring until frost with available moisture, flowering from July until September, and maturing during late summer and fall, varying regionally. Palatable to livestock and big game animals prior to frost and also used by small mammals and birds. Latter consume seeds (1).

### ECOLOGICAL RELATIONSHIPS

Grows naturally in diverse habitats: dry woods; prairies; and sand dunes. More common on well-drained, lighter-textured sandy and even rocky soils, weakly alkaline to weakly acidic in reaction. Mesophytic in apparent moisture relations, thriving in over 20 inches MAP zone but present in moisture-accumulating sites in semiarid zones. Weakly moderate drought tolerance compared to xerophytes but strong for a subhumid zone species. Moderate winter hardiness: native seed suitable for local use, but avoid seed from distant sources and habitats differing much from seeding site. Some shade tolerance but great variation among various ecotypes to be expected. Moderate to strong tolerance to burning when dormant; "hard" seed may be scarified by heat. Responds as a decreaser to grazing pressure or repeated, close defoliation. Good compatibility when well established and also moderately competitive (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 to 1/2 inch deep in a well prepared seedbed. Plant 20 to 30 PLS per square foot (4 to 6 pounds PLS per acre) for a full stand. Decrease rate to the percent composition desired in mixtures: 50 percent or less for simple grass-legume mixes, aesthetic landscaping, or for so-called prairie restorations. Usually only 1 pound PLS per acre recommended for seeding with native grass mixtures (4). Plant scarified or prechilled seed in spring and untreated seed in late fall or winter to stimulate germination by providing long prechilling treatment. Ten weeks damp-prechilling ("stratification") resulted in four times as much emergence as dry-prechilling in Wisconsin prairie restoration efforts (3). Possible to plant in late summer if long growing season and enough moisture to ensure adequate seedling development before killing frosts (4).

#### Seed Cleaning and Quality

Small native stands can be harvested for seed by hand-stripping, processing in hammermill, and recleaning in fanning mill. Field plantings can be combined, processed in hammermill, and cleaned in a fanning mill. Seed quality not standardized: 95 percent purity; 60 percent germination (including hard seed). about 2 percent emergence obtained from damp-prechilled seed in Wisconsin, and only about 0.5 percent from dry-prechilled seed; 174,000 seed per pound (2,4).

### Germination and Seedling Characteristics

Seeds begin to germinate in 7 days and reach peak germination in 14 to 22 days. Germination is enhanced by scarification (5). Seedling vigor is good for a perennial forb. Two years usually necessary for stands to develop and reproduce (3). Some plants may flower first season with favorable growing conditions (5).

### MANAGEMENT

Species recommended and/or used in plantings on roadsides and park and recreation areas for stabilization and beautification, also in wildlife habitat areas, and used in mixtures that simulate native prairie. Seed also may be included in warm season grass mixtures for species and dietary diversity. It can be transplanted as year-old nursery-grown plants or interseeded into disturbed prairielike vegetation in restoration projects. Protect seedlings and restoration plantings from close grazing during establishment and control competitive weeds. Grazing or mowing and leaving a high stubble about 1 month before regular flowering promotes lateral bud development and greater floral display if moisture will sustain later growth, as in humid zones. Delaying further defoliation until after seed maturity restores plant energy for greater production and persistence while allowing reproduction. Inoculate seed just before planting where lespedeza has not grown previously. Correct acidity and phosphate deficiency before planting. Except for conservative defoliation, little maintenance should be necessary when grown with native warm season species.

### ASSOCIATED SPECIES

Species occurs in native plant mixtures with tallgrass prairie dominants including big and little bluestem (*Andropogon gerardii*; *Schizachyrium scoparium*), yellow Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and many forbs and shrubs; in sand prairies with prairie sandreed (*Calamovilfa longifolia*) and sand bluestem (*Andropogon hallii*); and in oak woodlands with a diverse mixture of other forbs, grasses, shrubs, and trees. Species seeded alone or more commonly in warm season grass mixtures often including the above prairie dominants.

### PESTS AND DISEASES

Grasshoppers, leaf-sucking insects, and rodents menace new seedlings and reduce forage supply. No serious diseases noted on this species.

### IMPROVED VARIETIES

None.

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Figure 40. Roundhead lespedeza (*Lespedeza capitata*). Plant x 2; fruit (curved) and calyx x 4. (Calyx after Gleason 1963.)

## LEWIS FLAX

*Linum lewisii* Pursh  
[= *Linum perenne* L. (1)]

### ORIGIN

Native and widely distributed in western prairies, plains, and mountains of U.S.; also occurring in Eurasia. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, herbaceous, nonleguminous, short-lived perennial forb.

Stems slender, erect or drooping, up to 3 feet tall, often branching at base from a thickened, woody, branched root crown. Plants with a woody perennial taproot. Leaves alternate on stems, smooth, linear, pointed, sessile, green or glaucous. Flowers stalked, several in a loose racemose or flat-topped panicle, each with five overlapping sepals and five blue 1/2 to 1 inch long petals and bearing a round capsule containing up to 10 seeds (1).

Growth resumes in spring, flowering occurs between May and September, and maturity about 1 month to 6 weeks later. Showy flowers open at sunrise on clear warm days, and the petals fall by noon. Vegetative growth continues until frost with adequate moisture. Fair palatability to livestock when green; good palatability to big game. Edible forage not retained into late fall or winter. Birds consume seeds in fall and winter (1).

### ECOLOGICAL RELATIONSHIPS

Thrives on well drained, porous soils of benches, slopes, and ridges from prairie to alpine elevations throughout western North America. Intolerant of poor drainage, flooding, and high water tables. Grows on moderately basic to weakly acidic reacting and somewhat salty soils. Plants more abundant and vigorous in the 16 to 20 inches MAP zones but commonly occur in 10 to 15 inches zone and sometimes sparsely into semidesert zones. Only fair tolerance of shading but occurring in southwestern and California pine woodlands. Somewhat vulnerable to wildfires but usually surviving by seed. Good winter hardiness of local plant materials but great variation in regional sources and strains requiring use of adapted materials. Moderately tolerant of grazing but damaged by close, continuous defoliation. Compatible with moderately vigorous growing herbs (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed 1/4 to 3/4 inch deep or broadcast and cover with soil to similar depth. Adapt seeding rate to desired composition in seeding mixture, usually no more than 5 to 10 percent of a full stand seeding rate of 20 to 30 PLS per square foot (about 3 to 4 pounds PLS per acre) for semiarid zones. Increase rates 50 to 100 percent for humid zones, broadcasting, and for harsh sites, especially those on erosive soils, steep slopes, and south and west exposures. Plant at time optimal for primary species in seeding mixtures, preferably before the most humid growing season. Plant the species alone either late fall of seed-harvest year, the following spring, or the second fall; tests indicate latter date results in greater emergence (4).

#### Seed Cleaning and Quality

Harvest seed from small stands by hand-stripping, drying and fanning, or by processing strippings in a head thresher equipped with spiked cylinder and concave and/or by mechanical flail equipped with screens; reclean in fanning mill. Lewis flax can be grown in cultivated rows and harvested by direct combining or swathing first like the seed flax crop. Seed quality not standardized: about 95 percent purity; about 75 percent germination; 71 percent PLS; and 285,000 seed per pound.

### Germination and Seedling Characteristics

Seeds germinate in 10 to 15 days indoors at 60-70°F and in 15 to 30 days in the field with variable moisture and temperature. Seedling vigor good for a wild perennial herb but only fair compared to domesticated vigorous grasses. Might begin to head out by third year or, under more favorable conditions, by the end of the second.

### MANAGEMENT

Considered to have low potential for revegetation of subalpine lands and for wildlife habitat improvement in western Colorado; one of few forbs adapted to salt desert. Flax may be seeded alone or included in minor amounts in seeding mixtures designed to restore native vegetation on disturbed sites; also can be included in seeding mixtures for aesthetics and diversity. Protection from grazing and control of undesirable competitors may be needed during seedling establishment. Perpetuation of composition dependent on careful management by periodically deferring grazing or mowing until after seed maturity. Species not very fertility demanding but nitrogen may stimulate seed production as in flax crop production.

### ASSOCIATED SPECIES

Species commonly associated with grasses and forbs in a great variety of grassland types from prairie and plains to open pine, subalpine, and alpine elevations. Seedlings can be mixed with grasses of only moderate competitiveness or separate the less competitive element from stronger components in alternate row plantings.

### PESTS AND DISEASES

None reported to be serious. Rusts, root rots, and leaf spots observed on plants.

### IMPROVED VARIETIES

'Appar', dark blue petaled plants, bloom for about 6 weeks. Originally selected in South Dakota; recommended for use in the intermountain region with 10 or more inches MAP.

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Figure 41. Lewis flax (*Linum lewisii*). Plant x 1/2; flower x 3/4; fruit (capsule) x 1 1/2.

## ALFALFA

*Medicago sativa* L.

### ORIGIN

Indigenous to southwest Asia. Grown in all 50 States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool and also warm season, herbaceous, perennial, leguminous forb.

Numerous erect stems, usually 2 to 3 feet tall from narrowly to relatively broadly-based woody root crowns. Leaves alternate, pinnately trifoliate; leaflets denticulate and hairy. Inflorescences loosely arranged racemes with several small purple, white, or sometimes yellowish or bronze colored pealike flowers bearing small kidney-shaped seeds in spirally twisted pods upon maturing (1).

Stout, deep, taprooted plants bearing nodules that fix nitrogen when inoculated. Taproots may be 10 to 30 feet in length. Plants resume growth in early spring, later at higher altitudes and latitudes, flower in early to late summer, and make excellent regrowth after flowering or cutting, usually sufficient to produce multicrops of hay or pasturage. Peer forage plant nearly worldwide for production, nutrition, and good acceptance by most herbivores. Dense cover resists erosion, provides food and cover for birds and small mammals, and attracts big game. Green herbage induces bloat in ruminants correctable by diligent management and bloat-suppressing supplements (1,2).

### ECOLOGICAL RELATIONSHIPS

Thrives on fertile, deep, loamy soils having porous subsoils. Tolerant of deep sand and sandy soils with adequate moisture and well adapted to deep soils with water tables within 5 to 9 feet of surface. Better adapted to basic reacting soils with liberal calcium content; not performing well on acid soils unless neutralized by liming. Lower pH tolerance of 5.5. Tolerant of moderately saline soils. Moderately good drought tolerance of established plants, more susceptible at seedling stage of development. Generally useful in the 15 to over 20 inches MAP zones but survives in the 12 to 15 inches zone in cooler or moisture-accumulating habitats. Considerable variation in winter-hardiness. Usually good hardiness among improved varieties of variegated alfalfa; be certain of the hardiness of "common" strains/sources before using. Alfalfa grown from below sea level in Imperial Valley, California to 8,000 feet in elevation in Colorado. Only fair shade tolerance. Fire-resistant when green and good fire tolerance when dormant. Moderate grazing tolerance; intolerant of continuous grazing during growing season. Established plants moderately to strongly competitive; compatible with strongly competitive grasses like smooth brome grass (*Bromus inermis*) and Russian wildrye (*Elymus junceus*) (1,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 inch deep in loamy soils of firm, moist seedbeds; up to 1 inch deep on drier, sandy, or loose seedbeds; and only 1/4 inch deep or seeded on surface with press-wheel drill or in a cultipacker drill in finer textured and moister soils. Seed at greater depth in fall; seed at shallower depths in spring, unless dry or windy. Seed 5 to 10 pounds PLS per acre; lower rate when drilling and in lower precipitation zones; and higher rate when broadcasting and for seeding harsh, erosive, and south and west-facing sites. Use 12 to 18 PLS pounds per acre for eastern and midwestern, humid zone minesoils. Use conservative fractional rates in seeding mixtures to keep composition in stands well below 50 percent in rangeland and grazed areas to minimize bloat and prevent grass suppression. Plant before the growing season consistently having adequate surface moisture conditions for germination and seedling establishment; early spring in northern Great Plains, August to October in central and southern Great Plains and lower elevations of intermountain and Pacific Northwest regions, and late fall or as early as possible to seed in spring or summer in higher mountains under dryland conditions. Seed in spring or late summer to fall under irrigation but in time for seedlings to make enough growth to overwinter safely. Do not seed alfalfa with companion crops unless adequate water exists for both crops. If seeded together, seed in alternate rows or at an angle to each other

to minimize competition. Seeding in dead crop stubble or providing supplemental mulch aids stand establishment on harsh, windy, and erosive sites. Seed requires inoculation to induce nitrogen fixing nodulation except when alfalfa has been grown previously on site (1,3).

### Seed Cleaning and Quality

Combine seed crop standing in field or windrow, dry several days, and thresh with a pickup combine. May shock windrowed hay and haul to thresher when cannot thresh immediately in windrow. Clover huller well adapted for threshing alfalfa seed. Seed can be cleaned in a fanning mill but usually must be run through twice. Seed quality: 99 percent purity; 90 percent germination; 89 percent PLS; and 220,000 seed per pound. Seek seed with 10 percent or less hard seed.

### Germination and Seedling Characteristics

Seeds germinate rapidly in 7 to 10 days, except for considerable hard seed with delayed germination. Seedling vigor is good to excellent compared to grasses and most small-seeded forage legumes. Stands establish moderately rapidly, usually by second growing season and sometimes by end of first season by using preemergence herbicides (1,3).

### MANAGEMENT

Traditional main uses: forage either for hay or pasture; less commonly used for erosion control, minesoil stabilization, and wildlife cover. Species provides excellent pasturage mixed with orchardgrass (*Dactylis glomerata*), smooth brome (*Bromus inermis*), or tall fescue (*Festuca arundinacea*); also used with crested wheatgrass (*Agropyron cristatum*), intermediate wheatgrass (*A. intermedium*), and pubescent wheatgrass (*A. trichophorum*), and other forbs and shrubs for big game restoration and rangeland improvement in foothill to mountain elevations of West. New seedings require weed control and protection from grazing. Optimal quality/quantity of forage obtained by harvesting in 1/10 bloom stage, by grazing conservatively in a rotation plan; plants should not be defoliated during the 30 days preceding first killing frost. Use a fertilizer program geared to soil tests and harvested offtake. Control insects when moderately abundant in both seedling and mature stands (1,3,5).

### ASSOCIATED SPECIES

Commonly seeded with cool season grasses for tame pastures or hay and as a minor nitrogen-fixing, higher protein ingredient in rangeland seedings. Less commonly mixed with taller warm season grasses, but should be. Better stand establishment and persistence results from planting alfalfa and grasses in alternate rows, especially in drier areas.

### PESTS AND DISEASES

Stands and forage quality and quantity greatly damaged by grasshopper infestations. Pocket gophers are particularly troublesome and are controlled by dispensing poison with a burrow-builder. Alfalfa weevil larvae consume forage, weaken vigor, and thin stands throughout U.S. Only semiresistant varieties exist. Aphids weaken plant vigor and may secrete a mold-attracting honeydew, lowering hay quality. Aphid-resistant varieties now exist. Lygus bugs and alfalfa seed chalcids affect seed production but are controllable by insecticides. Leaf spot, root rot, and stem nematodes occur. Nematode-resistant varieties exist (1,3).

### IMPROVED VARIETIES

U.S. alfalfa cultivars were developed from three species: bluish-purple *Medicago sativa*, which includes Turkestan, Flemish, and so-called common alfalfas that vary greatly in winterhardiness; yellow-flowered *M. falcata*, a native of Siberia, with good winter hardiness, spreading growth habit, and deeper-set crowns; and *M. sativa media*, probably a natural cross of the previous two species, which exhibits great variation in flower color, good winter hardiness, and is more commonly used in colder northern and mountainous regions. Two spreading or so-called pasture types of alfalfas also exist: rhizomatous, growing short.

semihorizontal rhizomes from crown buds; and creeping-root, which develops adventitious stem shoots from enlarged sections of lateral roots (1). There were more than 80 cultivars on a National list in 1977. Consult with agricultural specialists about superior varieties for specific areas, sites, and purposes.

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Figure 42. Alfalfa (*Medicago sativa*). Plant x 1; flower x 2.



Figure 42. Alfalfa (*Medicago sativa*). Plant x 1; flower x 2.

## YELLOW SWEETCLOVER

*Melilotus officinalis* (L.) Lam.

### ORIGIN

Introduced from Eurasia and either used or escaped in all States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Biennial, cool season, leguminous forb.

First season growth vegetative forming one leafy, branched central stem, fleshy roots, and buds on slightly sunken crowns; second year forming well branched stems 2 to 6 feet tall, flowering, fruiting, and then dying. Leaves trifoliate, dentate-margined, with small narrow stipules. Inflorescence of numerous elongated, loose racemes with small pealike yellow flowers bearing small one-seeded pods which shatter early (1).

Self-seeding in favorable years and dormant seed in soil germinating in subsequent favorable years. Strongly taprooted and containing nitrogen-fixing nodules. Growth resumes in early spring or later in colder areas, flowers in late spring or early summer, and makes fairly good regrowth before flowering but none after maturing. Palatable to livestock and big game in vegetative stages and well used by small mammals and birds. Contains coumarin, giving cut plants distinctive aroma, and causing bleeding disease of livestock; also contains bloating ingredients (1,2).

### ECOLOGICAL RELATIONSHIPS

Tolerant of all soil textures and to soils varying from strongly alkaline to weakly acidic with lower pH limit of 5.5. Especially lush growing on blackland soils derived from limestone in the Texas to Alabama region. Thrives in the over 15 inches MAP zones but vigorous in favorable sites with 12 inches or sometimes less. Vigorous invader and naturalizing on roadcuts and in borrow pits. Only weakly shade-tolerant. Sensitive to grazing during the first growing season. Sensitive to phenoxy herbicides. Cold-tolerant and good drought tolerance. Some fire tolerance when dormant. Strong competitor as seedlings or mature plants; not very compatible with any species except those with strong seedling vigor. Compatible when planted in alternate rows with less competitive species. Tolerant of some flooding and seasonally shallow water tables (1,2,3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

Culture similar to alfalfa. Use scarified seed. Inoculate seed to induce nitrogen-fixation. Drill seed 1/2 to 1 inch deep. Good emergence from 2 inch depths on lighter and drier soils. Plant 20 to 30 PLS per square foot (3 to 5 pounds PLS per acre) for full stands in semiarid zones; increase rate in subhumid zones, for hay, and for harsh sites; use only 1/2 to 2 pounds PLS per acre in rangeland seedings to keep proportion of clover always at less than 50 percent of stands in order to minimize bloat hazard. Sow in late winter to early spring in warmer to cooler plains and foothill areas for maximum first season pasture; otherwise, before the moistest growing season (1,2).

#### Seed Cleaning and Quality

Combine standing crop following use of desiccants or windrow crop with damp atmosphere when pods brown or black. Use pickup combine after 4 or 5 drying days. Seed quality: 95 percent purity; 90 percent germination; 85 percent PLS; and 262,000 seed per pound (3).

#### Germination and Seedling Characteristics

Most seeds germinate rapidly within 7 days but the "hard" seeds are delayed unless scarified. Strong seedling vigor; usually makes a good cover first season with considerable grazing possible in areas with longer growing seasons.

## MANAGEMENT

Peer plant for soil improvement purposes. Widely used for temporary pasture, hay and silage crops; and quick cover on disturbed lands; requires liming of acid soils for good performance. Plants are valuable wildlife food for mammals and birds. Weed control not commonly used, but may be grown with a grain companion crop to suppress weeds in seedling stands when grain harvested early. Graze conservatively first season before August 15 in northern Great Plains-Corn Belt regions or September in southern regions to allow carbohydrate root storage. Second year sweetclover should be grazed when 8 to 10 inches tall and rather heavily during stem elongation period to keep it from becoming stemmy and unpalatable. Graze perennial grass-sweetclover mixtures conservatively to permit some self-seeding of clover for future years.

## ASSOCIATED SPECIES

Commonly sown in mixtures with companion grain crops in humid regions, with high-yielding tame pasture grasses such as smooth brome grass (*Bromus inermis*), or seeded at low rates in range restoration and soil stabilization seedings for added benefits of soil nitrogen and dietary protein.

## PESTS AND DISEASES

Sweetclover weevil, sweetclover root borers, sweetclover aphids, and grasshoppers are major pests. First and last destroy stands, former in Corn Belt, latter in rangeland areas. Others (leafhoppers, cutworms, caterpillars, green cloverworms, webworms, and clover leaf weevil) usually minor. Some root rot, black stem, and stem canker to be expected in humid areas, such as Corn Belt.

## IMPROVED VARIETIES

'Madrid', from Spain, has good seedling vigor, resistance to fall freezing, and excellent seed production; 'Goidtop', developed in Wisconsin, has excellent seedling vigor, is 2 weeks later in maturing, higher yielding, and has better quality forage; 'Yukon', a Canadian release, was selected from Madrid and is equal or higher yielding of both forage and seed (2).

White sweetclover  
*Melilotus alba* Desr.

Mostly biennial but some annual forms grown. Biennial similar to *M. officinalis* but coarser stemmed, of poorer forage quality, later maturing, usually taller, and more productive. Thrives in moister areas and sites than yellow sweetclover. Strong invader and volunteering in loose and sandy soils. Somewhat weedy in croplands, but regarded as valuable soil stabilizing and wildlife cover and an important wildlife food plant on strip mine areas in the Central States (6).

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Figure 43. Yellow sweetclover (*Melilotus officinalis*). Plant x 1.

## COMMON SAINFOIN

*Onobrychis viciaefolia* Scop.

### ORIGIN

Introduced from Eurasia, chiefly from Russia and Turkey. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, short-lived, perennial, nonbloating, leguminous forb.

Stems semierect from a branched root crown, mostly 1 to 3 feet tall. Leaves pinnately compound with 11 to 27 elliptic to lance-shaped leaflets and reddish-brown lance-shaped stipule. Numerous showy pink to purple pealike flowers borne in racemes. Olive to brown or black colored, kidney-shaped seeds borne singly in lens-shaped pods with reticulate (net veined) surfaces (1).

Root system a deep, main, taproot with several large and many fine laterals. Growth resumes earlier than alfalfa (*Medicago sativa*) in spring, continues to regrow throughout summer with moisture but more slowly than alfalfa. Makes more than one cutting for hay under irrigation but only one cutting and fair regrowth quantity under dryland conditions. Sainfoin is as palatable and nutritious to livestock as alfalfa; preferred by deer, elk, and sage grouse (2).

### ECOLOGICAL RELATIONSHIPS

Species thrives on deep, fertile, sandy to silty textured soils that are well drained. Also good performance on calcareous soils; tolerant of moderately saline and weakly acidic soils. Short-lived in wet soils; not very productive on shallow soils. Better performance in 16 to 20 inches MAP zones but grows moderately well in the over 13 inches zone. Best performance with adequate irrigation; probably advantageously used in cool season grass mixtures where irrigation water is limited. Tolerant of strong salinity in irrigation water. Some tolerance of manganese concentrations toxic to crops. More winter hardiness than alfalfa; grown in Canada and in mountain valleys of West. Moderate drought resistance, less than alfalfa. Weak shade tolerance. Weakly moderate grazing tolerance; less tolerance and longevity than alfalfa. Moderately strong competitor for a legume; good compatibility with bunchgrasses but not with vigorous rhizomatous species (1,2,3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

Drill pods or shelled seeds 1/2 to 1 inch deep. Broadcasted seed need soil covering of similar depth. Drill 26 pounds PLS per acre for pure stands on dryland or 34 pounds PLS per acre under irrigated conditions. Use 16 to 22 pounds PLS per acre for dryland and 23 to 34 pounds PLS per acre with irrigation when grown with grass in alternate 24 or 28 to 12-inch row spacings, respectively. Plant before the growing season with most favorable conditions for rapid germination and seedling establishment in dryland areas, usually early spring, and, where feasible, on fallowed land. Late spring or early summer seeding satisfactory with irrigation. Inoculate seed with specific inoculum just before planting to induce better nodulation and nitrogen-fixation (1,2,3,4).

#### Seed Cleaning and Quality

Seed ripens over several weeks due to indeterminate growth. Swath seed crop at about 40 percent moisture content or before lower seed pods turn brown; dry in windrow before threshing. Easy to separate weed seed but not grain seed from sainfoin in fanning mill. Seed quality: 90 percent purity; 75 percent germination; 68 percent PLS; and 18,000 seed (in pods) per pound, or 26,000 shelled seed per pound (1,2).

#### Germination and Seedling Characteristics

Seeds germinate quickly in 8 days at 68°F under ideal conditions. Good germination between 60 and 73°F.

Germination delayed an extra week in highly saline soils but not reduced. Good seedling vigor; often some plants head and fair crop made by end of first growing season under favorable conditions (1,2).

## MANAGEMENT

Species seeded for dryland or irrigated hay or pasture, especially in the northern intermountain and western Northern Great Plains. Seedling stands require weed control and grazing protection until well rooted. Optimal management when only one crop (hay/pasture) taken and regrowth stockpiled (left unused) for nutritious, leafy, fall pasture. Can rotate grazing during summer, allowing 12 to 15 inches growth before grazing and 4 to 6 inches stubble after each use. Better seeded with cool season grasses and birdsfoot trefoil (*Lotus corniculatus*) for irrigated haying and stockpiling forage system so birdsfoot trefoil persists after sainfoin dies out in about 5 years. Use NP-starter fertilizers because inoculum only partially effective; fertilize according to soil test afterward. Species has good soil improvement, wildlife food and cover, and aesthetic qualities. Not well suited for extensive disturbed land stabilization purposes due to higher palatability and earlier growth than most associates, resulting in intensive selective overuse by livestock and big game (1,2,3).

## ASSOCIATED SPECIES

Either seeded alone, in grass mixtures, or in alternate row seedings with cool season bunchgrasses. Usually better stand establishment and longevity when grass and sainfoin seeded in alternate rows. When used with birdsfoot trefoil grass mixtures, seed sainfoin with grass and isolate trefoil in alternate rows due to its weaker vigor. Variety of cool season bunchgrasses compatible; few start growth synchronously.

## PESTS AND DISEASES

Minor insect damage from rhizobium-nodule-eating weevil (*Sitona scissifrons*), lygus bug, and sainfoin bruchid. A crown and root rot pathogenic complex limits production and causes rapid stand thinning. Associated with pods wounding seedling and crown tears. Disease more prevalent with irrigated stands.

## IMPROVED VARIETIES

'Eski', developed from a Turkish introduction by Montana Agricultural Experiment Station, is recommended in Montana for dryland pasture in areas with at least 13 MAP or on irrigated land with limited water. 'Remont', also a Montana release, is recommended for irrigated pasture and where more than one hay cutting is possible. It has superior regrowth. 'Meirose' is adapted in Canada and recommended for pasture, hay, and seed in western Canada.

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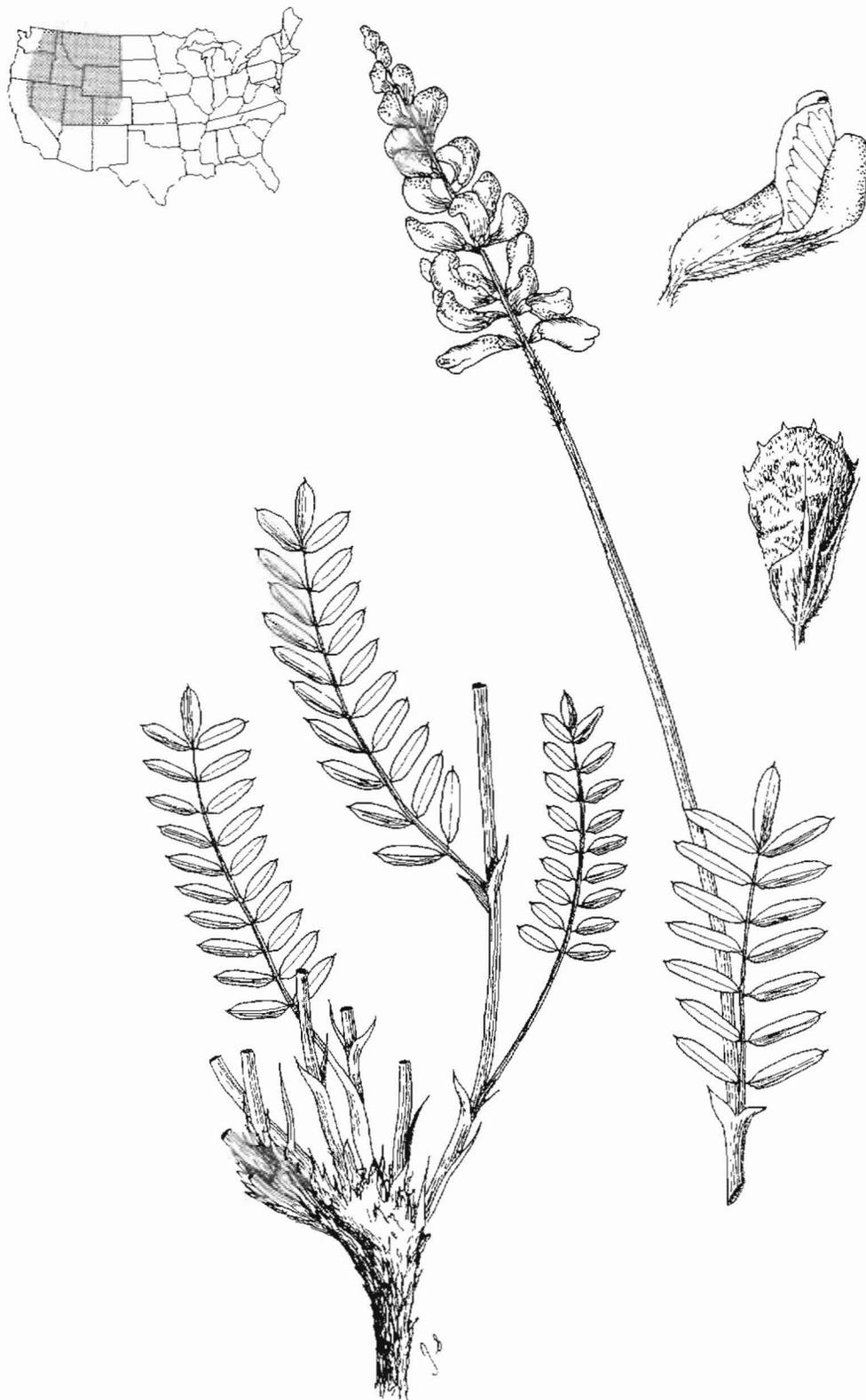


Figure 44. Common sainfoin (*Onobrychis viciaefolia*). Plant x 3/4; flower, pod x 4. (Flower and pod after C. L. Hitchcock et al. 1961).

## ROCKY MOUNTAIN PENSTEMON

*Penstemon strictus* Benth.

### ORIGIN

Native to northeastern Arizona and New Mexico northward to southern Wyoming. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Herbaceous, long-lived, cool season, perennial, flowering forb.

Stems several, smooth, sometimes glaucous, and strictly erect, 1 to 2.5 feet tall. Basal leaves form rosette-like tufts, often purplish in fall. Leaves opposite, petioled, reverse lance-shaped below and lance-shaped and clasping above, often curling or reflexed. Inflorescence a one-sided raceme of numerous ascending flowers, leafy bracted at base with two-lipped, snapdragon-like corollas, deep blue or purple at throat and lighter blue in tube (1).

Great variability in plant size and characteristics. Few large and many fine, fibrous, somewhat shallow roots. Decumbent stems layer: grow roots when in contact with moist soil. Growth commences in early spring, flowers from late May through June, and matures in July at foothill elevations or later at higher elevations. Palatability poor for cattle and sometimes fair for sheep until maturity; only occasional use made by big game and small mammals (2).

### ECOLOGICAL RELATIONSHIPS

Thrives in rocky and sandy loam soils, usually in open shrublands, woodlands, and forests, often on rather thin-soil sites. Range of occurrence includes weakly acidic and alkaline soils. Common and more frequently blooming vigorously in 15 to 20 inches MAP zones. Weakly moderate drought tolerance, vigor and size dependent chiefly on moisture, considerable regional variation among strains and ecotypes. Local strains winter hardy; avoid seed sources from habitats differing greatly from site being seeded. Occurs between 6,000 and 11,000 feet in elevation. Common in semishaded sites; more common in open and exposed sites. Fire sensitive when actively growing; tolerant in dormant state. Moderately compatible with other species and moderately competitive when fully established (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 inch deep on well prepared seedbeds or broadcast and cover with soil to similar depth. May be covered by cultipacking to press seed into soil. Drill 5 pounds PLS per acre for full stands; reduce rate to desired or original percent composition on suitable sites. Seed before the moistest growing season: usually as early as possible in spring; just before or early during summer rainy season in Southwestern mountains; or in late fall to provide prechilling for stimulating germination of small percentage of dormant seeds. With irrigation, seed any time between April or May until late summer, but early enough to permit adequate growth and rooting before killing frosts. Supplemental mulch may aid establishment in very dry, loose, and erosive seedbeds if free of grain/weed seeds, not too dense, and not mold-inducing.

#### Seed Cleaning and Quality

Harvest native seed crop by hand-stripping; dry, chop or mechanically flail, and clean in a fanning mill. Seed quality not standardized: acceptable purity 90 percent; germination 65 percent; PLS 58 percent. About 7 to 8 percent of seeds dormant when tested with tetrazolium chloride (4).

#### Germination and Seedling Characteristics

Viable seeds germinate in about 2 weeks with favorable temperatures and moisture. Seedling vigor good for native perennial forbs but only fair compared to vigorous grasses. Good vegetative growth made by second

season and flowering in third season under irrigation or best dryland growing conditions. Some flowering possible in second year with longer growing seasons, good moisture, and fertility.

#### MANAGEMENT

Fibrous root system and layering indicate potential usefulness in soil stabilization. Long-blooming, attractive flowers and semievergreen, colorful leaves suggest potential value for roadside beautification (2). Plants also have incidental forage values for wildlife and livestock. Species occasionally added to seeding mixtures designed to simulate original vegetation and for variety in game range restoration mixtures. Prior suppression of overstory vegetation may be necessary to aid establishment and periodically afterward to perpetuate seeded stands. Seeding weaker components of mixtures separately and/or in alternating rows with stronger competitors benefits establishment and persistence. Reclamation and improvement projects demand good range and wildlife management for sustained benefits (5).

#### ASSOCIATED SPECIES

Species naturally occurs in shrublands, woodlands, open forests, and parks with big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), Utah and oneseed juniper (*Juniperus osteosperma*; *J. monosperma*), pinyon (*Pinus edulis*), true mountain-mahogany (*Cercocarpus montanus*), Saskatoon and Utah serviceberry (*Amelanchier alnifolia*; *A. utahensis*), mountain snowberry (*Symphoricarpos oreophilus*), Gambel oak (*Quercus gambelii*), ponderosa pine (*Pinus ponderosa*), and numerous other associated graminoids, forbs, and woody plants.

#### PESTS AND DISEASES

Small mammals and rabbits damage stands when abundant; big game also attracted to small seeded acreages. No serious diseases known.

#### IMPROVED VARIETIES

'Bandera', increased and recently released from a collection in ponderosa pine zone in northern New Mexico, has most of the characteristics described for the species and probably is adapted to the natural range of the species (2).

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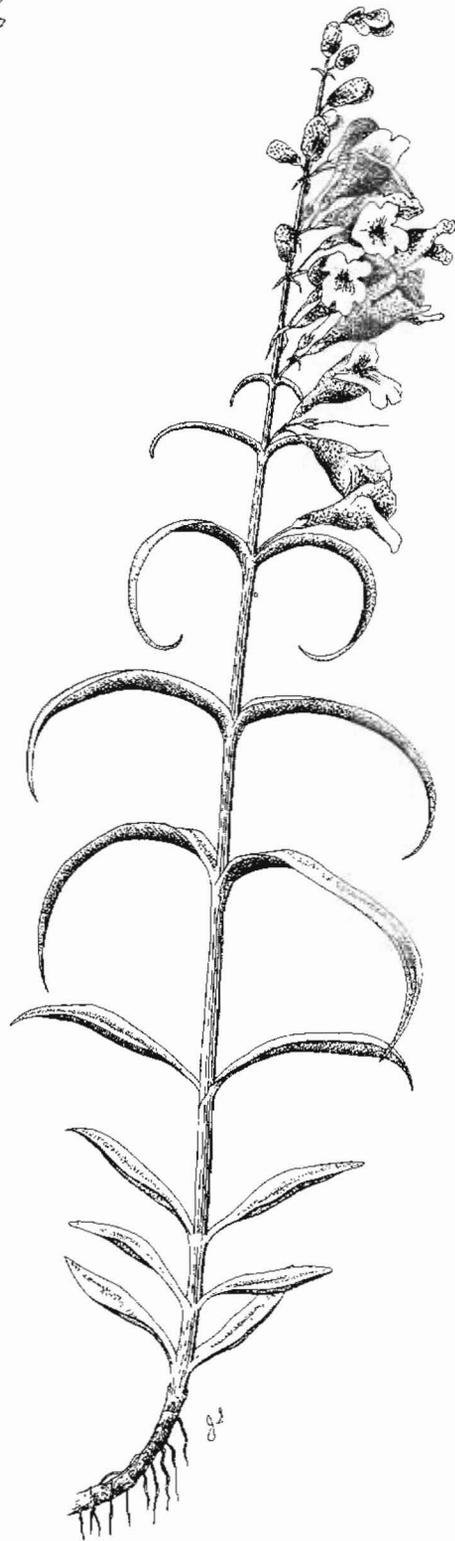


Figure 45. Rocky Mountain penstemon (*Penstemon strictus*). Plant x 1/2.

**PURPLE PRAIRIECLOVER**  
*Petalostemum purpurem* (Vent.) Rydb.  
(= *Dalea purpurea* Vent.)

**ORIGIN**

Native to Great Plains and adjacent areas. See map for distribution in the U.S.

**SPECIES CHARACTERISTICS**

Warm season, perennial, herbaceous legume.

Stems several, branched, streaked, and ascending or erect 1 to 3 feet tall. Leaves stalked typically with five (three to seven) linear to broader leaflets, gland-dotted below and folded. Inflorescence a dense oblong to cylindrical terminal spike, 1/2 to 2 inches long, composed of numerous small rose-purple flowers bearing one or two-seeded pods shorter than the hairy calyx. Flowers not truly pealike, only one petal well developed (1).

Woody taproot and several surficial branches with a few vertical rootstocks. Plants resume growth in mid to late spring, flower from late May to July or later at higher elevations, and mature seeds during July and August or later. Regrowth potential medium in quantity during the growing season, largely related to available soil moisture. Fairly palatable to sheep, less so to cattle; some use made by birds and small mammals (2).

**ECOLOGICAL RELATIONSHIPS**

Species grows on prairies, plains, and hills with soils ranging from clay loams to loamy sands. Found growing more commonly or vigorously on well drained sites and moderately alkaline calcareous soils. Thrives in 16 to 20 inches MAP zones but found in suitable sites of the 12 to 15 inches zone. Local ecotypes winter-hardy; avoid distant southern or lower altitude sources of seed unless known to be adapted. Species found up to about 7,000 feet in elevation in Rocky Mountains. Moderate drought tolerance; more thrifty in rather open communities. Fair shade tolerance indicated by occurrence in open woodlands. Fair fire tolerance in dormant state; injury in growing state and stimulation of seed germination to be expected. Moderately tolerant of grazing and defoliation. Medium in competitiveness and compatibility (2,3,4).

**CULTURE**

Planting Depth, Rate, and Time

Drill seed 1/4 to 1/2 inch deep in a well prepared seedbed. Broadcasted seed needs to be covered with soil to similar depths. Drill 20 PLS per square foot (3 pounds (PLS) per acre) for full stands. Reduce rate to desired percent composition in mixtures or to prairieclover's composition in climax or good condition rangelands. Use no more than 1 pound per acre in native grass mixtures. Drill seed in spring that has been dry-prechilled at 4°C overwinter or seed in spring or fall with seed that has been dry-stored at room temperature for a year. Drill scarified seed before the moistest growing season. Seed should be inoculated before planting on sites lacking any prairieclover history (5,6).

Seed Cleaning and Quality

Collect seed from native stands by hand-stripping pods; process by mechanically flailing or hammermilling and recleaning in fanning mill. Field stands can be combined and cleaned in fanning mill. Seed quality not standardized: acceptable purity 95 percent; germination (including 5 to 25 percent hard seed) 80 percent or better; 76 percent PLS; and 275,000 seed per pound (5,6).

Germination and Seedling Characteristics

Most seeds germinate in 7 to 10 days in standard seed testing; 50 percent of dry-prechilled seed germinate in 2 to 3 days. Seedling vigor medium; poor stands result from transplanting seedlings directly into sod without reducing competition; good stands obtained by seeding when competition reduced (3,4).

**MANAGEMENT**

Potentially useful plants in roadside and rest areas, gardens, park and recreation areas, and for reestablishing prairies. Species also used in mixtures on dam structures and critical areas. The following

forb seed mixture optionally added to range site seed mixtures on other than wetlands in adapted zones in Nebraska.

Purple prairieclover ( <i>Petalostemum purpurem</i> )	0.2 pounds PLS per acre
Pitcher sage ( <i>Salvia azurea</i> vs. <i>grandiflora</i> )	0.2 pounds PLS per acre
Maximilian sunflower ( <i>Helianthus maxmiliani</i> )	0.5 pounds PLS per acre

Control weeds when they become a problem, noting forb sensitivity to phenoxy herbicides, and withhold grazing of seedling stands. Moderate defoliation to 4 to 6-inch stubble about 1 month before normal blooming may stimulate dormant bud development and longer and showier floral display. Deferring later defoliation until after fall dormancy restores energy to roots for overwintering and vigorous spring growth and allows self-seeding. Conservative harvesting with periodic rests during growing season and legume persistence will minimize maintenance (3,4).

#### ASSOCIATED SPECIES

Species naturally occurs with nonwetland tall, true, and mixed prairie associates, such as the following; either seeded with them or transplanted into existing stands (with more success as year-old plantlets): big bluestem (*Andropogon gerardii*); little bluestem (*Schizachyrium scoparium*); and sideoats grama (*Bouteloua curtipendula*). Such mixtures, when used for prairie restoration, include several other forb species and may include low shrubs, such as leadplant amorphia (*Amorpha canescens*). Better stand establishment ensured by planting weaker and stronger competitive species in separate or alternate rows.

#### PESTS AND DISEASES

Grasshoppers and small mammals in moderate numbers endanger seedling stands. No serious diseases known, although rusts and a root rot have been reported on prairieclover. Green seed left in pods after seed harvesting quickly infected by fungi.

#### IMPROVED VARIETIES

'Kaneb', developed from several seed accessions at Manhattan, Kansas, is widely adapted to other than wetland sites in Nebraska, eastern Colorado, Kansas, Oklahoma, Texas, and New Mexico, and has performed well as far north as Bismarck, North Dakota, and Bridger, Montana (2,3,6).

White prairieclover  
*Petalostemum candidum* Michx.

White prairieclover is similar to *P. purpureum*, differing in white flowers, often more decumbent spreading growth form, five to seven leaflets, and in its tolerance of less precipitation and somewhat coarser, drier, and disturbed soils/sites. Distributions overlap and *P. candidum* extends into Mississippi and Mexico.

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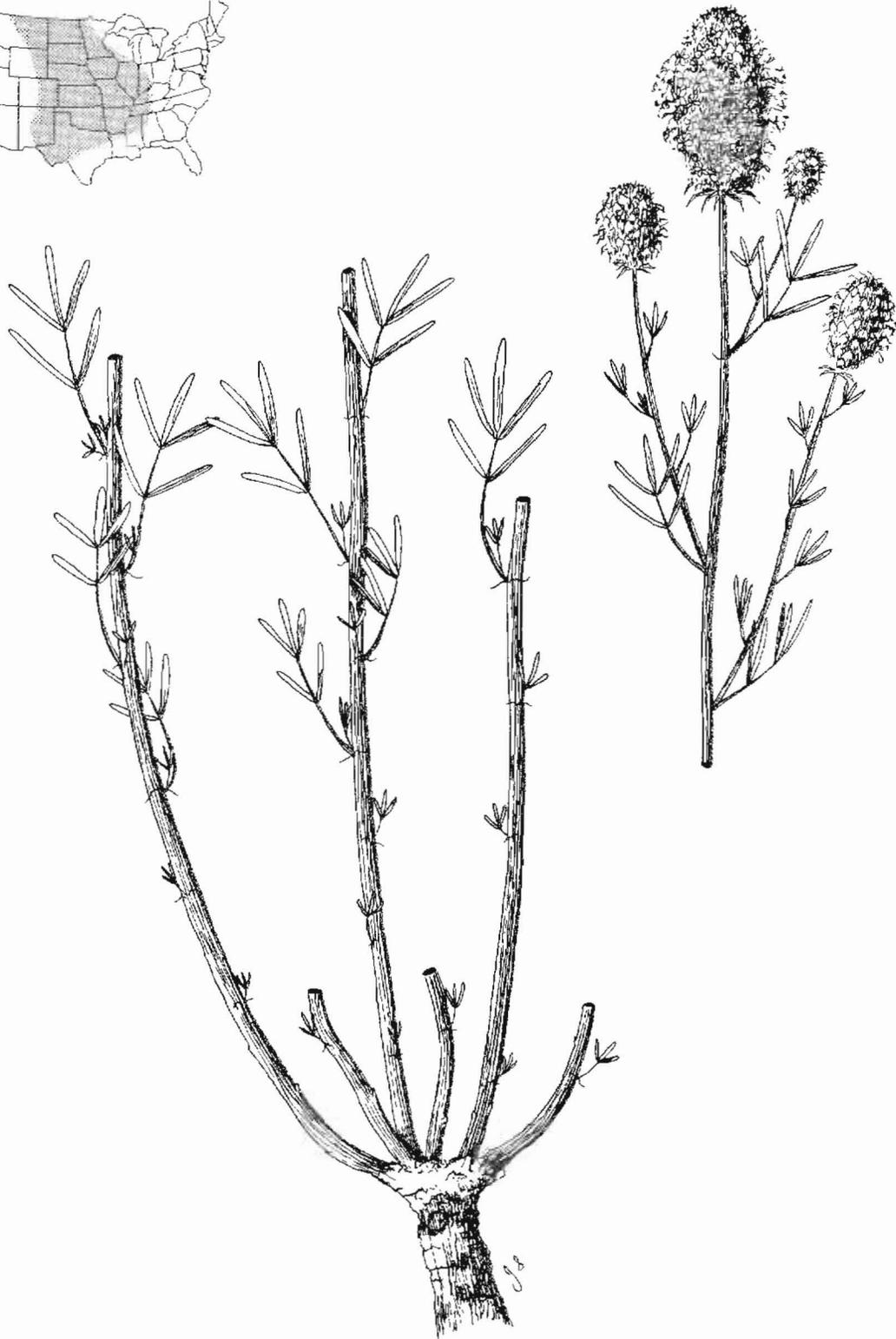


Figure 46. Purple prairieclover (*Petalostemum purpureum*). Plant x 1.

## UPRIGHT PRAIRIECONEFLOWER

*Ratibida columnaris* (Sims.) D. Don.

### ORIGIN

Native to Great Plains and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, herbaceous, nonleguminous, perennial forb.

Stems upright, minutely hairy and branching both above and from a woody caudex, 1 to 3 feet tall. Leaves borne at midstem, alternate and divided into five to seven narrow segments. Flowers showy, borne in terminal heads of yellow to purple, drooping ray, outer flowers and green to brownish disk flowers on a cone-shaped column (receptacle) producing angular, winged achenes (1).

Plants with relatively shallow taproots and branch roots and developing short rootstocks. Species resumes growth in spring, flowers from May to August in various parts of its range, matures from July to September, and regrows vegetatively somewhat in proportion to moisture up until maturity. Palatable to livestock prior to heading. Flowers and heads distinctive and aesthetic (1,2).

### ECOLOGICAL RELATIONSHIPS

Widely distributed in prairies, plains, and open shrublands and woodlands in subhumid to semiarid zones. Thrives on deep, well-drained loams but found growing in thin, rocky, gravelly, and sandy soils. Tolerant of weakly acidic to moderately alkaline and weakly saline soils. More vigorous in 15 to 20 inches MAP zones; less frequent but growing in 10 to 15 inches zones. Local ecotypes and strains developed from them winter hardy; make certain southern and lower elevation sources are fully adapted. Weak shade tolerance and usually found in open or exposed sites. Fire sensitive when actively growing; tolerant in dormant state. Variable grazing responder often increasing in mixtures with more palatable species but decreasing in many mixed prairies lacking other palatable forbs (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 to 1/2 inch deep in well prepared, firm seedbeds or broadcast and press seed into soil by cultipacking or by rolling with a weighted lawn roller for small projects. Plant 20 to 30 PLS per square foot (1 to 1 1/2 pounds PLS per acre) for full stands on semiarid sites; increase rate 50 to 100 percent for humid zones, critical or erosive sites, and poor seedbeds. Decrease rate in seed mixtures to either desired or original percent composition on seeding site. No more than 1/4 pound PLS per acre recommended for prairie or plains mixtures. Plant before the moistest growing season that meets germination and seedling growth requirements. Planting dry-stored seed in spring, when soil temperatures approximate 68°F, probably best in Northern Great Plains. Transplanting year-old plantlets successful in prairie restorations; interseeding with other prairieconeflowers successful but better stands result when competition fully reduced prior to seeding (3,4).

#### Seed Cleaning and Quality

Hand-strip seed of small stands, mechanically flail or hammermill, and clean in a fanning mill. Field plantings can be direct-combined, hammermilled, and recleaned in fanning mill. Seed quality not standardized: 90 percent purity; 65 percent germination (average of 10 commercial lots); 58 percent PLS; and 900,000 seed per pound (3,4,5,6).

#### Germination and Seedling Characteristics

Seeds germinate in 27-day period in seed testing; about 50 percent germinate in 7 days. Seedling vigor not reported but expected to be only fair due to small seed energy and somewhat slow and variable emergence.

Probably will require second growing season to flower like closely related pinnate prairieconeflower, *R. pinnata* (4,5,6).

#### MANAGEMENT

Species recommended for use in roadsides and rest areas, gardens, park and recreation areas, and for reestablishing prairies. Better stands and persistence expected by planting weakly competitive species separate or in alternate rows with stronger competitors. Careful grazing may aid stand establishment when direct seeding or transplanting into prairie-like sod; also with other seedings using prairie species. Defoliation of established stands to about a 6-inch stubble 2 weeks to 1 month before normal flowering may force lateral buds, produce bushier growth, compacter floral displays, and prolong flowering. Withholding subsequent defoliation until after fall dormancy ensures some self-seeding and more vigorous plants. Well adapted and compatible native plant mixtures usually require minimum maintenance (3,5,6).

#### ASSOCIATED SPECIES

Species commonly grows in mixed stands with little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), western wheatgrass (*Agropyron smithii*), blue grama (*B. gracilis*), and a variety of other forbs and a few shrubs in Great Plains grasslands. Occurs less frequently in eastern and western woodlands and shrublands and also with tallgrass prairie vegetation. It can be seeded with these and similar native, usually warm season, grass or grass-forb mixtures for variety, beautification, and as a conspicuous native prairie species.

#### PESTS AND DISEASES

None reported; grasshoppers might damage seedling stands.

#### IMPROVED VARIETIES

None. Few accessions under observation.

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Figure 47. Upright prairieconeflower (*Ratibida columnaris*). Plant x 1/2.

## SMALL BURNET

*Sanguisorba minor* Scop.

### ORIGIN

Native to Eurasia. Locally used in cooler areas of West and occasionally escaped in Northcentral and Northeastern States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, herbaceous, long-lived, perennial, evergreen forb.

Plants tufted with many ascending stems 1/2 to 2 feet tall arising from a branched caudex. Leaves petioled, stipulate, and unevenly pinnately compound with small egg-shaped, dissected leaflets. Flowers unisexual or bisexual, borne in a dense head or terminal spike. Flowers without petal produce a 4-ribbed woody achene fruit enclosed in a persistent thimble-shaped calyx (1).

Plants potentially good self-seeders and have taproots and short rootstocks. Growth resumes in early spring, blooms in early summer, and matures in late summer, varying regionally and with environmental conditions. Flower and seed development is indeterminate, from bottom to top. Palatability good to livestock and big game, especially in late winter and spring. Seeds consumed by birds and avidly by rodents (1,2).

### ECOLOGICAL RELATIONSHIPS

Species well adapted to sandy and clayey textured soils and optimal in silty and loamy soils. Tolerant of moderately saline, moderately alkaline, and relatively infertile soils. Not well adapted to poorly drained soils which have shallow water tables. Well adapted to 12 inches or more MAP zones in full sunlight but tolerant of partial shade in open shrublands and woodlands. Species with good winter hardiness but potentially variable from commercial "common" seed. 'Delar' variety has withstood -33°F with minimal snow cover. Moderately tolerant of grazing but can be thinned and dwarfed by too intense defoliation. Good compatibility with other species in seeding mixtures and stands. Usually fire-resistant due to evergreenness and succulence (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed at 1/4 to 3/4 inch depths in seedbeds as weed free and firm as possible. Adapt depth to soil texture, moisture, and firmness; seed slightly deeper in fall than spring. Cover broadcasted seed with soil to similar depths. About 20 to 30 PLS per square foot (20 to 30 pounds PLS per acre) will produce a full stand. Reduce rate proportionately to composition desired in seeded stands; usually 1 to 3 pounds PLS per acre recommended in seeding mixtures. Increase rates 50 to 100 percent when broadcasting and for seeding disturbed lands, harsh sites, and critical areas. Supplemental mulching; light, frequent irrigation; and fertilization to correct nutrient deficiencies may aid stand establishment on the difficult sites. Dryland sites should be seeded before the growing season that has adequate surface moisture for rapid germination and seedling establishment. Late fall in the intermountain region, early spring or late fall in northern Great Plains and Midwest, and either late fall or early to midsummer for mountain seedings commonly recommended. Successful seeding possible from an early spring to July or August with irrigation. Also possible to propagate by root divisions (4).

#### Seed Cleaning and Quality

Harvest small lots of seed by hand-stripping; dry and clean in a fanning mill. Direct-combine row plantings or seed fields with platform set high to harvest most seed but least green material. Dry seed to prevent heating. Possible to swath and combine with pick-up attachment after drying in the field but with more seed loss. Cleaning in a fanning mill produces a commercial product. Seed quality not standardized: 95 percent purity; 70 percent germination; 66 percent PLS; and about 50,000 seed per pound. 'Delar' variety has about 42,000 seed per pound (2,4,5).

## Germination and Seedling Characteristics

Seeds germinate and emerge readily but stands develop rather slowly and are not fully established before a second growing season (4,5).

## MANAGEMENT

Species recommended in seed mixtures used for revegetating rangelands, minespoils, game range restorations, and for other disturbed areas. In Utah, recommended for use in range restorations in juniper-pinyon, mountain brush, blackbrush, big sagebrush, and shadscale saltbush types. Occasionally included in higher elevation seedings in Rocky Mountains and sometimes grown in gardens. Protect seedling stands from grazing or reduce stocking, and control weeds before they suppress seedlings. Burnet is sensitive to many herbicides and their safe use has not been developed. Practice good vegetation management; make moderate use of herbage (not over 50 percent) and provide periodic rests to encourage some self-seeding and ensure greater stand longevity (2,3,4).

## ASSOCIATED SPECIES

Species sometimes used as minor component in grass, grass-legume, or more complex seeding mixtures because of advantages of evergreen leaves, color, attractive foliage, game cover and food, and for diversity in plant species, nutrition, and seasonal herbage supply.

## PESTS AND DISEASES

Rodents seek out seed and reduce stands and reproductive potential. Small acreages of evergreen or very early growing herbage attract wildlife and damage by otherwise normal populations. Grasshoppers menace both stands and herbage. Minor leaf spots, rusts, and powdery mildew occur.

## IMPROVED VARIETIES

'Delar', recommended for planting in the intermountain region, has most of the characteristics of the species and very good winter hardiness (4).

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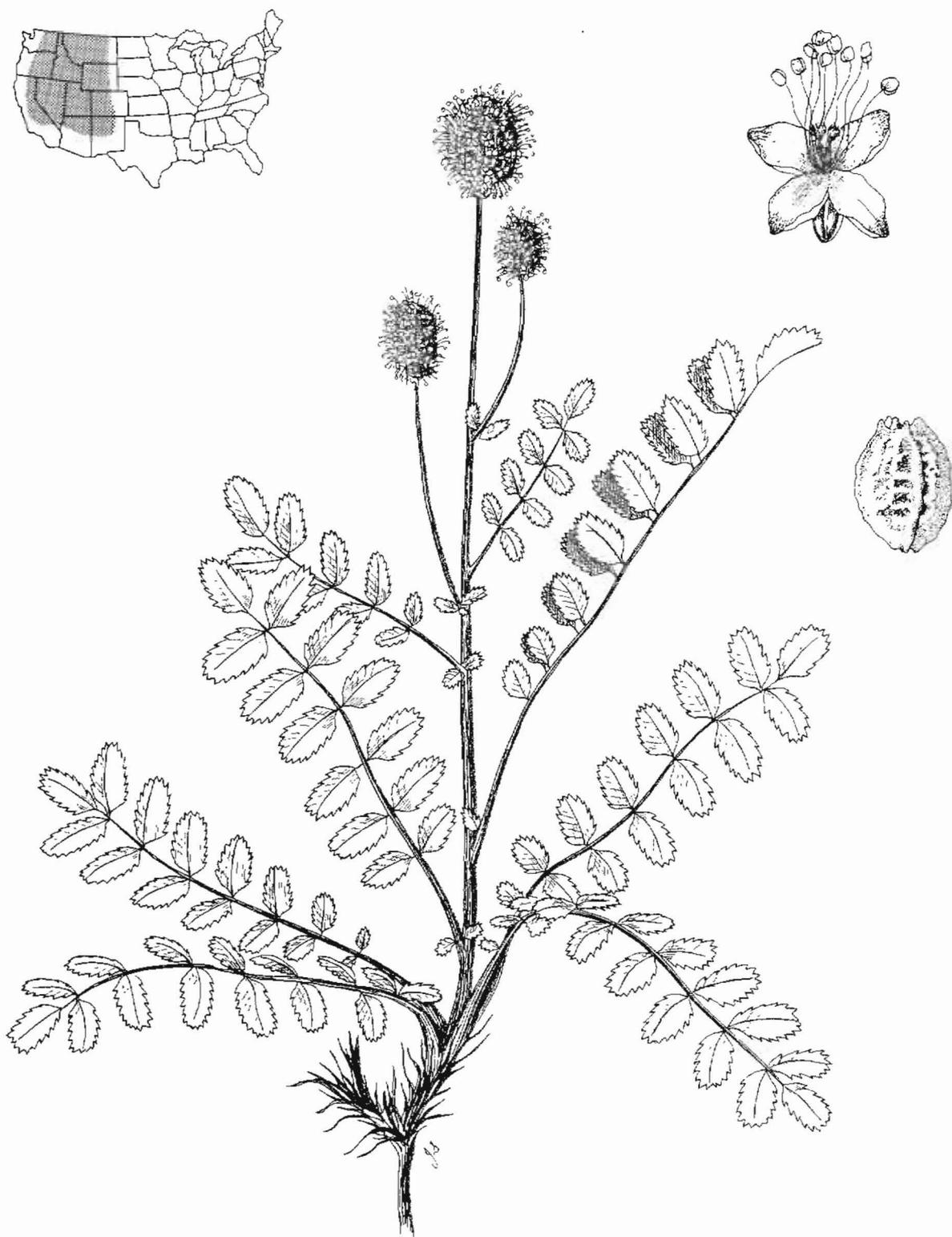


Figure 48. Small burnet (*Sanguisorba minor*). Plant x 2/3; flower x 10; mature calyx x 5. (Flower and calyx after C. L. Hitchcock et al. 1961.)

## MISSOURI GOLDENROD

*Solidago missouriensis* Nutt.

### ORIGIN

Native to Midwest and Western States. See map for distribution of the U.S.

### SPECIES CHARACTERISTICS

Warm season, herbaceous, perennial forb.

Stems mostly 1 to 2 feet tall, erect, and often clustered from short rhizomes. Basal leaves oblanceolate, petioled, and toothed; stem leaves narrow-lance shaped, pointed, and nearly hairless. Inflorescence an arched, one-sided panicle of small, congested, composite flowerheads with about eight yellow rays, fewer than miniature disk flowers, bearing small, variably hairy achenes (1).

Root system rather superficial, mostly from short rhizomes. Plants resume growth in spring to early summer, bloom in various habitats between June and September, mature about 6 weeks later, often shed basal leaves after flowering, and make variable regrowth in summer but little after maturing. Palatability poor for cattle and fair for sheep, especially when leafy and succulent; only incidental uses made by small mammals and birds (2).

### ECOLOGICAL RELATIONSHIPS

Plants common in diverse habitats of dry prairies, plains, foothill shrublands, and open forests of mountains. More common on well-drained sites in silty and clay loam to rocky and sandy loam-textured soils. Species occurs on sites indicative of tolerance of weakly acid to moderately basic and weakly saline soils; often found in open communities with reduced competition along roads, ditches, fences, and where sod is broken. More conspicuous, due to greater vigor and abundance, in 16 to 20 inches MAP zone but present at lower frequency in 12 to 15 inch zone. Habitats of common occurrence associated with winter hardiness, moderate drought tolerance, tolerance of partial shade, and good survival from fire due to rhizomes, especially on damper sites and in dormant state. Similarly, natural occurrence indicates weak compatibility and competitiveness in dense grasslands but moderate aggressiveness and ability to invade and dominate open stands by seeds and/or rhizomes. Goldenrods have a reputation for being good self-seeders and becoming somewhat weedy. Some question whether it is wise to encourage use of such species, especially when costly seed treatment is involved (3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill or broadcast seed at shallow depths and cover with soil not over 1/4 inch deep. May need to be about 1/4 inch deeper when sown with most grasses, despite some loss in stands. Seed about 1/4 pound PLS per acre in pasture mixtures or about twice as much in mixtures for disturbed lands with harsh sites. Plant seed at optimum time for dominant elements in seed mixes or either very early in spring or late fall to induce better germination when planted separately. Well prechilled seed can also be seeded in spring. Better success reported in transplanting 10-week old seedlings into disturbed prairie in midwestern prairie restoration trials, suggesting that rootstock divisions might be equally successful for small projects (3,4,5).

#### Seed Cleaning and Quality

Collection methods unreported; scattered occurrence of wild populations may necessitate hand-stripping, although occasionally patches are large enough to windrow. Process collections by mechanical flailing or trampling, followed by scalping and/or fanning. Seed quality not standardized: acceptable purity probably 80 percent (no reports); germination 12 percent in one test (another report indicated no germination after 5 years storage in dry, unheated shed but 10 percent after 11 years when stained red in tetrazolium chloride). One report of 1,356,000 seed per pound (3,4).

### Germination and Seedling Characteristics

No rate of germination precisely recorded. Considering the miniature size of seed, likely seed energy, and uncertain and probably slow germination of many dormant seed, slow seedling and standard development are predicted.

### MANAGEMENT

Utility of species may include soil stabilization, watershed cover, aesthetics, and diversity in range and wildlife plantings. As mentioned before, transplanting of rootstock divisions or plantlets, while costly and time consuming, may be the only certain way of ensuring stand establishment. Except for sheep, grazing during establishment may suppress competition and enhance establishment. After establishment, grazing or mowing about 1 month before normal flowering may induce more flower buds to open in a compacter pattern and extend flowering where desirable on roadsides and in parks or wild flower gardens. Permitting flowers to mature before any further defoliation in fall may induce greater persistence.

### ASSOCIATED SPECIES

Species occurs in dry prairies, favored sites in mixed prairies, and in open shrublands and forest openings or woodlands; often associated with little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), true mountain-mahogany (*Cercocarpus montanus*), and ponderosa pine (*Pinus ponderosa*) in such communities. May be mixed with native or exotic, usually warm season, grasses and legumes for a variety of revegetation purposes. Such seedings may be more successful if the weaker components are seeded in rows alternating with rows seeded to aggressive members of any seeding complex.

### PESTS AND DISEASES

Rodents and grasshoppers may endanger new seedings. Leaf spots and rusts noted on plants and dodder (*Cuscuta* sp.) sometimes parasitizes stands, especially in more humid regions.

### IMPROVED VARIETIES

None.

Stiff goldenrod  
*Solidago rigida* L.

*S. rigida* is stiffly erect with rather erect branches; short, gray, hairy leaves and stems; and a flat-topped to dome-shaped inflorescence with relatively large, but somewhat less dense, flowers. It occurs from the Continental Divide eastward into the prairies. No germination reported except after dry-prechilling seed treatment; 10 weeks of seed treatment induced poor germination that resulted in only fair direct seeding results compared to excellent and good stands resulting from transplanting 10-week old seedlings and 1-year old plants, respectively (5).

Gray goldenrod  
*Solidago nemoralis*

*S. nemoralis* occurs almost throughout the Great Plains except for drier sections and appears to be better suited to revegetation; good germination is reported without seed treatment in Wisconsin prairie restoration investigations (5).

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### Germination and Seedling Characteristics

No rate of germination precisely recorded. Considering the miniature size of seed, likely seed energy, and uncertain and probably slow germination of many dormant seed, slow seedling and standard development are predicted.

### MANAGEMENT

Utility of species may include soil stabilization, watershed cover, aesthetics, and diversity in range and wildlife plantings. As mentioned before, transplanting of rootstock divisions or plantlets, while costly and time consuming, may be the only certain way of ensuring stand establishment. Except for sheep, grazing during establishment may suppress competition and enhance establishment. After establishment, grazing or mowing about 1 month before normal flowering may induce more flower buds to open in a compacter pattern and extend flowering where desirable on roadsides and in parks or wild flower gardens. Permitting flowers to mature before any further defoliation in fall may induce greater persistence.

### ASSOCIATED SPECIES

Species occurs in dry prairies, favored sites in mixed prairies, and in open shrublands and forest openings or woodlands; often associated with little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), true mountain-mahogany (*Cercocarpus montanus*), and ponderosa pine (*Pinus ponderosa*) in such communities. May be mixed with native or exotic, usually warm season, grasses and legumes for a variety of revegetation purposes. Such seedings may be more successful if the weaker components are seeded in rows alternating with rows seeded to aggressive members of any seeding complex.

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### IMPROVED VARIETIES

None.

Stiff goldenrod  
*Solidago rigida* L.

*S. rigida* is stiffly erect with rather erect branches; short, gray, hairy leaves and stems; and a flat-topped to dome-shaped inflorescence with relatively large, but somewhat less dense, flowers. It occurs from the Continental Divide eastward into the prairies. No germination reported except after dry-prechilling seed treatment; 10 weeks of seed treatment induced poor germination that resulted in only fair direct seeding results compared to excellent and good stands resulting from transplanting 10-week old seedlings and 1-year old plants, respectively (5).

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Figure 49. Missouri goldenrod (*Solidago missouriensis*). Plant x 3/5; ray flower, achene x 5 1/2. (Achene after C. L. Hitchcock et al. 1955.)

## GOOSEBERRY GLOBEMALLOW

*Sphaeralcea grossulariaefolia* (H. & A.) Rydb.

### ORIGIN

Native to Great Basin. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, perennial, nonleguminous forb.

Stems gray-green, erect, 1 to 2 1/2 feet tall, growing from loose tufts. Leaves egg-shaped in outline, palmately three-parted, lower divisions lobed again, like a gooseberry leaf, covered with gray stellate hairs. Inflorescence a compound raceme. Flowers borne on short branches, with showy, reddish petals, central staminal tube, and producing several two-seeded carpels (1).

Branched taproot with several surface feeding roots. Growth resumes in early spring, flowers May to July, and matures June to August, varying largely with elevation. Greens up again in the fall. Moderately palatable to livestock, especially so for sheep, and for big game when green (2).

### ECOLOGICAL RELATIONSHIPS

Species grows on most soil textures, especially from sandy to clay loam; may be found in coarse gravelly and thin soils of foothills. Tolerant of moderately saline, but not sodic, soils. More abundant in open communities and disturbed sites. Semixerophytic and more abundant in the 8 to 12 inch MAP zones than in higher or lower MAP zones. Rather shade-intolerant but grows in openings in juniper-pinyon woodlands. Winter-hardy in Great Basin but may not tolerate dry snow-free winters of the Great Plains. Good grazing tolerance but may be injured by close defoliation in late spring. Weakly moderate in competitiveness; tends to thrive in openings and bare spaces and, for that reason, compatible and useful in mixtures (1,2). Poorly tolerant of fire (3) but globemallows (*Sphaeralcea* spp.) may increase from seed reserves on bare surfaces after disturbances, including fire.

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed less than 1 inch deep, varying with soil texture, moisture, and firmness and quality of seedbed. Plant only about 10 percent of this species in seeding mixtures or use about 1/4 pound PLS per acre. Fall and winter planting dates preferred to take advantage of late winter-early spring moisture and to provide a prechilling seed treatment (4).

#### Seed Cleaning and Quality

Harvest wild populations or small plots by hand-stripping. Dry material, then run through a Dybvig seed cleaner and reclean in a Clipper or fanning mill if necessary. Seed quality not standardized: 90 percent purity; 70-80 percent germination; 62-73 percent PLS; and 500,000 seed per pound (4,5).

#### Germination and Seedling Characteristics

Scarified seed germinate moderately rapidly but untreated seed show considerable delay and poor germination. Once seedlings emerge, they show good vigor and may mature by the second growing season (4). Hard seed germinates better after acid or mechanical scarification or after using diethyl dioxide and at alternating 59 and 72° F temperatures (6).

### MANAGEMENT

Species considered potentially useful in seeding mixtures to stabilize disturbed and eroding lands,

including minespoils, and for range revegetation and roadside beautification. Seedling stands need protection from grazing and trampling and may require mowing to suppress competitors. Graze established stands moderately and provide for periodic rests during growing season to encourage self-seeding and maintain vigor and production (2,4). Species is one of only four forbs considered adapted for revegetation purposes in the salt desert (7). Sheep make 80 percent use of this species on moderately grazed winter ranges.

#### ASSOCIATED SPECIES

Species grows in mixed populations with shadscale saltbush (*Atriplex confertifolia*), spiny hopsage (*Grayia spinosa*), galleta (*Hilaria jamesii*), Utah juniper (*Juniperus osteosperma*), and winterfat (*Ceratoides lanata*). May be seeded with them and other native species or with introduced grasses adapted to Great Basin sites. Separation of stronger competitors and seeding either separately or in alternate rows with weaker competitors often aids establishment of better stands which persist longer.

#### PESTS AND DISEASES

Moderate to high population levels of jackrabbits, rodents, and grasshoppers or Mormon-crickets damage seedlings and sometimes established stands. Minor rusts reported on plants.

#### IMPROVED VARIETIES

None.

Scarlet globemallow  
*Sphaeralcea coccinea* (Pursh) Rydb.

*S. coccinea* is primarily a Great Plains species, similar to gooseberry globemallow but shorter, with more finely divided leaves and widely spreading rhizomes, more commonly found on clayey soils and disturbed sites. Used some by antelope, livestock, and small mammals; has some potential for use in seeding mixtures to stabilize disturbed areas, such as gullies and roadsides. Flowers are attractive and bloom May to July or longer with favorable moisture. It is a low producing plant.

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Figure 50. Gooseberry globemallow (*Sphaeralcea grossulariaefolia*). Plant x 1.

## WHITE CLOVER

*Trifolium repens* L.

### ORIGIN

Introduced from Eurasia, widely used and escaped in moist areas of United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Prostrate growing, perennial, herbaceous legume.

Stems freely branching from base, stoloniferous and rooting at nodes but sometimes erect. Leaves stipulate, petioled, trifoliate; leaflets reverse egg-shaped, usually finely to coarsely toothed, and blotched with white at base. Inflorescence a nearly round flower head of many small pealike flowers having green, narrow-toothed calyxes and white or pinkish corollas producing four to five-seeded miniature pods (1).

Polymorphic species with small, prostrate, wild or common types often of large diameter; others large, upright, and tall; many intermediate types. Initially taprooted but later replaced by finer branched root system. Plants resume growth in early to midspring or later in higher elevations and latitudes; flower in May to July or summerlong in cooler, moist areas but become semidormant under hot, dry conditions; mature about 3 weeks to 1 month later; and make abundant regrowth in summer but less in fall. Good palatability to domestic and wild herbivores, especially in summer; seeds consumed by a variety of birds. Occasionally may cause bloat in ruminants and contains estrogens that may induce animal reproductive problems (2,3).

### ECOLOGICAL RELATIONSHIPS

Species thrives in clay to silt loam soils; not very tolerant of wet soils but can be grown in sandy soils having a high water table if soil reaction and nutrient deficiencies are corrected by liming and fertilization. Tolerant of soils weakly acid to weakly basic in reaction but not tolerant of soil salinity. Thrives in cool temperate and humid climates. Best adapted to over 20 inches MAP zones. Strains and sources variable in winter hardiness; small types from New York and Idaho origin most reliable. Species exhibits remarkable elevational adaptation from near sea level to the alpine; exhibits similar latitudinal tolerances. Moderately drought-tolerant, thrives in full sunlight, and declines with grassy overstory but grows in partial shade of aspen and oak woodlands. Three types of clovers (large, intermediate, and small) exhibit increasing tolerances to grazing in order listed. Species grows on sites not frequently burned but is vulnerable in actively growing state; tolerant when dormant with damp soils; capable of survival by hard seeds. Compatible with grasses when grass is closely defoliated (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill or broadcast and cover seed with soil 1/4 to 1/2 inch deep in a well prepared seedbed. Drill grass and clover seed in alternate rows where feasible; otherwise, seed at different times and in approximately opposite directions or overseed clover to avoid cross-contour seeding. Drill 2 to 4 pounds per acre in grass mixtures in humid regions or with irrigation; 1 pound PLS per acre is adequate for grass mixtures in dryland western sites. Drill seed in spring or late fall in cooler climates to avoid frost-heaving and winterkill. Late summer seedings satisfactory in warm temperate and southern climates with adequate moisture or under irrigation. Inoculate seed with proper rhizobium just before seeding. Interestingly, some natural reseeding of clover accomplished by intact seeds scarified in passing through alimentary tracts of animals (2,3).

#### Seed Cleaning and Quality

Pasture seed crops are mowed, swathed, and combined by making skillful adjustments of equipment. Clean threshing done in a clover huller and preliminary recleaning in a fanning mill but commercial recleaning necessary for quality product. Seed fields grown under irrigation with beehives for better

pollination can be combined out of windrow or direct-combined after spray curing. Seed quality: 96 percent purity; 90 percent germination, including moderate hard seed content; 86 percent PLS; and about 825,000 seed per pound.

### Germination and Seedling Characteristics

Seed germinate rapidly in 7 days under ideal conditions. Only fair in seedling vigor, not establishing good stands until second or third season, varying with growing conditions and length of growing season (2).

### MANAGEMENT

Important as pasture legume and useful for stabilizing disturbed and eroding land surfaces, including mine spoils and roadsides. Included in grass-forb mixtures and wildlife food plantings; also used in lawns and turf planting and for interseeding and overseeding depleted or renovated bluegrass and other pastures. Protection from close grazing and weed control needed during seedling year. Fertilize to correct tested soil deficiencies, especially of phosphates. Should be grazed or defoliated moderately close during rapid grass elongation stages to reduce competition and maintain vigorous growth and persistence of clover (3).

### ASSOCIATED SPECIES

Species commonly seeded with tame pasture grasses [smooth brome (*Bromus inermis*), timothy (*Phleum pratense*), and orchardgrass (*Dactylis glomerata*)] for N-fixation and improvement of soil fertility and nutrition; also seeded with bluegrasses (*Poa* spp.) and other turf-forming grasses to eliminate need of costly N fertilizers and with hardy high altitude or sod-forming grass for disturbed land stabilization and forage production benefits.

### PESTS AND DISEASES

Stands menaced by rabbits and small mammals and several insects, chiefly potato leafhoppers. A stolon and root rot complex, including several pathogenic organisms, may deplete stands; virus diseases are objects of continuing research because the problem is only partially alleviated by improved cultural practices and use of adapted plant materials (3).

### IMPROVED VARIETIES

Several cultivars of the large Ladino-type (sometimes considered a botanical variety) and a variety of sources of small and intermediate types exist. Consult with plant materials specialists for adapted material for specific purposes in your area.

Red clover

*Trifolium pratense* L.

European biennial or short-lived perennial; usually taller than wild white clovers; tufted without stolons, but with larger, oblong, hairy leaflets, white-blotched in center, and having larger rose-purple flowerheads. Strong seedling vigor; one-cut, late types produce leafy rosettes first year; early two-cut types head out first year. Thrives in cool and humid or irrigated areas; less drought-tolerant than alfalfa. Tolerant of moderately acid to neutral soils, better performing with pH of at least 6; not tolerant of salinity. Thrives on fertile, well-drained soils with high moisture-holding capacity; better adapted on medium to fine-textured soils. Usually demands good soil phosphate content for best performance. Commonly used in short rotation hay crops but included in some irrigated or humid pasture mixtures for its quick, short term establishment. Useful in surface-mined land reclamation for contributions to N fertility and diversity in wildlife plantings. Provides inadequate winter cover alone and needs to be seeded with long-lived perennial grasses. Can be seeded in spring in North or early fall in South. Consult with plant materials specialists for superior varieties adapted to your area and purposes (5).

Strawberry clover

*Trifolium fragiferum* L.

Southwest Asian, prostrate growing, pasture type, stoloniferous legume with creeping stems that root at

the nodes. Leaves similar to white clover but without white splotching. Distinctive round flower head, pink to white in color, resembling strawberry fruits. Valuable for its tolerance of moderately saline, alkaline, and seepy soil conditions and of 1 to 2 months of flooding; not sufficiently productive to justify use on drylands. Good winter hardiness except for Shearman's variety. Close grazing required to maintain clover in grass-legume mixtures, but plants should be rested from grazing in the fall.

Species has been established in most Western States but considerable variation in hardiness and production likely from various environments. Species shows good promise for seeding in lawn or turfgrass mixtures for lawns, parkways, and low slopes and drainages along highways where soils are salty or are accumulating salt from highway and walkway deicing. Likely useful for reclamation of wet, saline areas around surface mined coal operations.

Alsike clover  
*Trifolium hybridum*

European, short-lived, perennial or biennial legume, of tillering habit, has smooth prostrate to ascending stems that bear pink and white blossoms in dense, globose heads. Species tolerant of acid and basic-reacting soils and wet sites. Best used with timothy and red clover in wet meadows or under irrigation. Naturally escapes in wet sites, such as road borrow pits and along drainages, suggesting utility, but shorter lived and provides less cover and soil binding than white clover in most situations.

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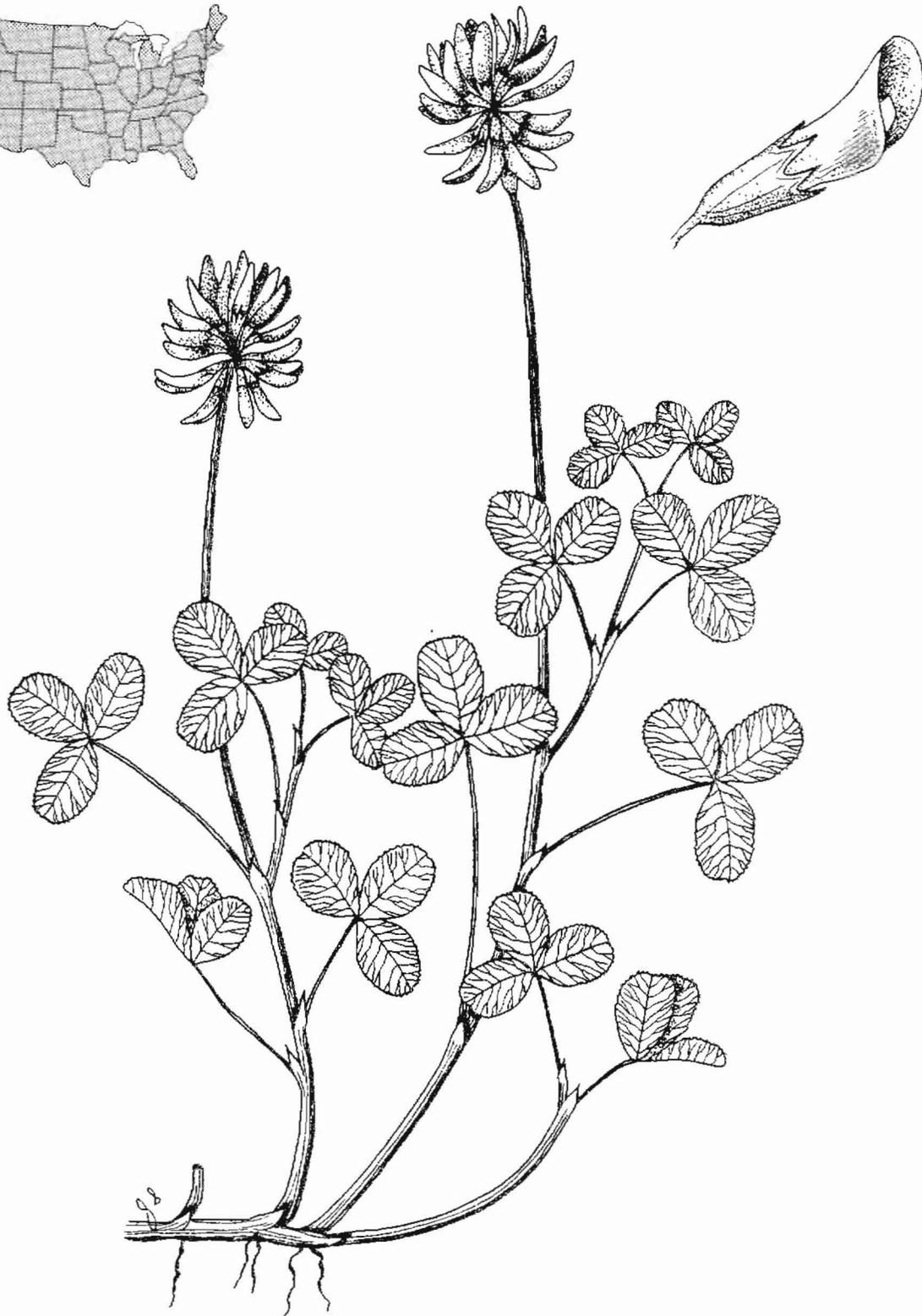


Figure 51. White clover (*Trifolium repens*). Plant x 1 1/2; flower x 4. (Flower after C. L. Hitchcock et al. 1961.)

## AMERICAN VETCH

*Vicia americana* Muhl. ex. Willd.

### ORIGIN

Native to northern United States; extends southward in western mountains. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, perennial, herbaceous, leguminous forb.

Stems angled to four-sided, trailing, ascending or climbing, 0.5 to 2.5 feet tall with spreading, sometimes shallow rhizomes. Leaves pinnate with small, dissected stipules and 8 to 12 leaflets, linear to oval, variable in texture, hairiness, and apex; and terminated by simple, branched, or clasping tendrils. Inflorescence a loose raceme of up to 10 purplish pealike flowers 1/2 to 1 1/2 inches long, each producing a flat pod 1 to 1 1/2 inches long and containing two to several pealike seeds (1).

Plants shallowly to moderately deeply rooted from branched taproots and spreading rhizomes. Species polymorphic with at least three subspecies and numerous ecotypes. Reportedly short-lived in humid regions. Plants renew growth early in spring to early summer, varying with environment; flower from May to August; and mature about 1 month later. Vegetative growth or regrowth continues almost summerlong with available moisture at higher elevations; becomes semi-dormant at lower elevations. Species very palatable to domestic and wild herbivores (2,3).

### ECOLOGICAL RELATIONSHIPS

Various ecotypes adapted to sandy, clayey, or medium-textured soils; usually more abundant in deep, porous loams rich in organic matter in western mountains; often more common in clayey soils, especially on plains and some foothill range sites. Soils vary from slightly acidic to moderately basic, or alkaline, and sometimes moderately saline. Species more abundant in the Douglas fir-aspen, Gambel oak, and ponderosa and lodgepole pine zones receiving over 14 inches MAP; also present in northcentral and prairie regions with over 20 inches MAP. Ecotypes inhabiting plains and saline soil show strong drought tolerance. Strongly cold-tolerant stock found from plains to subalpine elevations; make sure any material used is adapted to area. Many mountain ecotypes are fully shade-tolerant; some other ecotypes are not shade-tolerant or are probably only weakly so. Species is classed as a decreaser; poor in tolerance to grazing and trampling due to high preference for species shown by animals and vulnerability of its trailing stems. Good fire tolerance when dormant. Slow establishment and growth rate and high palatability probably depreciate species' compatibility and usefulness in mixtures without special management (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/2 to 1 1/2 inches deep in coarser and finer textured soils or on moister and drier sites, respectively. Drill enough seed in mixtures to produce desired or original percent composition on sites being seeded; usually 10 to 25 percent composition produced by drilling 4 to 10 PLS per square foot (about 3 to 8 pounds PLS per acre). Greater rates needed for harsh sites, including those eroding and saline. Plant scarified seed before the growing season most favorable for quick germination and seedling establishment, usually in early spring; unscarified seed can be planted in late fall to help break seed dormancy. Large seed amenable to airplane seeding on rough, mountainous terrain.

#### Seed Cleaning and Quality

Seed collection methods not documented but most likely collectable by handstripping from native stands. Collected materials mechanically flailed and cleaned in a clipper cleaner. Field grown stands should be harvestable like pea crops. Seed quality not standardized: purity should be 95 percent or better; germination at least 60 percent; PLS 57 percent or better; and 33,000 seed per pound (5).

### Germination and Seedling Characteristics

Germination rated "good" with strains used in game range restoration in Utah but initial establishment and growth rate only rated "fair", suggesting somewhat weak seedling vigor and/or rate of spread (3).

### MANAGEMENT

Species considered promising for revegetating open and depleted aspen game ranges, including burned over and thinned conifer areas in Utah. Genus also considered important for revegetating coal-mined lands, roadsides and critical site stabilization and beautification, and surface-disturbed lands. Some suppression of competition may be necessary before seeding and periodically afterward. Reduced stocking or withholding grazing will aid stand establishment. Good range and game management essential for sustained benefits.

### ASSOCIATED SPECIES

This polymorphic species occurs in diverse mixtures with prairie, mountain shrub, Gambel oak, aspen, and pine and fir forests and associated park and meadow vegetation.

### PESTS AND DISEASES

Seeds, foliage, and stands vulnerable to insect and rodent damage. Leaf spots, downy mildew, rust, and seed smut reported on plants but seldom of economic importance.

### IMPROVED VARIETIES

None.

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Figure 52. American vetch (*Vicia americana*). Plant x 1/2.

## SASKATOON SERVICEBERRY

*Amelanchier alnifolia* Nutt.

### ORIGIN

Native to Northcentral United States, Northern Great Plains, and Central and Northern Rocky Mountain States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, clump-forming, deciduous shrub or small tree.

Stems numerous, branching, ascending to erect, 3 to 15 feet tall, and growing from root crowns or short rootstocks. Young twigs and buds hairy; leaves alternate, simple, oblong to nearly round, up to 1 by 2 inches in size, with margins toothed above the middle and somewhat hairy beneath. Flowers showy, in short, erect, clustered racemes, having five-lobed, bell-shaped calyxes and five strap-shaped, white petals about 1/2 inch long, bearing red to purple diminutive applelike pome fruit, containing 4 to 10 dark brown seeds with leathery seedcoats (1).

Plants sprout suckers moderately vigorously at base and clumps gradually enlarge. Roots well branched and both deep and surficial. Plants resume growth April to May, flower May to June, and mature July to September. Palatability fair to cattle, especially after midsummer; good palatability to sheep and to deer and elk, varying regionally, seasonally, and with associated plants. Fruit quickly consumed by birds and small mammals after ripening (2).

### ECOLOGICAL RELATIONSHIPS

Species tolerant of most soil textures but thrives in deep, fertile, well-drained, medium-textured soils (3). Commonly occurs in weakly acid to weakly basic soils but not tolerant of saline soils and high water tables. Plants thrive in 16 to over 20 inches MAP zones of ponderosa pine and adjacent semi-shaded woodland and shrubland sites; also present in the 12 to 16 inches zone on moister sites; moderately drought-tolerant. Winter hardy; occurs from near sea level to about 9,000 feet in elevation in Rocky Mountains but probably has geographic races and ecotypes varying in hardiness when used beyond natural ranges. Good fire tolerance of native and established stands; recovers from sprouts in about 3 years. Moderately strong tolerance to close browsing or defoliation. Compatible with other species in natural and seeded stands; sometimes more palatable when dwarfed by herbaceous competition (2).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seeds 1/4 inch deep. Nurserymen seed this species at a rate of 25 PLS per foot of row (4). Reduce seeding rate to obtain desired or original composition on sites being restored or improved. Only 1/2 to 1 pound per acre recommended in game range restoration mixtures (2). Plant unstratified seed in late fall and moist prechilled seed in spring. Transplants or container stock should be planted as early as possible in spring. Moist soil, mulch, and partial shade enhance nursery propagation. Readily propagated in greenhouse from softwood and root cuttings; stands can be established by transplanting seedlings or nursery stock. Using older nursery stock may be advantageous on difficult sites. Bare-rooted stock survived better than container stock in pine zone in South Dakota (5).

#### Seed Cleaning and Quality

Harvest good seed crops as soon as ripe by knocking seed onto a canvas or into hoppers. Either macerate fruit in water and wash over screens or clean in a Dybvig cleaner that separates pulp from seed when used with water, dry products, and reclean in a fanning mill (2,4). Seed quality not standardized: 95 percent purity; 60 percent or more germination; at least 57 percent PLS; and a mean of 61,000 seed per pound (range 36,000 to 113,000) (6).

## Germination and Seedling Characteristics

About half of quality live seed may germinate in 8 days under ideal growing conditions (6). Cold stratification recommended for 4 to 6 months. Germination is epigeal; i.e., the cotyledons act as the absorbers of the stored energy of the seed and are brought above ground (4). Seedlings exhibit good vigor but growth rate is somewhat slow. The species is slow in developing a forage supply and may not flower and reproduce before 10 years or longer, especially on harsh sites (2,5).

## MANAGEMENT

Species used primarily for limited game range restoration and wildlife plantings, occasional windbreak plantings, and for low maintenance or native plant landscaping, primarily in mountain elevations. Reducing on-site plant competition and animal stocking, and separating slower and faster developing or less competitive elements from aggressive elements in seeding mixtures by planting them separately or in alternate rows, strips, or blocks, aids quicker and better stand establishment. Moderate browsing or defoliating with periodic closer use may induce greater twig production and keep the shrubs within reach of browsing and/or grazing animals.

## ASSOCIATED SPECIES

Species naturally occurs mixed with big sagebrush (*Artemisia tridentata*), Gambel oak (*Quercus gambelii*), pinyons (*Pinus* spp.), mountain snowberry (*Symphoricarpos oreophilus*), quaking aspen (*Populus tremuloides*), Douglas-fir (*Pseudotsuga menziesii*), and foothill and/or mountain forbs and grasses. Recommended in seeding mixtures for game range restoration on sunny exposures in the mountain brush type in Utah with a mixture of primarily cool season exotic and native grasses and forbs together with big sagebrush, rabbitbrushes (*Chrysothamnus* spp.), four-wing saltbush (*Atriplex canescens*), antelope bitterbrush (*Purshia tridentata*), golden currant (*Ribes aureum*), mountain-mahoganies (*Cercocarpus* spp.), Mexican cliffrose (*Cowania mexicana*), green Mormon-tea (*Ephedra viridis*), and Woods rose (*Rosa woodsii*) (2).

## PESTS AND DISEASES

Small mammals make liberal use of fruit, seeds, and herbage and are a hazard for new seedlings. Grasshoppers and Mormon-crickets very infrequently reduce leafage. Periodic cicada infestations attack the plant, causing some loss in vigor. Cedar-apple (*Gymnosporangium*) rust causes early defoliation, shoot dieback, and fruit malformations (7). Subject to fireblight (*Erwinia* spp.)

## IMPROVED VARIETIES

None.

Utah serviceberry  
*Amelanchier utahensis* Koehne

A shrub similar to *A. alnifolia*, with finely hairy green to golden-yellow, dry, persistent fruit with smaller seeds; occupies drier ridge and slope habitats in big sagebrush, juniper-pinyon, and aspen communities. More abundant in the southern Great Basin. Species used in place of *A. alnifolia* in seeding big sagebrush and juniper-pinyon game ranges. Earlier grower and bloomer than associated species, good cattle forage, good to excellent sheep and goat browse; deer use chiefly in winter. Persistent dried fruit may be emergency food source for birds and small mammals.

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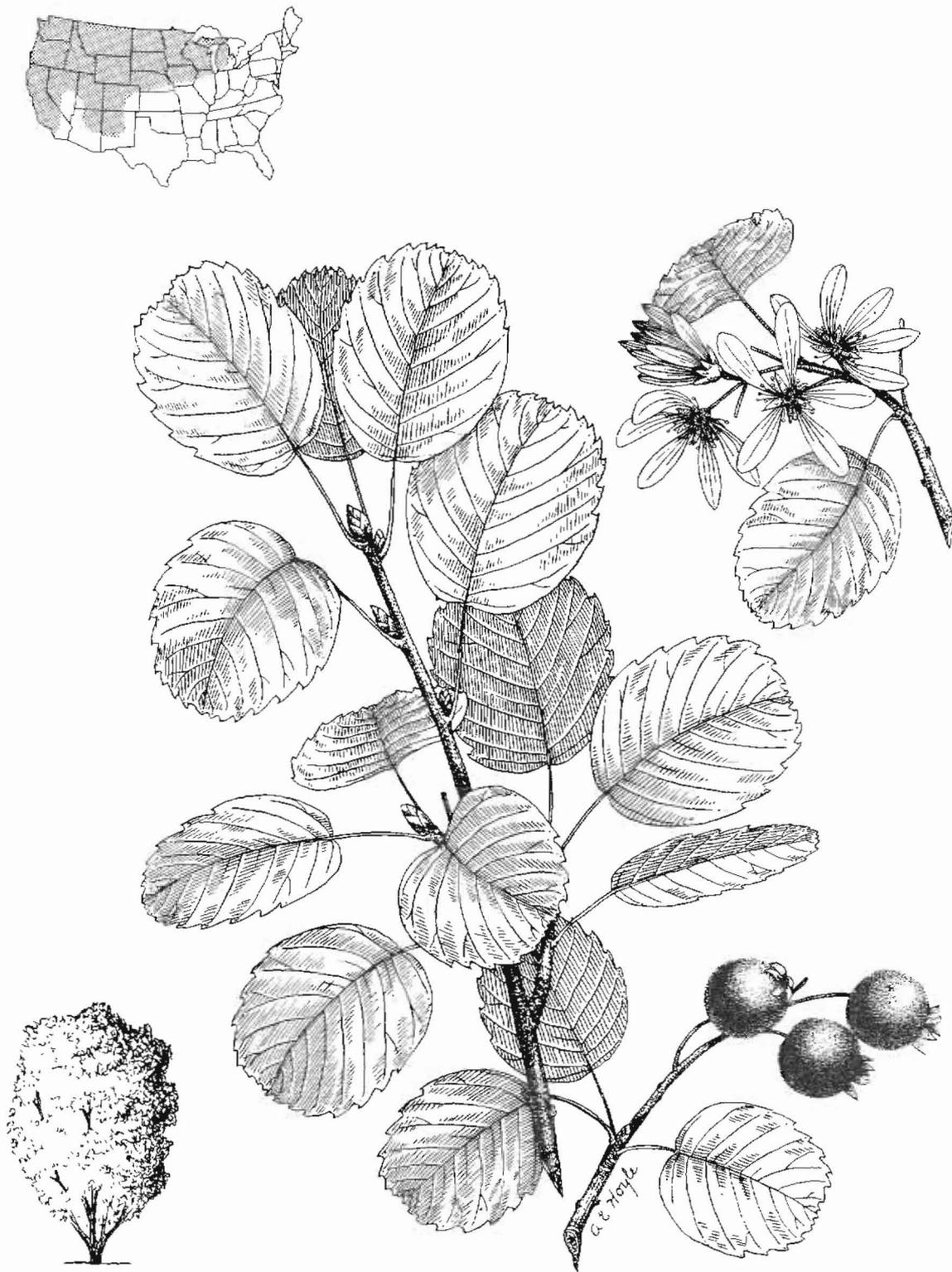


Figure 53. Saskatoon serviceberry (*Amelanchier alnifolia*). Twig x 1/2; pome fruit x 2; flowers x 1/2.

## LEADPLANT AMORPHA

*Amorpha canescens* Pursh

### ORIGIN

Native to Great Plains and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, leguminous, perennial half-shrub.

Stems several, upright, canescent and herbaceous, 1 to 4 feet tall from a woody base. Leaves odd-pinnate with 15 to 45 elliptic to oblong leaflets having abrupt toothlike tips. Inflorescences several terminal spikelike racemes, 4 to 10 inches long, with overlapping showy flowers having villous canescent, five-lobed calyxes and single violet purple petals (the standard), bearing small hairy one- to two-seeded pods (1).

Attractive silvery gray shoestringlike foliage. Deep and branched root system absorbs moisture and nutrients mostly below level of grass roots, minimizing competition. Plants resume growth about May 1, flower in late June and July, mature in August to September, and stay green until frost. Forage of good palatability and nutritive quality. Plants provide valuable cover and incidental food for wildlife (2,3,4).

### ECOLOGICAL RELATIONSHIPS

Thrives in sandy to silt-textured soils. Tolerant of weakly acid to moderately alkaline and to weakly saline soils. Common in over 15 inches MAP zones; more productive in 18 to over 20 inches zone; found infrequently in moisture compensation sites with as little as 12 inches MAP. Strongly winter hardy but avoid using untested seed from distant southern or low altitude sources. Good drought tolerance. Seedlings exhibit good shade tolerance and species grows in partially shaded ravines and open woodlands. Fire tolerance rated good in Utah and good in sandy plains sites when dormant. Intolerant to close grazing and defoliation; species usually reacts as a decreaser in upland prairies and generally has been thinned by close defoliation. Compatible with native prairie associates and tolerant of grasses in seeded stands, particularly after satisfactorily established (2,5).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed at depths two to four times the thickness of seed in humid zones in firm seedbeds and when seeding in spring; four times the depth in semiarid zones, sandy soils, loose seedbeds, and when seeding in fall. Plant 20 to 30 PLS per square foot for rare, full stands of this species. Usually only 1/2 to 1 pound PLS per acre is recommended for seedings in grass or grass-forb mixtures. Plant untreated seed in late fall or very early spring to induce good germination and scarified seed or seed otherwise treated to enhance germination in spring. Species can be propagated by greenwood cuttings in early summer, hardwood cuttings in fall, or by layers or suckers. Transplanting success poor in prairie restorations, probably because competition not adequately reduced (3,4).

#### Seed Cleaning and Quality

Harvest seed from scattered native plants by hand-stripping from terminal branches. Mowing and windrowing large patches recommended. Use mechanical flail, then double clean in clipper cleaner and seed blower. Dry in containers at 41° F. Better germination can be induced by soaking in hot water (180 to 200° F) for 12 hours and moist chilling at 41° F for 30 days before planting. Seed quality not standardized: 98 percent purity; 30 percent germination or better; 29 percent PLS; and 165,000 seed per pound (6).

#### Germination and Seedling Characteristics

Seeds germinate in 14 days in laboratory testing and in 20 days in the field under favorable conditions. Germination is epigeal. Seedling vigor rated good in Utah; poor success and slow stand development of seedlings in prairie restoration studies suggest only fair seedling vigor (7,8).

## MANAGEMENT

Species useful for wildlife and watershed cover, environmental and landscape plantings, and in grass seeding mixtures because of its nitrogen contribution to soil and diet. Reduce competition by preparing firm, weed-free seedbeds and planting legumes separately or in rows alternating with grasses. Withhold grazing and control weeds by mowing above seedlings during establishment period. Graze or mow conservatively, leaving high stubble, and periodically defer late summer defoliation until fall dormancy for sustained cover and production improvement.

## ASSOCIATED SPECIES

Species grows in native stands with big and little bluestem (*Andropogon gerardii*; *Schizachyrium scoparium*), prairie dropseed (*Sporobolus heterolepis*), heath aster (*Aster ericoides*), prairieclovers (*Petalostemum* spp.) and other tallgrass, true, and sand prairie species. Very infrequently seeded, interseeded, or transplanted on prairie sites with native warm season grasses.

## PESTS AND DISEASES

Grasshoppers, leafhoppers, and small mammals may reduce stands and herbage supplies. Leaf spots, rusts, downy mildew, and *Cytospora amorphae* reported on plants but not considered serious.

## IMPROVED VARIETIES

None.

Indigobush amorpha  
*Amorpha fruticosa* L.

A taller shrub commonly 6 to over 10 feet tall with growth form and appearance similar to sumac (*Rhus* spp.). More moisture demanding and less drought-tolerant than *A. canescens*. Better adapted to calcareous soils, nitrogen-fixing, and stimulating associated planted or pioneer herbs. Tolerant of pH as low as 4.0; tolerant of moderate shade. Planted somewhat on central Illinois strip mined areas and more commonly in Appalachian Region. Seeded spring, fall, or winter; 1/2 to 1 pound per acre (seed in pods) for wildlife food and cover and watershed protection; can be established by planting 1-0 seedlings and using special inoculum. Due to hard seeds, germination may be delayed until second or third year; stand establishment reported to be good but, due to slow growth, may take 3 years to attain 2 foot heights (9). Reportedly being direct seeded at 16 to 20 pounds per acre on northeastern highway cuts and fills; also faster growing in northcentral Texas (10).

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Figure 54. Leadplant amorpha (*Amorpha canescens*). Flowering branch x 1/2; flower x 6; fruit x 6. (Flower and calyx after Gleason 1963.)

## SILVER SAGEBRUSH

*Artemisia cana* Pursh

### ORIGIN

Native to the intermountain West and adjacent Northern Great Plains. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small, evergreen shrubs, growing in cool season but flowering in the warm season.

Freely branching stems, mostly 2 to 5 feet tall, with silvery canescent twigs and leaves; latter linear, mostly entire, occasionally toothed irregularly. Inflorescence a narrow, leafy panicle with rayless small, inconspicuous, composite heads in dense, crowded clusters, having 5 to 15 perfect disk flowers, bearing dry, ellipsoidal, achene fruit, covered with granules.

Plants producing shallow to deep, well branched root system, sprouting at the base; some plants layering and some rhizomatous. Growth resumes in early spring, flowers in late summer, and matures in late summer to fall. Species highly aromatic. Low palatability to cattle; fair palatability to sheep; and good palatability to deer, elk, and antelope, especially in winter and when snow covers low growing vegetation. Important food and nesting cover for sage grouse (1,2).

### ECOLOGICAL RELATIONSHIPS

Species commonly occurs on most soil texture classes, except dense clays; probably more vigorous in medium-textured soil. Various subspecies grow well near mountain streams and meadows with moisture equivalent to over 15 inches MAP; on plains and draws in 12 to 15 inches; and onto semidesert sites with only 8 to 10 inches. Tolerant of weakly acid to moderately basic and weakly saline soils. Tolerant of imperfect drainage, high water tables, and flooding; tolerance varying somewhat by subspecies but some forms quite tolerant. Good drought tolerance, particularly subspecies other than *viscidula*, but species generally requires more moisture than big sagebrush (*A. tridentata*). Strong winter hardiness but probably restricted to bands of latitude and elevation; be certain of adaptation before using plant material from habitats differing much from planting site. Somewhat intolerant of shade, usually grows in full sunlight. Good tolerance of close grazing and injury or severing of stems due to sprouting habit. More resistant than big sagebrush to fire, grazing, phenoxy herbicides, and mechanical control practices. Recovers from burning in 2 years in Utah. Fairly compatible with other shrubs and grasses, especially after fully established (1,3).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed on the surface or very shallowly; better germination reported with light and at temperatures between 50° and 86° F. Plant 10 to 20 PLS per square foot (0.5 to 1.0 pound PLS per acre) for full stands. Species often seeded at reduced rates approximating original composition on sites; e.g., using 0.10 pound PLS per acre. Rates should be doubled or further increased for critical areas, steep slopes, and eroding surfaces. Because of tolerance to broad temperature range for germination, amenable to seeding almost any time of the year when there is adequate surface soil moisture, such as fall, early spring, spring, or summer (2). Hardwood cuttings, cultured in greenhouse and hardened before out-planting on surface mined soils, gave better stands and survival than direct seeding in Wyoming-Colorado investigations and were more tolerant than other species to wildlife browsing (4).

#### Seed Cleaning and Quality

Seed can be harvested by hand-stripping or more rapidly by electric headcutters where flowerheads are more abundant. Clean by mechanically flailing, in clipper mill, and in seed blower. Too intense flailing or hammermilling creates fragments similar in size and weight to seed and makes separation difficult. Seed quality not standardized: 90 percent purity may be possible (10 percent might be usable as in seeding *A. tridentata*); 90 percent germination; 81 percent PLS; and 846,000 seed per pound (2).

### Germination and Seedling Characteristics

Seeds germinate rapidly without need for scarification or stratification; 50 percent germination in 2 to 6 days under seed lab conditions (2). Seedling vigor generally only fair but rated good under drought induced conditions in Montana study. Data from study indicate that seedlings will tolerate 1-month drought (5). Species will take 3 years or longer to attain reproductive status.

### MANAGEMENT

Species used in seed mixtures for big game range restoration, highway stabilization and beautification, and to restore semioriginal vegetation on disturbed lands. Reduce competition in preparing a seedbed and reduce animal stocking and weed competition during seedling establishment period. Where feasible, may be advantageous to plant sagebrush and grasses in separate or alternate rows, strip, or patches. Practice good range, watershed, and game management to optimize investment and longevity of improvements.

### ASSOCIATED SPECIES

Species occurs with very diverse associates from western wheatgrass (*Agropyron smithii*) and sedges (*Carex* spp.) and rushes (*Juncus* spp.) to big sagebrush (*A. tridentata*) and basin wildrye (*Elymus cinereus*), with many other grasses and some forbs in the regional complex of sites from Northern Great Plains to intermountain foothills and mountains and adjacent Great Basin.

### PESTS AND DISEASES

Small mammals, ants, and the Aroga moth menace seed, seedlings, and foliage or forage supply. No serious pathogens are known. Small areas of improved cover attract animals in concentrated numbers and jeopardize its permanence.

### IMPROVED VARIETIES

None.

Mountain silver sagebrush  
*A. cana viscidula*

Only about 3 feet tall, readily layering, greener than associated *A. tridentata vaseyana*, with variable leaves, entire to notched, occurs along mountain streams from southwestern Montana and northwestern Wyoming south along Continental Divide and southwestward into central Idaho, Utah, and Nevada.

Silver sagebrush  
*A. cana cana*

Bears most of the characteristics of the species but generally has entire leaves which taper toward both ends, is upright and coarsely stemmed, up to 5 feet tall, does not readily layer but will in favorable habitats, and has rhizomes especially noticeable after fire. This subspecies reported to be more uniform in form and leaf type; occurs mostly east of the Continental Divide from Montana south to Colorado. Strongly aromatic, smelling like turpentine.

Bolander silver sagebrush  
*A. cana bolanderi*

A low, rounded shrub; thickly branching; erect or spreading; readily layering, with numerous vegetative sprouts, white stems and flowering stems; and tomentose to gray-green, linear to variously notched, leaves. Bolander sagebrush occupies alkaline soil habitats in Oregon and California and is rarely present in western Nevada (1).

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Figure 55. Silver sagebrush (*Artemisia cana*). Plant x 1/5; leaves x 1; flowerhead x 5; achene x 5; flower x 5.

## FRINGED SAGEWORT

*Artemisia frigida* Willd.

### ORIGIN

Native to western North America and to Eurasia. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, half-shrub, flowering in late summer or fall.

Stems annual, spreading to erect, growing from a short, branched, woody perennial base, 1/2 to 1 1/2 feet tall. Basal leaves densely crowded, rosettelike, and semievergreen in milder climates; silvery hairy, aromatic, and finely divided into linear segments, sparser and less finely divided on stems. Inflorescence a narrow panicle or reduced raceme with numerous small, globe-shaped, white-hairy, drooping, composite heads of small yellow tubular flowers, profusely pollen-producing, smelling like camphor, and bearing dry, hairless achene fruit in the hairy receptacles (1).

Plants with moderately deep, branched taproots; sometimes with fine roots where spreading stems contact soil, a process called layering. Plants resume growth in very early spring or late winter in cold temperate climates but stay green at base in milder climates; flower in late summer or fall; and mature seed in fall. Rated good to fair or poor palatability, varying regionally and seasonally, for livestock and big game animals; fairly nutritious in winter (2,3).

### ECOLOGICAL RELATIONSHIPS

Species commonly occurs in a wide range of soils that are coarse to medium-textured, well drained, relatively dry, and often thin, rocky, or gravelly. Tolerant of weakly acidic to moderately basic reacting soils and to weak soil salinity. Great range in moisture tolerance, favored on drier sites in the 8 to over 20 inches MAP zones, and somewhat more prominent in the intermediate 12 to 16 inches zone. Abundance usually somewhat greater in open communities, disturbed soils, and for several years following a year receiving good moisture coinciding with the normal flowering/fruitletting period. Good drought tolerance of both seedlings and mature plants. Fair shade tolerance; thrives in open, exposed sites but grows fairly well in partial shade of shrublands and woodlands. Cold-tolerant stock; probably limited more by heat at lower altitudes and latitudes. Use sources of seed from habitats similar to seeding site. Wildfire generally kills some plants and sometimes most plants but species recovers in about 3 years. Species often responds as an increaser on plains grassland ranges grazed by cattle and shows good tolerance to close grazing by domestic livestock. Well used by deer in winter and by antelope for longer seasons; might respond as decreaser with concentrations of such animals. Species rated moderately competitive and shows good compatibility with associates in a variety of plant communities and sites (2,4).

### CULTURE

#### Planting Depth, Rate, and Time

Surface seeding beneficial because light induces greater germination where surface moisture assured; e.g., with irrigation or where snowmelt extends for a few weeks. Otherwise, seeding at depths 4 times diameter of seed advised. No experience with rate reported; because it assumes bunch form similar to grass, recommend trying 20 to 30 PLS per square foot (about 0.2 to 0.3 pound PLS per acre) for full stands; usually only a fractional rate used for game range or native vegetation restorations (e.g., 1 ounce PLS per acre). Plant when soil temperatures are below 50° F; e.g., in late fall or early spring or just before the reliable surface soil moisture period that overlaps 2 months of 40° to 50° F surface soil temperatures (5). Montana study had better germination at 50° F but best results in New Mexico study were at 62° F, strongly indicating ecotypic variations (6,7).

#### Seed Cleaning and Quality

Harvest seed by stripping or rubbing into containers or, where heads are well extended, use electric headcutters. Clean by hammermilling or mechanically flailing; reclean in fanning mill. Small lots may be

sifted with a fan blowing off other plant material. Seed quality not standardized: 10 percent purity acceptable in Utah game range restorations; 73 percent germination (PLS basis) obtained at 50°F; and 4,136,000 seed per pound (4,5).

### Germination and Seedling Characteristics

About 50 percent of the seeds germinate quickly in 5 to 12 days in lab tests but the others germinate more slowly over a 30-day period. Seedlings withstand short term drought very well and show moderate competitiveness and vigor. Three year establishment period needed for plants to reach flowering under dryland conditions.

### MANAGEMENT

Limited use made of species in game range seeding mixtures, highway seedings, and for landscaping. Reduce competition in preparing seedbeds, reduce stocking of animals, and control aggressive weeds during establishment period. Separation of strongly competitive species in seeding mixes by planting them separately or in alternate rows with legumes or forbs usually benefits stand establishment and persistence. Moderate animal stocking and planting with native species minimize maintenance.

### ASSOCIATED SPECIES

Species occurs mixed with blue grama (*Bouteloua gracilis*), needle-and-thread (*Stipa comata*), mountain muhly (*Muhlenbergia montana*), true mountain-mahogany (*Cercocarpus montanus*), ponderosa pine (*Pinus ponderosa*), big sagebrush (*Artemisia tridentata*), and with other shrubs, forbs, and grasses. Can be seeded with nontree members of its many native habitats or with selected browse and herbaceous species that are more useful for specific improvement purposes.

### PESTS AND DISEASES

Small mammals may damage new seedlings. Grasshoppers dislike plants; in one North Dakota test, caged grasshoppers starved without ingesting any fringed sage herbage. Only two minor fungi reported on foliage. Meager data suggest it may be a very resistant species.

### IMPROVED VARIETIES

None.

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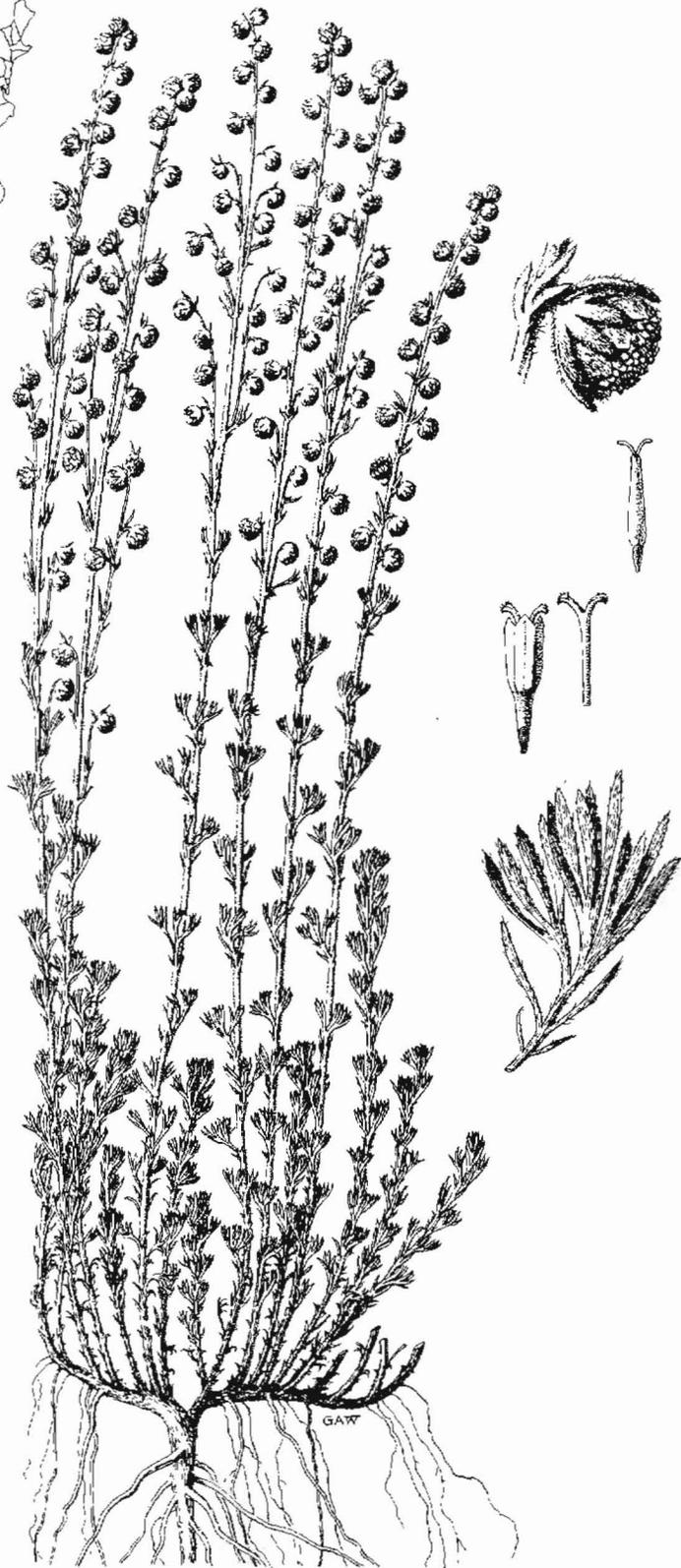


Figure 56. Fringed sagewort (*Artemisia frigida*). Plant x 1/3; leaves x 1 1/2; disk flower x 5; outer (functionally ray) flower x 5; flowerhead x 5.

## BLACK SAGEBRUSH

*Artemisia nova* Nelson

### ORIGIN

Native to intermountain West and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Semievergreen, persistent leaved, aromatic, low shrub.

Numerous vegetative branching stems from decumbent spreading main branches, infrequently erect, mostly 1/2 to 2 feet tall. Vegetative leaves about 0.6 inch or less in length, fan or wedge-shaped, and typically oily and dark green to greenish-yellow, but sometimes canescent, with a three-lobed apex shallowly to sometimes deeply lobed and becoming sparser, smaller, and linear up the flowering stems. Flowering stems few to many, erect, commonly about 1 foot long, drying a bronzish-brown, and persistent a second year. Inflorescence a narrow, elongated panicle with short, erect branches. Flowerheads borne single, occasionally clustered; involucre oval, becoming bell-shaped with age, with typically three to five small disk flowers maturing to dry achene fruit (1,2).

Not stump sprouting or layering. Moderately deep and extensive, well-branched, generalized root systems. New growth resumes in late April, heading in July, flowering in September, and fruit maturing in October in Wyoming. Fairly good palatability, particularly to deer and antelope, but palatability to livestock varies among ecotypes or biotypes and with season and associated vegetation (2).

### ECOLOGICAL RELATIONSHIPS

Common on relatively shallow, rocky, and sometimes calcareous soil/sites, usually in well-drained, medium-textured soils. Intolerant of wet sites and shallow water tables. Present on neutral to moderately basic and on weakly saline soils. Strong drought tolerance. Present in the 6 to 20 inches MAP zones; more abundant or thrifty in intermediate MAP zones. Local sources winter hardy but some frost sensitivity to be expected in seedlings from southern, low altitude, or unthrifty seed sources or strains. Latitudinal range from northern New Mexico and Arizona to Oregon and Montana; extends from about 4,000 feet to over 8,000 feet in elevation. Weak shade tolerance and only vigorous in exposed sites in open shrublands and woodlands. Fire-intolerant but fires uncommon in its habitat due to open communities and low volume of herbaceous fuel. Poor grazing tolerance associated with palatability and weak sprouting habit. Established plants exhibit good competitiveness, indicating fair compatibility with most associates (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Plant achenes 1/4 inch deep. About 100 PLS per square foot used in nurseries to obtain about 50 seedlings per square foot in optimizing limited space and intensive culture; 1 to 2 PLS per square foot should prove an adequate rate on rangelands under ideal growing conditions. Comparing planting site conditions and survival expectancy with that ideal standard suggests that 10 to 20 PLS per square foot (1/2 to 1 pound PLS per acre) might be adequate drill rates for full stands on average rangeland sites. Higher rates needed when broadcasting and when seeding severe, erosive, and critical sites. Species more commonly used as minor element in seed mixtures for range revegetation, partly due to limited seed supply. Plant either in late fall and winter or use seed pretreated to enhance germination (i.e., placed in moist blotters at 32° to 38° F for 10 days) in spring (4,5).

#### Seed Cleaning and Quality

Harvest seed (achenes) by shaking, beating, rubbing, or stripping into containers. Clean collections by hammermilling and, if necessary, fanning and screening. Seed quality not standardized: 10 percent purity and 80 percent germination acceptable in Utah game range work; 85 percent average germination (25 samples); and 907,000 seed per pound (4,5,6).

## Germination and Seedling Characteristics

Some achenes germinate rapidly in a few days, others not until 90 to 100 days in lab tests. Ratings of fair establishment, good rate of growth, and very good final stand establishment in Utah game range revegetation evaluations indicate good seedling vigor (4,5,6). Seeded stands flower in 4 years in Utah with favorable site and growing conditions (7).

## MANAGEMENT

Species optionally included in seed mixtures for revegetating big game ranges in shadscale and mountain brush types in Utah; shows potential for use in stabilizing disturbed lands and revegetating livestock ranges. Remove competing vegetation prior to or when planting seed or plants and reduce animal populations of both wildlife and livestock during seedling establishment. Planting seed in rows separate from herbs may improve stand establishment of both components in seed mixtures. Maintenance of moderate animal stocking necessary for sustained benefits from revegetation programs (4).

## ASSOCIATED SPECIES

Shadscale saltbush (*Atriplex confertifolia*), big sagebrush (*Artemisia tridentata*), winterfat (*Ceratoides lanata*), bottlebrush squirreltail (*Sitanion hystrix*), galleta (*Hilaria jamesii*), and sandberg bluegrass (*Poa secunda*) commonly associated with black sagebrush. Species occasionally mixed in complex grass, forb, and shrub seed mixtures that include both exotic and native species adapted and useful for game range revegetation.

## PESTS AND DISEASES

Sagebrush moth (*Aroga websteri*) periodically defoliates and kills plants; a leaf miner (*Bucculatrix tridenticulata*), larvae of *Trirhabda* spp. beetles, and grasshoppers infrequently damage stands. Browsing can prevent stand establishment and damage stands (8).

## IMPROVED VARIETIES

None. Variations in species should be amenable to improvement by selection and breeding.

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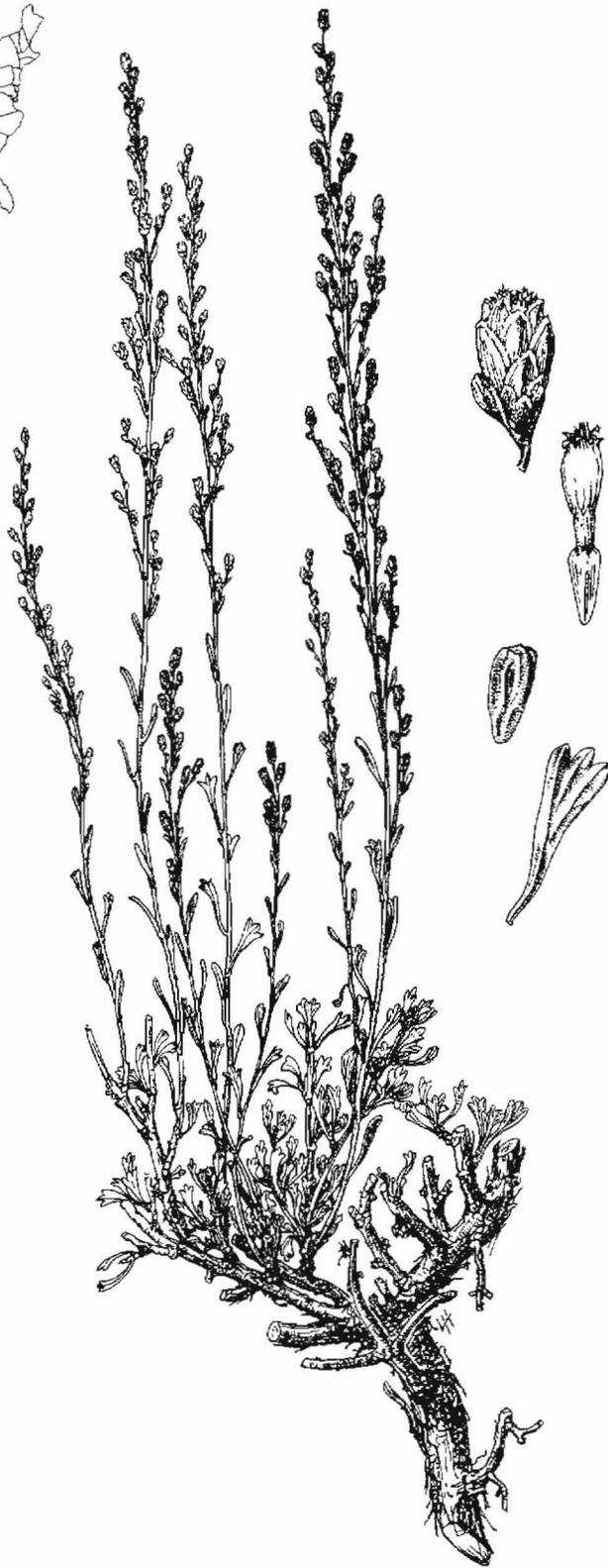


Figure 57. Black sagebrush (*Artemisia nova*). Plant x 1/3; leaf x 2 1/2; achene x 5; flower x 5; flowerhead x 5.

## BIG SAGEBRUSH

*Artemisia tridentata* Nutt.

### ORIGIN

Native to intermountain West and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small to medium-sized, cool season, evergreen shrubs.

Flat to irregularly crowned plants, commonly 2 to 5 feet tall or taller; crown composed of many short, spreading branches, growing from a stout, twisted, woody trunk, sometimes split with age. Twigs and leaves silvery canescent. Leaves 1/2 to 1 1/2 inches long, narrow, more or less wedge-shaped, three-lobed or three-tipped at apex but leaves in panicles often entire. Inflorescence paniculate or racemose, sometimes spikelike, of short-bracted heads with 2 to 15 miniature disk flowers producing dry granuliferous achenes enclosed in calyx tube fibers which readily attach to animal fur and help to spread seed (1).

Polymorphic species with several subspecies and forms. Three subspecies (and several forms) recognized: (1) *A. tridentata tridentata*; averages the tallest; with single trunk; irregular, round crown; larger panicles; long narrow leaves with shallow lobes and straight margins, giving a V-outline to leaf; (2) *A. tridentata wyomingensis*; Wyoming big sagebrush; usually 3 feet or less in height; irregular round-crowned; trunk divided at base; and shorter, wider leaves more deeply lobed and flared margined, appearing somewhat bell-shaped in outline; and (3) *A. tridentata vaseyana*; mountain big sagebrush; distinctively flat-crowned, with inflorescences only arising from tips of upper branches; shorter and narrower racemose panicles; proportionately wider leaves than the basin form, broadest just below the lobes; and maturing early. The species generally has a deep, well-branched root system; often hourglass-shaped in transverse outline; with a near-surface concentration, more pronounced in the Wyoming subspecies; and a deeper concentration, often about 3 feet or much deeper. Lateral spreads of 10 to over 16 feet have been recorded. New leaf activity starts in March and April; flower buds become visible in July or August; flowers between August and October; with seed ripening between October and January, varying by subspecies, ecotype, and environment. Palatability highly variable by sagebrush subspecies and biotype, environment (including associates and seasons), and animal species; generally poor palatability for cattle and fair palatability for sheep; palatability sometimes better, especially in winter; generally fair to good palatability for deer and antelope, particularly with mountain and Wyoming subspecies. Valuable nesting cover and/or food for sage grouse and small mammals (1,2).

### ECOLOGICAL RELATIONSHIPS

Species variably adapted to moderately deep, well-drained, near-neutral, salt-free soils in 8 to 16 inch MAP zone, but sometimes occurs in 20 inches zone. Habitat adaptation and preference varies by subspecies. Basin subspecies common in alluvial and residual floodplains, basin and valley sites in lowest precipitation zones on deep well-drained sandy to clay loam textures near neutral to moderately basic and only weakly saline soils, mostly below 7,000 feet in elevation. Wyoming subspecies on shallower, lower slope or foothill benchland sites with thinner, variably coarse to fine-textured soils in intermediate precipitation zones but often drier due to shallow and exposed soil/sites. Mountain subspecies on upper slopes, in mountain parks, and higher benchlands with medium to coarse soils of intermediate depth; greater precipitation, mostly in the form of snow. Species highly drought-resistant, less so in seedling stage. Mature plants generally winter hardy but seedlings sometimes frost sensitive, demanding use of adapted materials from similar habitats. Much variation to be expected in tolerances to moisture, winterkilling, and salinity. Fire-intolerant species but usually reinvades either from seed reserves in soil or from peripheral plants. Poor shade tolerance and only fair grazing tolerance, especially when rarely grazed closely in summer. The species is quite competitive when firmly established and, for that reason, is only fair in compatibility with grass and forbs (3,4).

## CULTURE

### Planting Depth, Rate, and Time

Either broadcast seed on the surface or plant at very shallow depth of about 1/4 inch. Light favors germination of basin-form, and seed will not emerge from 1 inch depths. Limited benefit of light noted with other two subspecies. One-fourth to 1/2 pound per acre or double these rates recommended for drilling and broadcasting seed in mixtures on sagebrush-adapted but depleted Utah game ranges. Plant either in spring, fall, or winter. Moist chilling seed treatment may be of benefit when planting the spring after seed harvest (3,5,6).

### Seed Cleaning and Quality

Adapt seed harvesting method to local conditions; can shake, beat, hand-strip, or rub seed into containers or use electric headcutters with heavier seed crops. Clean either by hammermilling or by mechanically flailing, followed by recleaning in fanning mill with or without seed blower. Seed quality not standardized: 10 percent purity usable in Utah game range restorations, better than 50 percent should be possible; 55 percent germination commonly attained with basin subspecies, and some lots attain 90 percent for all subspecies; 2,520,000 basin, 1,760,000 mountain, and 1,215,000 Wyoming subspecies seed per pound (5,6,7).

### Germination and Seedling Characteristics

Fifty percent of viable seeds germinate within 4 to 9 days under ideal lab moisture and temperature conditions, but the other seeds take 30 days or longer to germinate. Field germination occurred between February 1 and April 30 in interior Pacific Northwest sites. Seedling vigor weak in preliminary drought stressing tests with Wyoming subspecies in Montana and seedling growth of basin subspecies in Washington was slower than associated perennial and annual species. In Utah game seedings, species grows relatively rapidly and plants may mature in 4 years; transplants mature and spread from seed in 3 to 7 years (3,5,6,7).

## MANAGEMENT

Species is included in game range restoration seed mixtures for mountain brush, juniper-pinyon, and open aspen types in Utah; included in highway plantings in Nevada; and recommended for landscape purposes in intermountain West. Wilding and seedling transplants are more quickly established for soil stabilization purposes; e.g., gullies, mine spoils, and eroding hillsides. Prepare seedbed and reduce competition before or during seeding, reduce animal stocking, and control aggressive weedy growth where feasible during establishment period. Topsoil replacement and/or fertilization to correct tested soil deficiencies may be necessary on disturbed sites. Irrigation may ensure good establishment. Moderate stocking of wild and domestic animals is essential for continued benefits.

## ASSOCIATED SPECIES

Species occurs most commonly with cheatgrass brome (*Bromus tectorum*), species of rabbitbrush (*Chrysothamnus* spp.), bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), bottlebrush squirreltail (*Sitanion hystrix*), thickspike wheatgrass (*A. dasystachyum*), several species of needlegrass (*Stipa* spp.), antelope bitterbrush (*Purshia tridentata*), arrowleaf balsamroot (*Balsamorhiza sagittata*), and several species of phlox (*Phlox* spp.) and lupine (*Lupinus* spp.) It is seeded in complex grass, forb, and shrub mixtures for game range purposes with exotic and native species or more commonly with mostly native species on disturbed lands to restore a semi-original cover.

## PESTS AND DISEASES

The *Aroga* moth periodically defoliates or destroys plants in lowland areas. Jackrabbits also defoliate young plants. Leaf spot, rust, and black knot occur on plants and pale bastard toadflax (*Commandra pallida*) and cancer root (*Orobanche fasciculata*) are parasitic on roots (6).

## IMPROVED VARIETIES

None, but ecotypes and biotypes of superior palatability are under investigation, and breeding of improved plant materials is considered feasible.

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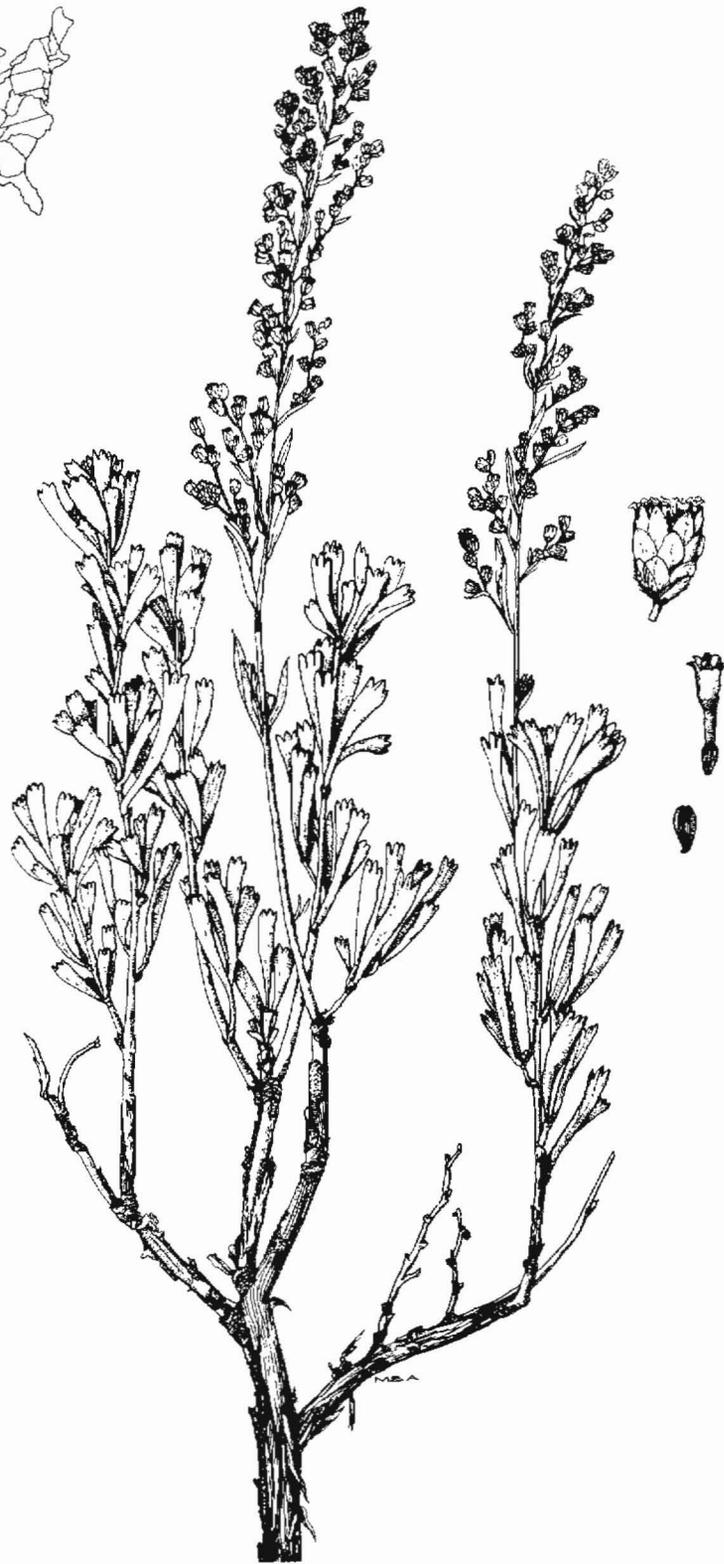


Figure 58. Big sagebrush (*Artemisia tridentata*). Plant x 1/2; achene x 2; flower x 2 1/2; flowerhead x 2.

## FOURWING SALTBUSH

*Atriplex canescens* (Pursh) Nutt.

### ORIGIN

Native to Great Plains, Southwest, and Intermountain West. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, medium-sized, deciduous to persistent-leaved or evergreen shrub.

Stems stout, loosely branched, spreading to erect, 1 to 5 feet tall with whitish twigs, hairy when young. Leaves alternate, simple and entire, elliptic to oblanceolate, gray-scurfy (canescent), up to 2 inches long with rounded ends. Mostly dioecious but infrequently monoecious; yellow to reddish staminate flowers clustered in dense spikes of terminal panicles; pistillate flowers inconspicuous and axillary, consisting only of pistils surrounded by two united bracts with conspicuous, papery four-wings and appearing like burs, about 1/2 inch in diameter (1).

Polymorphic species with marked gradations in plant size and form, leaf shape, and fruit characteristics, including both production and viability. Very deep, up to 20 feet, extensive, and branched root system. Plants sometimes root sprout and layer. Leaves evergreen in milder climates. Growth resumes in spring to early summer in Upper Sonoran and higher elevation zones and with summer rains in Lower Sonoran zone; flowers in May to July and July to August in the above zones, respectively; utricle-type fruit matures 3 to 4 months after flowering. Good palatability to livestock, deer, and Barbados sheep in all seasons; fair palatability to antelope all seasons; and good palatability to elk in fall and winter. Cyclic herbage consumption sometimes noted, possibly related to saltiness of herbage. Nutritional qualities and growth characteristics make winter use particularly advantageous. Rarely causes scours, bloat, and anemia. Valuable forage and cover for pheasants, quail, and cottontail rabbits (2,3).

### ECOLOGICAL RELATIONSHIPS

Species adapted to most soil textural groups. Native stands more abundant on weakly to strongly basic and moderate to strongly saline soils and less abundant on sodic soils. Epidermal trichomes ("scurf") serve as salt "sinks" and increase plant's salt tolerance; salts periodically washed off, increasing soil salt content. *Atriplex* spp. tolerate considerable boron. Intolerant of high water tables and protracted late winter flooding, but occurs in valleys and floodplains infrequently flooded either in winter or summer. Common occurrence in 8 to 15 inches MAP zones, particularly on calcareous soils; may occur infrequently with less or more MAP. Remarkably drought-tolerant and often remains green and actively growing when surface-rooted species are drought-dormant. Good cold tolerance of local sources and ecotypes but variable by geographic races and ecotypes with seedlings often frost-sensitive.

Use nearby seed sources or sources that are north of planting sites (4). Species occurs from about 1,000 feet above sea level to 8,500 feet in elevation in southwestern Colorado. Species mostly shade-tolerant but sometimes found in open woodlands. Well-established plants moderately competitive and compatible with native grasses. Good tolerance to wildfire; some plants sprout from crown and occasionally from rootstocks or layers. Moderate grazing resistance but usually reacts as a decreaser and suffers stand losses from continued overgrazing, particularly close grazing during the growing season (3,5,6).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed 1/2 to 3/4 inch deep in well-prepared seedbeds; use shallower depth with moister and finer textured soils; use the deeper placement for dry, loose, and coarse-textured soils. Mulching usually improves seedling emergence and survival. Seed 4 to 8 pounds per acre of dewinged seed and 8 to 15 pounds of winged seed for pure stands in favorable to less favorable habitats or site conditions (4) and when planting or broadcasting, respectively. Reduce rate to desired or original fraction of the cover on

planting sites when seeding in mixtures; 1/2 to 5 pounds per acre rates used in 10 to 30 pounds per acre total seedings in Utah game range restorations, the higher rates in blackbrush type and when broadcasting, 1/2 to 2 pounds per acre rates more commonly used on shadscale saltbush, black greasewood, big sagebrush, mountain brush, and juniper-pinyon types. Spring or midsummer seedings generally more successful than fall seedings in the Southwest. Often seeded in mixtures sown in late fall or winter in Utah. Transplanting is an effective method of establishing stands on small critical areas. Transplanting is done in spring, with damp soil conditions, either by hand in prepared seedbed or in water-concentrating furrows or basins, or by using scalper and transplantor, carefully hand-fed, keeping stock moist and avoiding "J-roots" (4,6).

#### Seed Cleaning and Quality

Harvest seed by shaking or hand-stripping into bags, baskets, or onto canvases. Also can be collected by vacuuming. Process seed in hammermill run at 1,500 rpm and equipped with 1/4-inch wire mesh; reclean in a fanning mill to desired grade. Seed quality not standardized: acceptable purity 95 percent; germination highly variable; e.g., CA seed 44 percent in 30 days, NM seed 70 to 94 percent in 30 to 34 days, UT seed 53 percent in 50 days; 52,000 (mean) dewinged seed per pound and 25,000 intact seed per pound (7).

#### Germination and Seedling Characteristics

Highly variable in germination characteristics from different sources, years, and position on plants. Seeds undergo afterripening for about 10 months after freshly harvested. Dewinging seed in hammermill hastens germination. Optimum temperature for germination of New Mexico sources 55° to 75° F. Moisture stress decreases and delays germination; seeds fairly tolerant of 7 atmospheres moisture stress with optimum between 1/3 and 2 atmospheres. Seedlings start emerging in 6 to 10 days and complete emergence in 12 to 20 days under nursery conditions. Better growth reported from soils of typical habitats than in nursery soil mixes. Nursery plantings begin reproducing by end of second growing season (counting late summer of planting year as one growing season). Requires 3 years or more for establishment and reproduction under rangeland conditions (4,6).

#### MANAGEMENT

Species used in game range restoration, range reseeding, and windbreak plantings; considered promising for disturbed land reclamation, particularly on surface coal mines. Reduction of competition during seedbed preparation, including scalping or furrowing, withholding grazing and reducing animal stocking (game, rabbits, and rodents), and controlling aggressive weeds during seedling year increases establishment and survival. Moderate stocking and winter grazing or periodic deferment until after seed maturity when summer grazed increases sustained herbage production and saltbush populations. Irrigation and mulching may be necessary for satisfactory survival of seedlings or plantings on minesoils and critical sites.

#### ASSOCIATED SPECIES

Species commonly associated with blue grama (*Bouteloua gracilis*), galleta (*Hilaria jamesii*), black grama (*B. eriopoda*), alkali sacaton (*Sporobolus airoides*), inland saltgrass (*Distichlis spicata stricta*), rubber rabbitbrush (*Chrysothamnus nauseosus*), black greasewood (*Sarcobatus vermiculatus*), blackbrush (*Coleogyne ramosissima*), black sagebrush (*Artemisia nova*), and bluebunch wheatgrass (*Agropyron spicatum*). Due to ease of establishment, species commonly planted with these native species but also in a variety of complex mixtures, including grasses, legumes, forbs, and other shrubs, often including some exotic species and a few trees for disturbed areas. May also be used as a shrub row in multirow windbreaks or seeded in one or two row strips.

#### PESTS AND DISEASES

Rabbits and rodents more serious enemies of plants than grasshoppers; latter are problems only in cotyledon stage. Repellents may improve survival. Fungicidal seed treatment partially controls pathogens on seedlings (4).

## IMPROVED VARIETIES

'Wytana', a dwarf form suitable for row planting and mechanical harvesting, is adapted to Montana, eastern Wyoming, and the western Dakotas. 'Wytana' has strong seedling vigor and has been used successfully on mine spoils and in range seeding mixtures at 1/2 pound per acre of dewinged seed. 'Marana' has been released in California; an improved strain may be released soon from New Mexico or Arizona.

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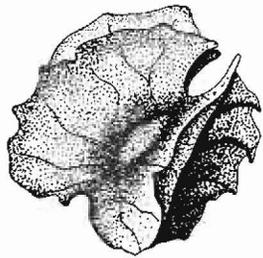


Figure 59. Fourwing saltbush (*Atriplex canescens*). Twig x2/3; utricles x1/2. (Growth form after Elmore 1976.)

## NUTTALL SALTBUUSH

*Atriplex nuttallii*

### ORIGIN

Native to intermountain West and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Warm season, small, suffrutescent half-shrub.

Stems annual, semierect, 1/2 to 2 feet tall, from a woody, branching, decumbent base. Plants often wider than tall. Leaves up to 2 inches long, typically gray-green to green, variably shaped from narrow elliptic to spatulate or obovate, rounded at apex. Mostly with sexes in separate plants (dioecious), but some plants monoecious. Staminate flowers densely clustered in terminal spikes or narrow panicles. Fruiting bracts thick, united, dentate at summit and sides, with smooth to tuberculate faces (1).

Plants have shallow to moderately deep, well branched root systems; some plants root sprout and layer. Plants somewhat persistent-leaved. Plants flower from May to July, and fruits mature from August until November. Good palatability for livestock, particularly sheep and deer in winter; fair palatability for antelope. Some use is made by elk during fall and winter (2,3).

### ECOLOGICAL RELATIONSHIPS

Adapted to medium to fine-textured soils but tolerant to all but extremely erosive sands or dense clays. Common in moderate to strongly saline soils but some ecotypes occupy salt-free habitats. Present in warm to cool deserts with over 5 inches MAP, but grows more vigorously in the 8 to 12 inches zone. Generally cold-tolerant but tolerance varies among ecotypes and sources; may show some frost sensitivity, especially in seedling stages, if imported from warmer zones. Fires rarely carry in its habitat due to lack of fuel; species resistant due to succulence; strongly root sprouts after burning. Greatly reduced in vigor and ultimately in stand by close, continuous grazing during the active growing season. Somewhat weak in compatibility and competitiveness due to slow rate of growth and low-growing stature (2,3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed 1/2 inch deep or up to 1/4 inch shallower or deeper in moister, firmer, and finer textured soils or in coarser and drier soils, respectively. Satisfactory stands obtained using 20 pounds per acre (bulk seed) or about 7 pounds PLS per acre in Montana (6); increase rate for broadcasting and stabilizing severe sites and reduce rate proportionately to fraction of cover desired or normal in mixtures on planting site. Fall and early spring or later planting dates used with effective moisture for establishment. Transplanted stock should be planted in early spring, immediately after spring thaw and may be the better method of establishment on difficult sites (2,5,7,8).

#### Seed Cleaning and Quality

Harvest seed by shaking or hand-stripping into containers or onto canvas; can also be vacuum harvested when fully ripe. Process seed by hammermilling and clean to desired purity by fanning. Seed quality not standardized: acceptable purity 90 percent; germination 35 percent; PLS 32 percent; and seed average 114,000 per pound (5,7,8).

#### Germination and Seedling Characteristics

Seeds germinate slowly over a 60-day period; half of seeds moist-prechilled for 1 or 2 months germinated at 50° to 80° F in 2 days in Montana lab tests. Considerable variation in germination capacity and temperature responses of geographical strains. Results of field plantings in California chaparral zone rated growth of one *A. nuttallii* source very slow and of *A. gardneri* fair. Sown plants of latter species were very much smaller than *A. canescens* at end of first season in other tests. Marked variation among seed sources in

seedling vigor and first year stand establishment noted in initial evaluation plantings on dryland mining sites in Wyoming. Seedling vigor rated good in Utah, and plants matured in 3 years (5,7,8,9,10).

## MANAGEMENT

Slow growth and establishment restrict use of species to harsh saline salt desert sites where few other plants are adapted. Control of plant competition before and during establishment is essential to obtain successful stands. Better stands and survival in mined land reclamation obtained by seeding grass separate from this species (6). Withholding grazing and reducing small and large mammal populations improve stand survival. Leaching of excess sodium from surface soils, ripping of dispersed soils to improve structure, fertilization and irrigation, and supplemental mulch may be necessary for good establishment on severe sites. Transplanted seedlings or wildings require watering at time of planting and either water-retaining basins or furrows for good survival. Fencing of critical sites and moderate stocking on established stands are prerequisites for survival and sustained cover and production.

## ASSOCIATED SPECIES

Species naturally occurs with salt desert vegetation including shadscale saltbush (*Atriplex confertifolia*), winterfat (*Ceratoides lanata*), black greasewood (*Sarcobatus vermiculatus*), and inland saltgrass (*Distichlis spicata stricta*). It is included in complex grass-forb-shrub mixtures for game range restoration in the inland saltgrass and black greasewood sites in Utah. It has been included and rated fair in experimental evaluations of succulent, high mineral-content plants for use as natural fire suppressants in chaparral openings.

## PESTS AND DISEASES

Rodents are potential menaces to seedling stands. No significant diseases noted in records.

## IMPROVED VARIETIES

None.

Gardner saltbush  
*Atriplex gardneri* (Moq.) Standl.

Plants of similar form and characteristics having narrowly oblong or oblanceolate leaves, smooth fruiting bracts, widest above the middle, common on clayey soils in the northern intermountain region but more widely used than Nuttall saltbush (2).

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Figure 60. Nuttall saltbush (*Atriplex nuttallii*). Staminate plant x 1; staminate flower x 16; pistillate branch x 3/4; utricle fruit x 6. (Flower after Hall 1923; plant and seed after C. L. Hitchcock et al. 1964.)

## CREeping BARberry

*Berberis repens* Lindl.

(= *Berberis aquifolium rotundifolium*?)

### ORIGIN

Native to 11 Western States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Low, evergreen, trailing undershrub.

Stems usually less than 1 foot tall with yellow wood and inner bark; leaves pinnately compound with three to seven leaflets, leathery textured and evergreen, oblong to oval, with bristle-toothed margins, dull green above and paler beneath. Inflorescence a dense raceme of numerous perfect, regular, six-parted, showy yellow flowers bearing ellipsoid-globose blue (or black) bloom-covered berries containing several seeds (1).

Plants with spreading rootstocks; sometimes layering. Growth intermittent during winter, resumes more actively in very early spring or, more evident, with snow disappearance; flowers from March to June; matures in summer and fall. Herbage preferred by native hoofed browsers and small mammals; some use of fruit by birds and mammals but relatively little use made of plants by livestock.

### ECOLOGICAL RELATIONSHIPS

Species common in medium-textured, well-drained loams and sometimes in fairly shallow, rocky, and sheltered sites. Usually more abundant in coniferous forests in over 15 inches MAP zones, less common in deep snow climates, and often present on north-facing slopes and other moisture-compensating sites on plains or foothill shrublands and low elevation woodlands in lower precipitation zones. Tolerant of weakly acidic to weakly basic soils and only weak tolerance of salinity. Intolerant of poor drainage and high water tables. Native stock winter hardy but some variation expected in stock from other habitat types. Species occurs from near sea level on Pacific Coast to about 10,000 feet in elevation in Rocky Mountains. Among the most resistant evergreen ground cover plants to leaf burn from exposure to winter sunlight. Tolerant of moderate or rather strong shade and common on semiexposed sites in douglas fir and aspen forests. Sprouts from rootstocks after burning. Little used by livestock but moderately to strongly tolerant of animal browsing and hedge-trimming, respectively. Moderate competitive ability after establishment and fairly compatible with variety of overstory plants; appears to thrive in open herbaceous communities (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Plant whole berries or, preferably, clean seed 1/4 to 1/2 inch deep; use the shallower depth in moister, firmer, and finer textured soil. Best rates of seeding unknown; try small plots using 10 to 20 PLS per square foot for full stands; usually advantageous to seed with vigorous grass to suppress weeds and provide more complete early soil cover until shrubs spread; otherwise, useful in 10 percent to usually less than 25 percent composition of seed mixtures for big game range improvement or disturbed land stabilization and beautification. Fresh seed preferably or mature berries can be sown in the fall or stratified seed in the spring or later if moisture and time are adequate to germinate and produce well-rooted plants before killing frosts. Most ornamental plantings made by transplanting plants grown from stem cuttings in greenhouse or lathhouse. Transplanting wildings and rootstocks possible but difficult in less humid, interior climates (2,3,4).

#### Seed Cleaning and Quality

Harvest ripe fruit by hand-picking while using heavy gloves or flail into containers or cloths placed below the bushes. Process fruit in a macerator with water and float off or screen out pulp. Dry seeds before using. Seed quality not standardized: 90 percent purity; 77 percent germination; 69 percent PLS; and seeds average 62,000 per pound (4,5).

### Germination and Seedling Characteristics

Moist prechilled seed germinates in 10 days with constant temperatures of 70° F in the lab. Stratification requires three phases: 1 month at 34° F; 2 months at 70° F; and 6 1/2 months at 34° F. Seedling vigor is good and plants flower by fourth year in Utah (4,5).

### MANAGEMENT

Species now chiefly used for ground cover in landscaping or low maintenance landscaping but potentially useful for game range improvement, mined land stabilization, and highway and recreation area aesthetics. Successful stand establishment requires reduction of competitive vegetation and animal stocking before and during establishment. Seeding or transplanting in separate rows, strips, or blocks may improve stand establishment and survival. Stand longevity dependent on control of wildlife populations; livestock grazing may be economic means of reducing plant competition. Transplants need to be watered when set out and provided with water-retaining basin unless planted in lister furrows (4).

### ASSOCIATED SPECIES

Junipers (*Juniperus* spp.), ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), quaking aspen (*Populus tremuloides*), and other conifers and numerous foothill and mountain shrubs, forbs, and grasses commonly occur in various mixtures with creeping barberry. It is most commonly planted alone in landscape patterns but can be mixed advantageously with its native associates and many exotic cool season forage and browse species.

### PESTS AND DISEASES

Native browsers that concentrate on small, oasislike plantings are chief hazards to plantings. Black stem rust uses plant as alternate host which should restrict plantings in wheat belts; plants are resistant to injury from the rust.

### IMPROVED VARIETIES

None.

Oregongrape barberry  
*Berberis aquifolium* Pursh.

A taller form of this broadleaved evergreen, native to the Pacific Northwest, that is more widely used for a landscaping ground cover outside its range where supplemental irrigation is available in cooler sections of the West. The two forms cross where their ranges overlap, raising questions about their classification. This latter form may be usable and provide more cover and browse above the snow in northern intermountain areas having fairly consistent winter snow cover; e.g., on north-facing and canyon aspects and lee slopes where snow drifts some. Species used by grouse, bighorn sheep, and blacktail deer; incompletely resistant to black stem rust.

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Figure 61. Creeping barberry (*Berberis repens*). Plant x 2/3; fruit x 1. (Fruit after Stephens 1973).

## SIBERIAN PEASHRUB

*Caragana arborescens* Lam.

### ORIGIN

Native to Siberia and Manchuria; widely used in the upper Midwest and Northern Great Plains for landscaping and windbreaks. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, leguminous shrub or small tree.

Stems numerous, loosely branching, green to greenish-brown, erect, and commonly 5 to 15 feet tall or taller. Leaves alternate, fascicled, pinnate, with four to six pairs of oblong leaflets up to 1 inch long, yellowish to bright green, and with spiny stipules. Flowers showy yellow, pealike, borne in few flowered fascicles and bearing linear cylindrical, several-seeded, yellow-green pods (1).

Moderately deep and extensive, well-branched root system not commonly suckering. Plants resume growth in early to late spring; generally flower from April to June; fruit matures June to August. Low palatability, in general, to most large mammals but browsed some by wildlife and occasionally by livestock when greener and more succulent than associated herbage; provides resting cover and some food for birds and probably for small mammals (2,3).

### ECOLOGICAL RELATIONSHIPS

Adapted to all soil textures and to strongly acid (pH of 4.0), strongly basic (reported on fly ash piles with pH levels of 10 to 11 in Poland), and moderately saline soils (4). Tolerant of rather shallow, infertile, and rocky soils but more productive in deeper, well-drained, sandy soils. Does not thrive in wet places or where water table is near the soil surface. Strong drought tolerance and fully winter hardy in Canadian Prairie Provinces. Only fair shade tolerance; thrives in full sunlight. Succulent herbage usually somewhat fire-resistant but usually killed when burned. Low palatability somewhat buffers species from grazing damage but plants can be killed by close, repeated grazing or clipping, especially during late summer. Good competitiveness; only fair compatibility with herbs and probably better grown in separate rows (3,5).

### CULTURE

#### Planting Depth, Rate, and Time

Nurserymen plant seed 1/4 to 1/2 inch deep in well-prepared seedbeds, but one Russian report recommended 1-inch depth, probably because greater survival is often experienced at this depth in droughty areas and in coarse, quick drying soils. Nurserymen plant 25 to 50 seeds per linear foot of row for 35 to 50 percent establishment. Species sometimes planted as minor element, usually at about 1 pound per acre or less, in game range revegetation mixtures in Utah. Plant seed either in late summer or spring. Plants, either 1-0 or 2-0 stock, set out for landscaping, windbreaks, and mined land reclamation. Either softwood or hardwood cuttings can be rooted; species can be propagated by root cuttings; and some other varieties are grafted onto *C. arborescens* rootstock (6).

#### Seed Cleaning and Quality

Hand-pick pods or knock them onto canvas as soon as they begin to open, usually in late July or early August; spread material out and dry under protection until pods pop open; then sift lightly, beat, and fan. Seed quality not standardized: 90 percent purity acceptable in game range work; 70 percent or higher germination; 63 percent PLS; and about 19,000 seed per pound (5,6).

#### Germination and Seedling Characteristics

Most seeds germinate in 21 days in laboratory tests at 68° F (night) and 86° F (day) temperatures, but some delayed germination occurs from hard, dormant seeds. Nurserymen soak dry, spring-planted seeds in warm water (up to 190° F) either overnight or for 2 to 3 days for better germination. Seedling vigor very good; seedlings mature to seed-bearing age in 3 to 5 years under favorable growing conditions (2,5).

## MANAGEMENT

Species used in game range restoration, for hedges and other landscaping, for windbreaks and barriers, and for mined land and other disturbed soils stabilization. Reduce competing vegetation either in preparing seedbed or during planting and reduce animal populations (both wildlife and livestock) by using mammal repellants, if necessary. Water planted stock when set out and either provide water-retention basins around plants or irrigate periodically, or both; cultivate or control weeds. Postestablishment animal population control essential for stand longevity and sustained production (5,7).

## ASSOCIATED SPECIES

Species sown in complex grass, forb, and shrub mixtures in mountain brush type on Utah big game ranges. Usually planted alone for hedges and in windward row in windbreaks in Northern and Central Great Plains. Planted alone in rows or blocks in mined land reclamation in Colorado and Wyoming; also used in mixed plantings or seedings.

## PESTS AND DISEASES

Grasshoppers defoliate and damage stands and blister beetles sometimes attack plants. Deer and antelope destructively browse small, oasislike plantings. No major diseases reported (1).

## IMPROVED VARIETIES

None. There are several horticultural varieties recognized for landscaping and several other closely related species used for similar purposes (2).

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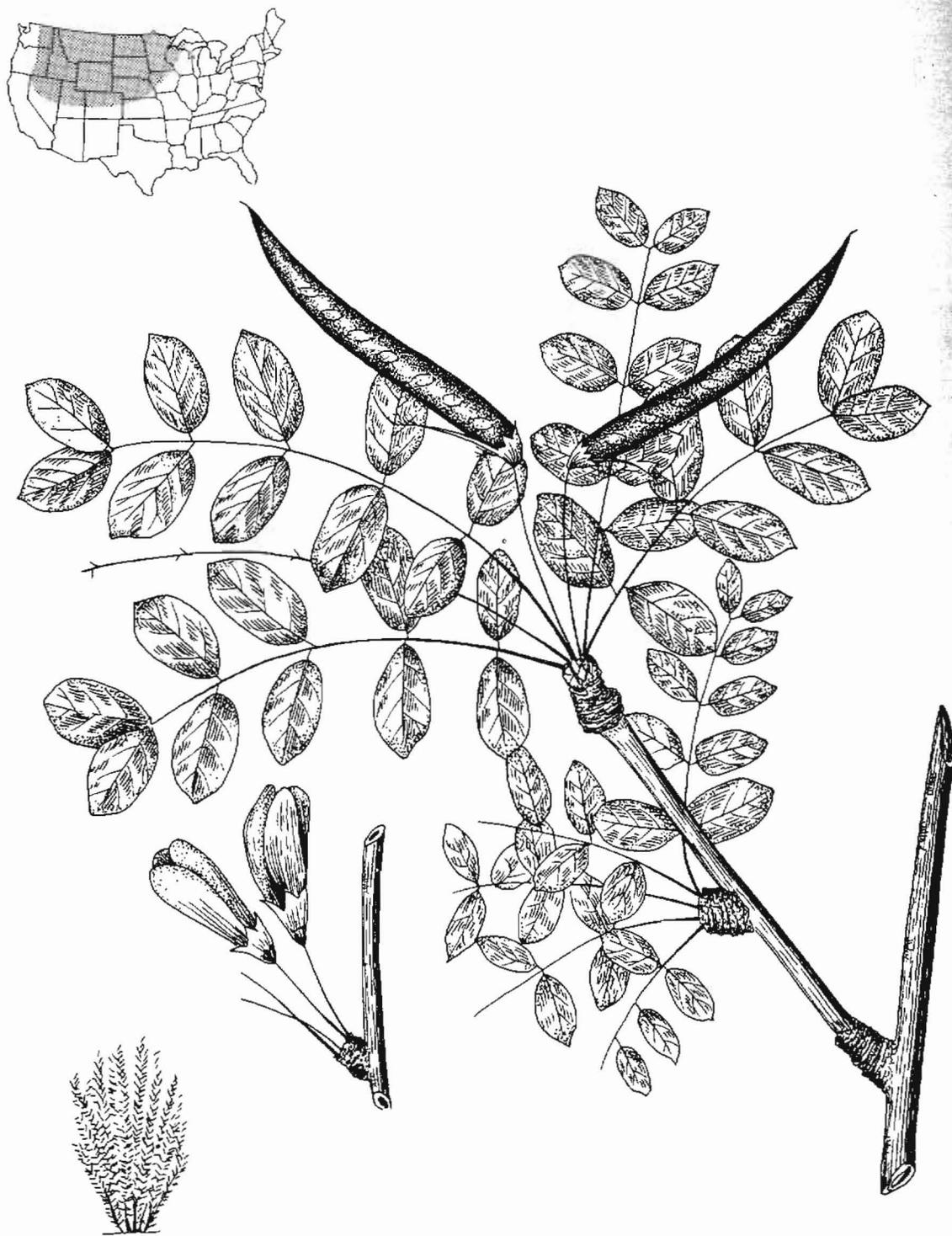


Figure 62. Siberian peashrub. (*Caragana arborescens*). Twigs, leaves, and pod x 1; flowers x 1 1/2.

## MARTIN CEANOOTHUS

*Ceanothus martini* Jones

### ORIGIN

Native to Utah, Nevada, northwestern Colorado, and northern Arizona. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Low, stiffly branched, deciduous shrub.

Stems spreading from a branched root crown, 1 to 4 feet tall; twigs and branches gray and without spines; leaves alternate, oblong to oval, smooth, green on both sides, prominently three-veined from base, often with minutely glandular-toothed margins. Inflorescence round-topped racemes, mostly from lateral branches; small, white flowers, bearing three-lobed capsules. Similar to Fendler ceanothus (*C. fendleri*) but without spinescent twig and branch tips, more oval leaves without gray undersides, and less prominently veined (1).

Generalized root system of moderate size; some rootsprouting and probably layering in moist litter or soil. Plants leaf out during spring and summer, bloom in May and June, and mature fruit in late summer. Good palatability to livestock and wild browsers and provides some cover for small mammals and birds (2).

### ECOLOGICAL RELATIONSHIPS

Relatively narrow geographic range in pinyon-juniper, ponderosa pine, and aspen types, centered about 7,500 feet in elevation. Sites of occurrence indicate tolerance of well-drained, medium-textured soils, often rocky and thin; also weakly acid to weakly basic and mostly nonsaline soils. Sites demand winter hardiness although less cold-stressing than snow-free areas. Moderate shade tolerance but plants more vigorous in somewhat exposed sites. Fair drought tolerance. Very good grazing/browsing tolerance; probably less tolerant than closely related spinescent Fendler ceanothus. Fair fire tolerance of plants due to some root sprouting; seeds of *Ceanothus* stimulated to germinate by fire and heat. Good compatibility reported in Utah revegetation work (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed at depth twice the greatest diameter of seed in a firm and weed-free seedbed. Best rates for seeding unknown. Recommended as an optional species for inclusion in game range seed mixtures in Utah; most such species seeded at 1 to 2 pounds PLS per acre in drill-seeding and broadcasted mixtures. Best time for seeding unknown; most shrub species used in Utah game range work are sown in fall. *C. fendleri* is sown in spring in California (2,4,5).

#### Seed Cleaning and Quality

Harvest fruit by hand-picking into containers and clean by drying, fanning, floating, and then fumigate. Small lots might be obtained by tying cloth sacks over green fruit on vigorous plants until seed is ejected naturally (as reported done with *C. fendleri*). Seed quality not standardized: 90 percent purity; germination reported "fair" (16 percent in *C. fendleri*); and 83,000 seed per pound (2,4,5).

#### Germination and Seedling Characteristics

Germination, initial establishment, and growth rate rated fair and about 5 years needed to flower in Utah (2).

### MANAGEMENT

Major obstacle to use of species is difficult seed production and handling. Recommended as optional species for use in game range revegetation mixtures in sagebrush, mountain brush, and juniper-pinyon types in Utah. Spreading habit, fire tolerance, and attractive flowers potentially useful in seedings or

plantings for stabilizing disturbed soils and for roadside beautification. Reduction in competing vegetation and in animal stocking necessary for good stand establishment. Periodic burning, where species a major element and fires controllable, may stimulate better production and nutrition. Control of both domestic and wild animal populations within conservative grazing capacity of range essential to sustained production and soil stability (2).

#### ASSOCIATED SPECIES

Most commonly associated with junipers (*Juniperus* spp.), pinyons (*Pinus* spp.), ponderosa pine (*P. ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), and quaking aspen (*Populus tremuloides*) and with the grasses, forbs, and shrubs that are common on shallow and rocky soil phases on the slopes of middle elevation mountains within this species' geographic range. Species recommended for use in complex shrub-forb-grass mixtures in Utah (1).

#### PESTS AND DISEASES

None reported. Anticipate rabbit and rodent damage and deer browsing, especially in small seeded areas.

#### IMPROVED VARIETIES

None. Spinescent twigs of Fendler ceanothus may prove advantageous in maintaining stands with high populations of browsers.

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Figure 63. Martin ceanothus (*Ceanothus martini*). Plant x 1; capsule (pod) x 3; flower x 3.

## WINTERFAT

*Ceratoides lanata* (Moq.) J. C. Howell

### ORIGIN

Native to western North America; a primary species in the intermountain salt desert vegetation. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season, suffrutescent half-shrub.

Stems mostly annual, 1 to 3 feet tall or taller, matted woolly hairy, branched and only woody at base, and arising from a woody root crown. Leaves simple, alternate, mostly linear, and revolute-margined. Flowers dioecious or polygamous in axillary clusters or terminal spikelike inflorescences; staminate in inconspicuous four-parted perianth, pistillate with only two united bracts, with long white or rufous hairs enclosing hairy utricle fruit (1).

Polymorphic with short and tall ecotypes commonly present on valley floors and mountainous terrain, respectively; one variety, *subspinosa*, with woody, spinescent-tipped branches, extends from southern Utah into southern California and northern Mexico. Plants strongly rooted with a generalized root system that includes a deep taproot and extensive fibrous roots capable of stabilizing soil. Active growth resumes in early to late spring, flowering in March to July, and maturing from September to November, varying with environmental conditions. Palatable and nutritious to livestock, advantageously so in winter; highly preferred by antelope and rabbits at all seasons; browsed by elk, desert bighorn sheep, and deer; provides cover and nesting material for rodents (2,3).

### ECOLOGICAL RELATIONSHIPS

Species relatively indifferent to soil textures; occurs on shallow rock outcroppings and from rocky and sandy loams to clays; usually more productive on finer textured soils. Preference shown for basic and limey soils; tolerant of weakly or moderately saline soils, varying among ecotypes, but intolerant of acid soils. Plants intolerant of flooding and suffer with excess water. Broadly adapted in arid to subhumid precipitation zones and fairly common from about 5 to 20 inches MAP; present on limestone soils with as much as 40 inches; desert ecotypes found in areas with under 5 inches. Strongly drought-tolerant and a C-3 plant surviving better than shadscale saltbush (*Atriplex confertifolia*), a C-4 plant, at the U.S. Desert Range near Milford, Utah, under intermittent drought conditions. Good cold tolerance when fully established but somewhat frost-sensitive in early seedling growth stages. Species occurs from near sea level to 10,000 feet in elevation. Seek seed sources from habitats similar to planting site or tested strains. Relatively shade-intolerant but occurs in open desert shrub and juniper-pinyon and other woodlands. Good fire tolerance in dormant state. Weak tolerance to continuous grazing that removes 25 percent of current annual growth during the growing season; tolerant of 60 percent removal by sheep during winter dormant season. Moderately competitive and compatible in both warm and cool season plant mixtures (2,3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed less than 1/2 inch deep; they can be broadcast on surface of saturated soils, but usually better results obtained by planting 1/16 to 1/4 inch deep and covering or pressing broadcasted seed in soil to similar depths. Firming seedbed below seed depth improves emergence, and mulch aids natural establishment. Species usually only planted in mixtures with rates of 1/2 to 1 1/2 pounds per acre drilled or 1 1/2 to 3 pounds per acre broadcasted in total seed mixes of 10 to 20 pounds per acre. Recommend trying 15 to 20 PLS per square foot (about 5 to 7 pounds PLS per acre) drill rates for full stands; however, usually advantageous to seed with vigorous adapted grasses where annual weeds, such as cheatgrass brome (*Bromus tectorum*) and halogeton (*Halogeton glomeratus*), threaten. Best season of planting unknown; late fall, winter, and spring seedings used or recommended; usually better to seed before the moistest growing season, provided surface soils not saturated more than week or two. Some propagating success reported using stem cuttings in Nevada; practice probably useful for propagating superior selections (3,4,6,7).

### Seed Cleaning and Quality

Adapt harvesting to equipment available and existing conditions. Hand-stripping into containers, using headcutters, vacuuming, mechanized or hand-operated strippers, and combining are options. Process collections in hammermill set at about 1,000 rpm equipped with 5/16-inch screen; clean in a fanning mill, if necessary. Strippings can also be mechanically flailed and cleaned in a clipper cleaner. Considered undesirable to remove seed from utricle because it will be more susceptible to early germination during temporary early warm spells and associated decimating factors. Seed quality not standardized: acceptable purity 50 percent in Utah game range restoration; germination 90 percent; and 123,000 average seed per pound (2,3,7).

### Germination and Seedling Characteristics

Fifty percent of afterripened fruit germinate in 2 days and 80 to 90 percent in 4 to 5 days under ideal lab conditions. Germination varies by geographic source or ecotypes. Afterripening period of 2 to 3 months met by room temperature storage. Optimum temperature for germination varies according to seed source. Germination decreased to a minimum by increasing moisture stress 10 to 15 atmospheres. Seedling vigor varies with source of seed. Vigorous strains often attain reproductive maturity by second growing season; dryland seedlings expected to take longer (2,3,7).

### MANAGEMENT

Considerable use in revegetating semidesert and salt desert rangelands and for big game range improvement. Potentially useful for soil stabilization purposes on those sites to which it is uniquely adapted; of value for dryland ornamental landscaping in intermountain region. Reduce plant competition in seedbed preparation or by scalping before or during planting operations, withhold grazing and reduce native animal populations, and suppress competitive weeds when feasible during establishment (3). Planting shrubs and herbs in separate rows or alternate strips may improve establishment and survival. Careful management to remove a safe minimum of herbage during the growing season and not over 60 percent in winter is essential to stand perpetuation. Use of taller strains advocated for winter ranges.

### ASSOCIATED SPECIES

Nearly pure stands occur on valley floors and plains; some of these are extensive but many have been invaded by weedy or less palatable invaders. Species commonly grows mixed with shadscale saltbush, Gardner saltbush (*A. gardneri*), black greasewood (*Sarcobatus vermiculatus*), spiny hopsage (*Grayia spinosa*), Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), black sagebrush (*Artemisia nova*), big sagebrush (*A. tridentata*), galleta (*Hilaria jamesii*), Indian ricegrass (*Oryzopsis hymenoides*), and bluebunch wheatgrass (*Agropyron spicatum*). Species commonly seeded with native and introduced warm and cool season grasses, forbs, and shrubs in blackbrush, shadscale saltbush, black greasewood, big sagebrush, and juniper-pinyon types; optionally included in mountain brush and inland saltgrass types on Utah game ranges. Also included in rangeland seedlings to restore native vegetation and shrubs on many ranges now devoid of palatable browse.

### PESTS AND DISEASES

Rabbits and rodents damage stands and may destroy seedling stands. Grasshoppers, Mormon crickets, and a variety of plant-sucking and other native insects commonly present but only infrequently damage stands beyond recovery. Minor plant pathogens include two leaf rusts and two stem infectors.

### IMPROVED VARIETIES

None other than the botanical variety *subspinosa*, noted under Species Characteristics.

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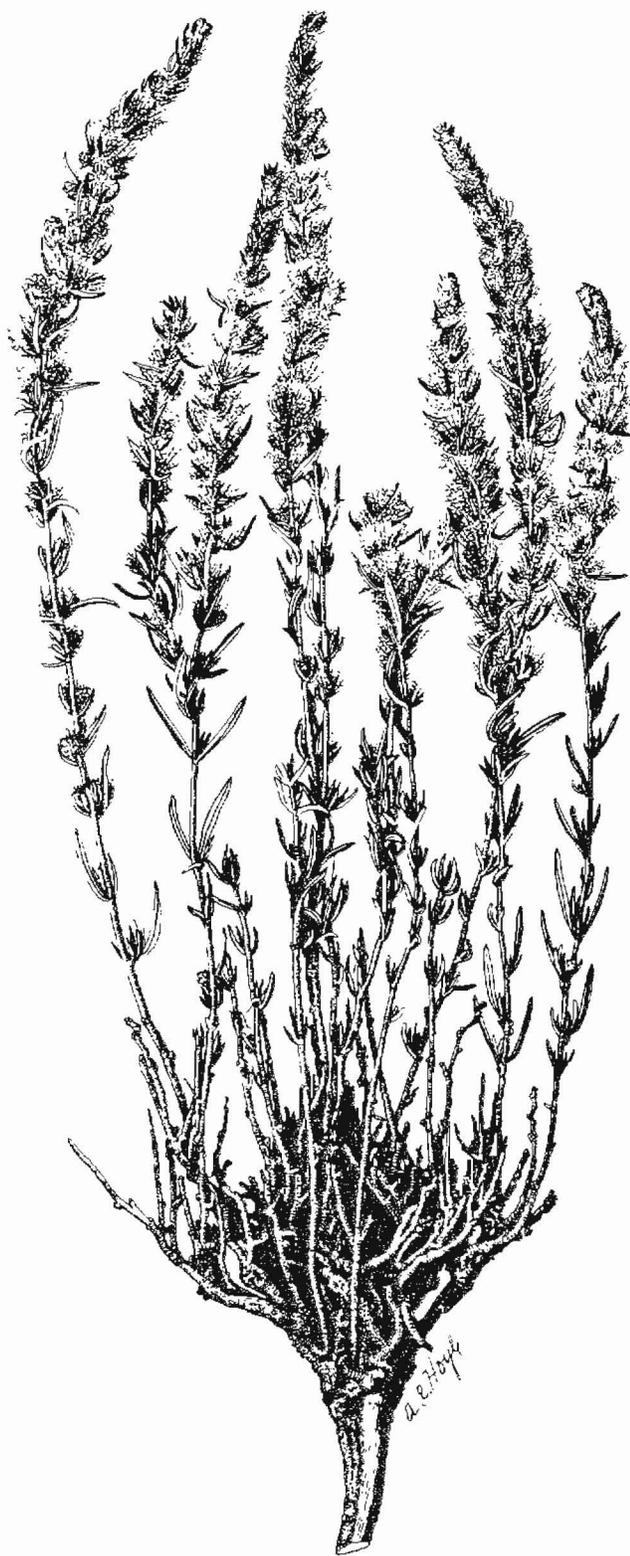
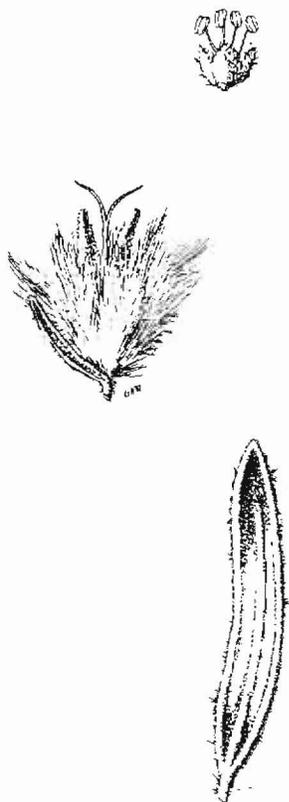


Figure 64. Winterfat (*Ceratooides lanata*). Plant x 2/5; leaf x 2 1/2; pistillate flower x 3; staminate flower x 3.

## TRUE MOUNTAIN-MAHOGANY

*Cercocarpus montanus* Ref.

### ORIGIN

Native shrub of western foothills and mountains. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, persistent-leaved or evergreen shrub or small tree.

Stems grayish, erect, and loosely branched from a woody root crown, 3 to 10 feet or taller. Leaves simple, alternate, mostly obovate, coarsely serrate above the middle, dark green above, whitish beneath, with tomentum. Flowers stalked, single, or occasionally in twos or threes, axillary. Petals absent, silky calyx tubes containing one or few dry achene fruits, ending in 2 to 4 inch fuzzy, persistent styles (1).

Deeply and extensively branched woody root system often ramifying rock crevices. Plants leaf out from March to May, flower from April to June, and mature fruit from July to October, varying regionally and elevationally. Very good palatability to deer, particularly in winter; good palatability to sheep and fair to cattle, mostly during growing season and fall. Some use made by elk, antelope, mountain sheep, and small mammals. Shrubs also provide cover for mammals and birds (2).

### ECOLOGICAL RELATIONSHIPS

More abundant on moderately coarse to moderately fine-textured and mostly well-drained soils. Habitats often rocky, gravelly, and thin-soiled. Grows in wide range of precipitation from 10 to over 25 inches MAP zones; thriftier stands appear to occur in intermediate precipitation zones. Tolerant of mildly acid to moderately basic-reacting and mostly nonsaline soils. Moderately strong drought tolerance. Fair shade tolerance evident by presence in mixed shrub and in open juniper-pinyon and ponderosa pine types; appears to thrive in full sunlight and on nonforested sites. Local seed sources and ecotypes winter-hardy and cold-tolerant; make certain southern, low elevation, and sources from other habitats are fully adapted to planting site. Good tolerance to winter browsing but may be dwarfed and made unproductive by repeated close use during the growing season. Species shows good tolerance of wildfires, responding by vigorous root crown sprouting and greater herbage production. Strongly competitive when fully established and compatible with a variety of associates (2,3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed (fruit) 1/4 to 1/2 inch deep; use deeper figure for drier and coarser (sandy or gravelly) soils or when sowing in fall. Species is rarely planted alone except as transplanted stock used for native hedges or landscaping. Usually seeded in seed mixtures at 1/4 to 1 pound per acre drill rates or 50 to 100 percent greater rates when broadcasted for game range improvement in Utah. Generally sown in fall but seed treated to enhance germination can be sown in early spring or as early as possible in higher mountain elevations. Planting stock is usually set out in spring after undergoing some hardening in cold frames; may be planted later with ample moisture or irrigation but needs about 2 months growth to become adequately established before frost (2,3,6,7).

#### Seed Cleaning and Quality

Harvest achenes by shaking them onto canvas or into hoppers. More viable seed may be obtained from plants growing on north slopes, in average or above-average rainfall years, and from widely spaced shrubs lacking much competition. Clean seed by hammermilling to remove hairy styles; fanning and screening; or put fanned, hammermilled material through a Dybvig cleaner, dry, and then fan. Seed quality not standardized: 80 percent acceptable purity in Utah game range work; 70 percent germination; 56 percent PLS; and 45,000 seed per pound (6,8,9).

## Germination and Seedling Characteristics

Most afterripened seed germinate in 9 days in lab tests but some may take a month or longer. Seed germination requirements vary for different ecotypes. A New Mexico source germinated best (70 to 72 percent) at 73° F (8 hours) and 53 to 60° F (16 hours) temperatures and at -2 bars moisture stress. Vigor of seedlings has not been critically evaluated. Container-planted stock used in the Black Hills of South Dakota and at the Manitou Experimental Forest in Colorado had approximately the stature of mature plants only after 10 and 7 years of age, respectively (2,6,7,8,9).

## MANAGEMENT

Limited use is made of this species for restoring big game ranges and nursery-grown plants are used for hedges, ornamental screens, and in experimental mined land reclamation. Remove competitive vegetation before seeding or planting and reduce animal populations, or take advantage of low population periods, to secure better establishment and survival. Probably better establishment and less weed competition occur if grasses are planted in alternate rows with forbs and shrubs. Control of animal populations and moderate use is essential to sustain improved production and cover (2,7,8).

## ASSOCIATED SPECIES

Serviceberries (*Amelanchier* spp.), junipers (*Juniperus* spp.), pinyons (*Pinus* spp.), Gambel oak (*Quercus gambelii*), skunkbush sumac (*Rhus trilobata*), mountain snowberry (*Symphoricarpos oreophilus*), ponderosa pine (*Pinus ponderosa*), and blue grama (*Bouteloua gracilis*), several needlegrasses (*Stipa* spp.), wheatgrasses (*Agropyron* spp.), and forbs are commonly associated with this plant. Associates used in seed mixtures include a complex of native and exotic grasses, forbs, and other browse species in game range restorations; some trees may be used in landscape or mined land plantings (2).

## PESTS AND DISEASES

Rodents and rabbits threaten new plantings and deer and antelope concentrate on, and decimate, small scale plantings. Gophers were particularly troublesome in one study. Plants are relatively free of insect and disease attack. Loopers and bark beetles and an unidentified fungus caused some damage or losses in the intermountain regions. Plants occasionally are attacked by western tent caterpillar. Plants rarely may cause some minor animal losses from hydrocyanic poisoning after frost or drought.

## IMPROVED VARIETIES

'Montane' was recently released from New Mexico (5).

Curlleaf mountain-mahogany  
*Cercocarpus ledifolius*

Curlleaf mountain-mahogany (*Cercocarpus ledifolius*), a shrub to small tree, with narrower, revolute margined leaves, occurs on exposed rocky foothills and lower mountain slopes in the northern intermountain region. A valuable wildlife browse and cover plant. Seed sometimes included in revegetation mixtures for game range restoration in mountain shrub and juniper-pinyon types in Utah.

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Figure 65. True mountain-mahogany (*Cercocarpus montanus*). Branch with achenes x 2/3; leaves x 1; twig with flowers x 2/3; achene with plumelike style x 2.

## RUBBER RABBITBRUSH

*Chrysothamnus nauseosus* (Pall.) Britt.

### ORIGIN

Native to western North America. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, composite, half-shrub to large shrub.

Stems mostly gray-white, felty, pubescent, branched from grayish-brown, stringy barked trunk or ascending main branches, forming somewhat rounded to flat-topped crowns, greatly varying in size from 1 or 2 feet (*C. nauseosus nauseosus*) to larger forms, up to 5 to 10 feet tall (*C. nauseosus graveolens*). Leaves simple, linear, entire, not twisted but often drooping and about 2 inches long. Leaves and stems somewhat resinous and aromatic. Flower heads borne in crowded, terminal, round-topped cymes. Involucral bracts numerous in overlapping, vertical rows; flowers golden-yellow, discoid, tubular, five-toothed, usually five per head and bearing five-angled dry achenes, encircled by a ring of capillary hairs. Very polymorphic, with several subspecies varying greatly in plant form and adaptation (1).

Plants display strong self-seeding habits, especially on disturbed sites; deeply branched taproots; and vigorous suckering habits. Plants resume growth in spring to early summer, flower mostly in August and September, and mature fruit about 1 month later in September and October, varying considerably with elevation. Species variably palatable to livestock and big game, with greater use made in fall and winter; provides some cover for mammals and birds (2).

### ECOLOGICAL RELATIONSHIPS

Some forms adapted from saline, clayey bottomlands or coarser, upland, sandy soils to weakly acidic mountain loams. Most common in well-drained, disturbed sites of open plant communities. Tolerant of somewhat poorly drained soils but not of permanent high water tables. Grows in 6 to over 20 inches MAP zones; subspecies vary in optima and tolerances, collectively more abundant or vigorously growing in intermediate areas but appear to be as dependent on less competition and disturbed site conditions. Moderate to strong drought tolerance, in part due to deep root system tapping subsoil moisture, but varies among subspecies and probably ecotypes. Mature plants winter-hardy but seedlings sometimes frost-sensitive, requiring use of adapted sources or strains. Species grows from about 2,000 feet to over 9,000 feet in elevation. Weak shade tolerance but good tolerance of burning evidenced by vigorously sprouting afterward. Strong grazing and browsing tolerance. Somewhat competitive with shrubby associates but quite compatible and sometimes beneficially associated with herbs and grasses, particularly noticeable in association with crested wheatgrass (*Agropyron cristatum*) (3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

Best planting depth unknown; use gardener's rule of 2 to 4 times largest seed diameter, about 1/2 to 1 inch deep. Game range direct seedings made in fall or winter in Utah, and roadside seedings made in November in Nevada. Natural germination occurs from March to June, suggesting possible safer seeding date with seed pretreated to enhance germination of just before or early during this period. No critical tests of optimum seeding rates appear in print. Rates of 1/2 pound per acre (drilled) and 1 pound per acre (broadcast) used in complex game range revegetation mixtures. Good stands reported from transplanting 3 to 5-month old seedlings in early spring from cans or milk cartons in Utah and some success in establishing them by aerial seeding (3,5,6).

#### Seed Cleaning and Quality

Harvest by knocking or shaking achenes or stripping heads into containers or onto canvas or by

vacuuming. Product can be cleaned by hammermilling or mechanically flailing and recleaning in a fanning mill. Seed quality not standardized: 10 percent acceptable purity in game range work, at least 70 percent possible; 63 percent average germination of eight samples; 693,000 seed per pound, average of 40 samples, and 463,000 average in recent Montana study, indicating variability to be expected from different sources, subspecies, and by years (3,5,6).

#### Germination and Seedling Characteristics

Lab testing indicates about half of untreated seeds may germinate in 5 to 21 days; half of those stored wet for 1 month at 39°F to enhance germination germinated in 2 days at 68°F. Reported good to fair initial establishment in Utah work; very good growth rate, good final stands, full growth attained in 4 years, and rapid spread by self-seeding attest to good seedling and juvenile vigor (5,6).

#### MANAGEMENT

Species included in seed mixtures for game range restoration, in seedings and plantings for highway stabilization and beautification, and exhibits some potential for stabilizing mined lands and other disturbed lands. Reduce plant competition before or when seeding or planting and reduce animal populations or take advantage of low population periods for better stand establishment. Control animal populations on revegetated sites to perpetuate improved cover and production. Species can become weedy without management.

#### ASSOCIATED SPECIES

Big, silver, and fringed sagebrushes (*Artemisia tridentata*, *A. cana*, and *A. frigida*, respectively); Douglas rabbitbrush (*C. viscidiflorus*); and a very diverse group of plains, foothill, desert, and lower mountain grasses, forbs, shrubs, and some open stands of trees naturally associate with rubber rabbitbrush. It is seeded with similar native species but also with some exotic species, often in very complex seed mixtures, on game ranges.

#### PESTS AND DISEASES

Species attracts a variety of insects and butterflies and is somewhat susceptible to gall-forming insects and wood borers, but usually survives attacks. Seedlings and sometimes stands menaced by rodents and small mammals.

#### IMPROVED VARIETIES

None. Knowledge of subspecies is helpful in revegetating different sites. Subspecies *albicaulis* and *consimilis* occur in salt desert type, *leiosperma* and *hololeucus* are lowland forms. *nauseosus* and *graveolens* occur in varied plains to mountain habitats, while *salicifolius* is a high elevation form.

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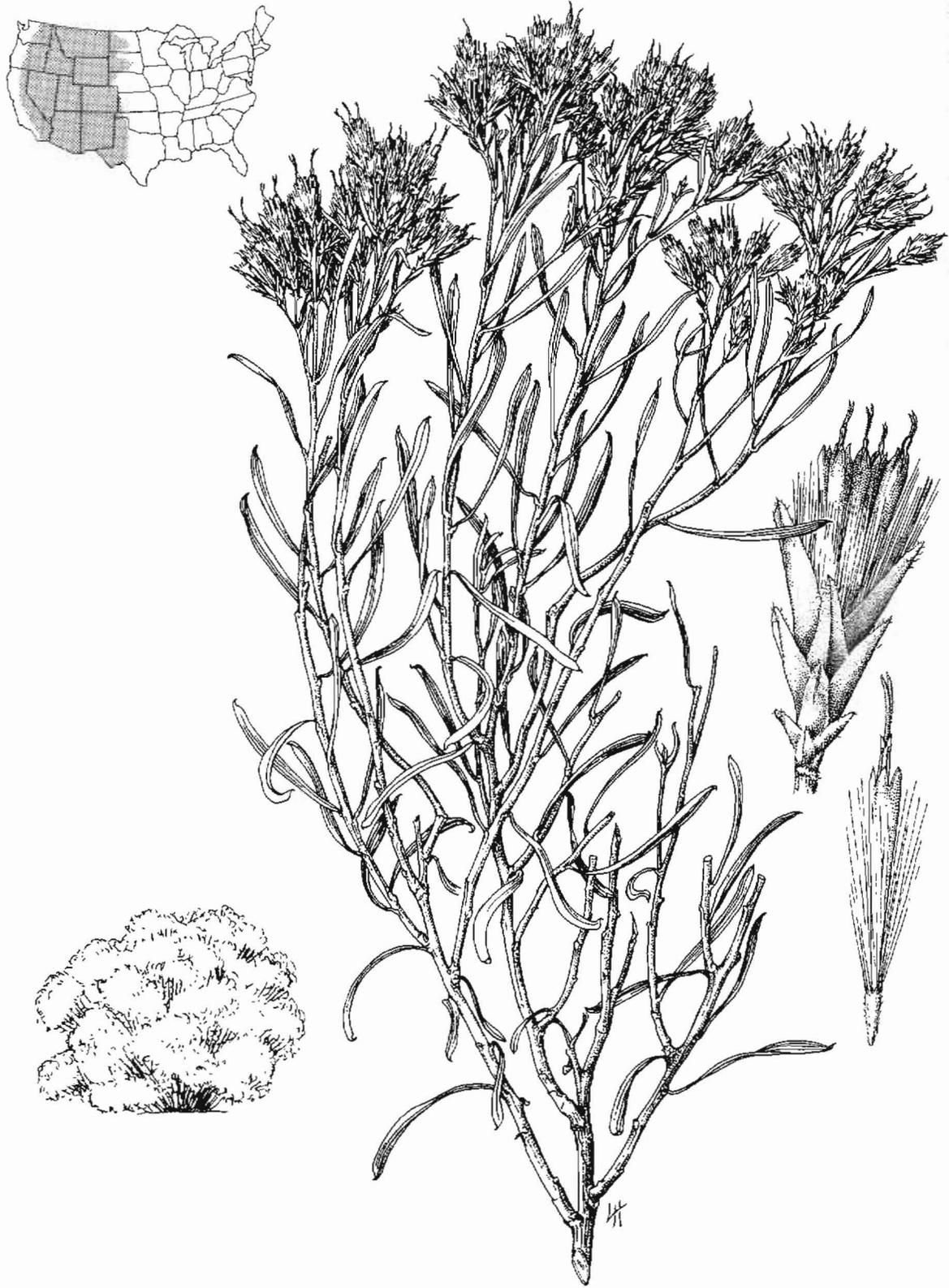


Figure 66. Rubber rabbitbrush (*Chrysothamnus nauseosus*). Branch x 1/2; flowerhead x 6; disk flower x 5. (Growth form after Elmore 1976).

## DOUGLAS RABBITBRUSH

*Chrysothamnus viscidiflorus* (Hook.) Nutt.

### ORIGIN

Native to western United States; more abundant in the intermountain region. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Typically small but some forms large, deciduous shrubs.

Twigs ascending to erect, semiherbaceous, from a much branched woody base. Leaves linear to lanceolate, twisted or flat, about 1 to 2 inches long. Flower heads in a terminal round to flat-topped cyme; outer flower bracts several, not in well-defined rows, often with a thick brown or green spot near apex. Small, lobed, yellow disc flowers typically five per head, bearing hairy five-angled achenes (fruit) surrounded by a ring of hairs (1).

Plants sprout strongly at base, especially after injury or top removal; equipped with medium depth, well-branched, generalized root systems. Polymorphic species with several integrading subspecies differing in form and adaptation. Plants resume growth in spring or early summer, flower in late summer and fall, and mature fruit in late summer and into winter, varying environmentally and by subspecies. Sheep make fair use of plants, cattle less; variable use by big game; furnishes some cover for small mammals, lizards, and birds (2).

### ECOLOGICAL RELATIONSHIPS

Species exhibits broad adaptations to soil texture and reaction; occurs on clayey, saline, bottomland soils to well-drained medium to coarse-textured, nonsaline and weakly basic soils and sometimes on weakly acid mountain soils. Species adapted in 6 to over 20 inches MAP zones; probably somewhat more productive in intermediate MAP zones and in open communities. Generally good drought tolerance, varying somewhat among subspecies. Some variation in winter hardiness and frost sensitivity of seedlings to be expected among subspecies and seed sources, requiring choice of adapted planting materials. Species occurs up to 10,000 feet in elevation. Fair shade tolerance exhibited by low forms growing in understory of shrublands and woodlands but generally thrives in full sunlight. Good fire and grazing tolerance due to strong sprouting habits. Fair compatibility with associated vegetation (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed about 1/4 inch deep or two to four times seed diameter. Best rate of seeding and optimal depth not known. Species used at 1/4 to 1/2 pound per acre drilled and broadcasted rates, respectively, in complex game range seeding mixtures in Utah. Game range seedings are made in late fall and winter. Germination studies indicate it can be seeded "anytime after harvest through the second fall with good germination results" (4). Survival studies expected to show that either late fall or early spring may be optimal times, or possibly later at higher elevations and where precipitation comes mostly in late summer. Good success from transplanting seedlings or wildings reported in Utah (2,4,5).

#### Seed Cleaning and Quality

Shake branches, knock seed, or strip heads into containers or onto canvas or vacuum harvest seed. Cleaning difficult: 30 to 50 percent chaff not removable with mechanical flail, clipper, and seed blower. Only hammermilling used in Utah game range work. Seed quality not standardized: probably 10 percent purity acceptable, similar to *C. nauseosus* in Utah; germination 60 percent in Utah and 97 percent in Montana, varying due to different temperature and storage regimes and probably due to regional strain differences; 782,000 seed per pound (10 Utah samples) and 584,500 seed per pound (2 Montana samples) (2,4,5).

### Germination and Seedling Characteristics

Fifty percent of achenes germinated in 1 to 9 days at optimal lab temperatures with light in Montana study. Two-month old achenes germinated 97 percent at 86° F, whether stratified or not, and at same rate at 68° F when 1-year old. Achenes lose viability rather quickly after 2 years of age. Good seedling vigor and among the more aggressive species that are rapidly established and spread (2,3,5).

### MANAGEMENT

Various subspecies used in game range revegetation mixtures in shadscale saltbush, black greasewood, sagebrush, and mountain brush types in Utah. Management similar to rubber rabbitbrush (*C. nauseosus*). This species somewhat less productive and shorter, making less browse available above snow. The more generalized root system may be somewhat more competitive with herbs and competition might be lessened by planting separately or in alternate rows where feasible. Species can become weedy without careful management.

### ASSOCIATED SPECIES

Big sagebrush (*Artemisia tridentata*), winterfat (*Ceratoides lanata*), shadscale saltbush (*Atriplex confertifolia*), Utah serviceberry (*Amelanchier utahensis*), Sandberg bluegrass (*Poa secunda*), bluebunch wheatgrass (*Agropyron spicatum*), and junipers (*Juniperus* spp.) commonly occur in varying mixtures with species. Included as a minor component in complex grass, forb, and shrub mixtures seeded on game ranges in need of restoration in Utah. Appears to have potential for stabilizing disturbed soils, such as road shoulders, mine spoils, and gullies, due to its sprouting and self-seeding characteristics (2,3).

### PESTS AND DISEASES

No major problems reported; rodent damage of plants occasionally noted and probably some seed depredation to be expected.

### IMPROVED VARIETIES

None. Use adapted subspecies in their native habitats.

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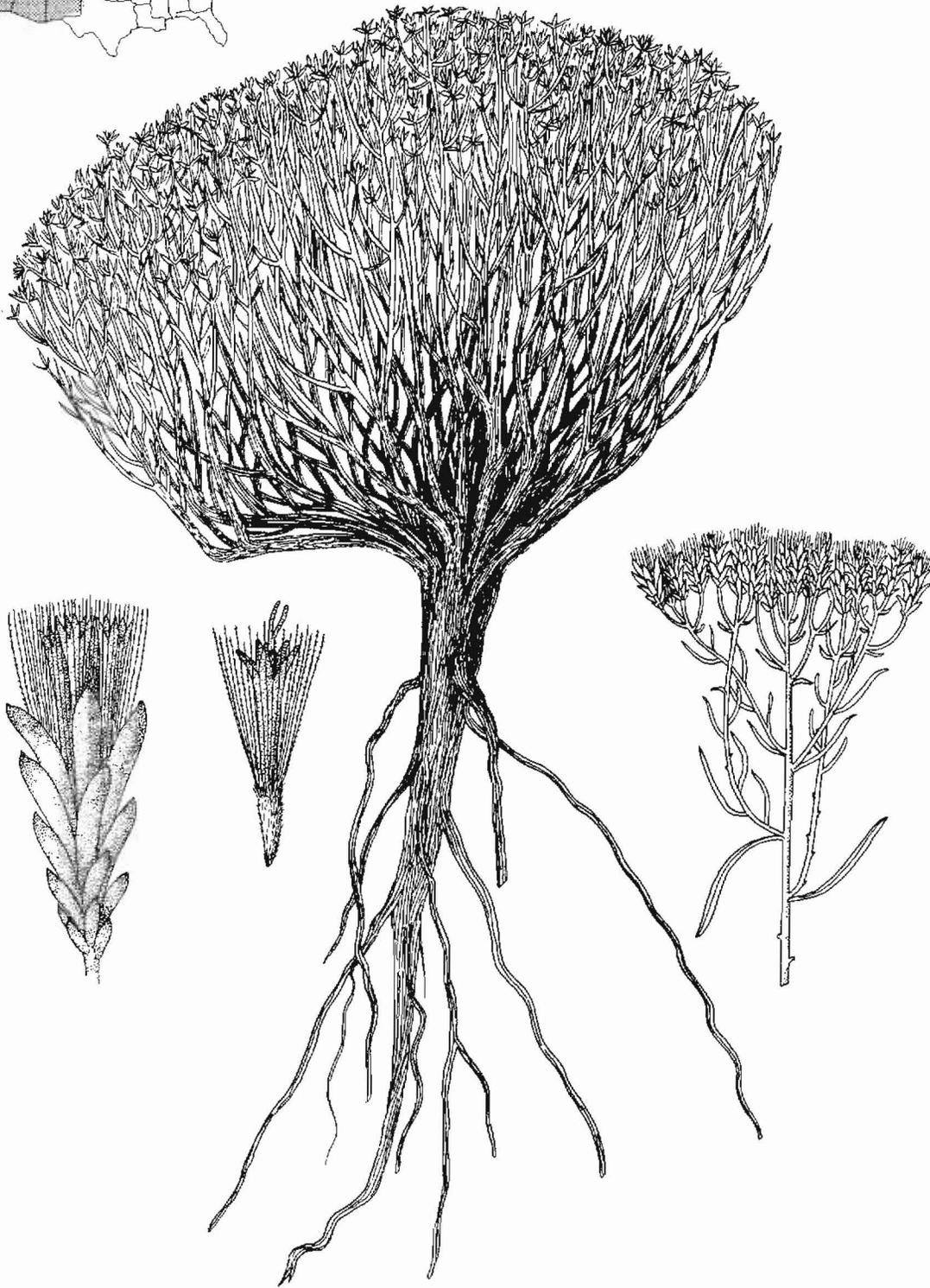


Figure 67. Douglas rabbitbrush (*Chrysothamnus viscidiflorus*). Plant x 1/5; flowerhead x 6; disk flower and achene x 6; inflorescence x 4/5.

## WESTERN VIRGINSBOWER

*Clematis ligusticifolia*

### ORIGIN

Native to western United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Woody climbing or clambering vine.

Stems 10 to 20 feet long or tall. Leaves pinnate with five to seven leaflets 1 to 2 inches long, lanceolate to egg-shaped, narrow-tipped, and finely to coarsely-toothed. Flowers in flat-topped clusters; sexes in separate plants (dioecious), without petals, sepals petallike, about 1/2 inch long, bearing hairy achenes with 2-inch long, silky hairy, persistent styles (1).

Root systems shallow, fibrous, and producing rootstocks. Flowering June to August and maturing seed in fall and winter. Low palatability and herbage production for livestock, furnishing some deer browse, and of some utility for cover and restoration of disturbed lands and natural vegetation (2,3).

### ECOLOGICAL RELATIONSHIPS

Common along drainages, roadsides, and in disturbed sites; often with woody plants, steep slopes, banks, or boulders for support; mostly in coarse, rocky, sandy, and well-drained soils. Adapted to broad range of soil reactions from weakly acid to moderately basic and in somewhat saline soils. Rather abundant in the 12 to 20 inches MAP zones but more vigorous in moisture-concentrating sites with reduced competition along drainages and at edge of woods. Weakly moderate drought tolerance, responding with reduced growth and seed production. Moderate shade tolerance, appears more productive in partial shade or bordering shade. Generally not frost-sensitive, particularly in sheltered habitats; some sensitivity to be expected to both cold and heat among regional strains and ecotypes. Plants may be badly injured or killed by wildfire; some survival from root stocks or ultimately by dispersal of fuzzy fruit. Common habitats suggest only fair competitiveness and compatibility with only certain associates; probably thrives better with shade and support (3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Optimum depth and rate of seeding unknown; plant seed two to four times as deep as seed diameter and cover broadcasted seed to similar depth. For game range revegetation, always use species with other grasses, forbs, and shrubs, with grasses comprising less than 50 percent of seed mixtures. Usually no more than 1 pound per acre of seed in seed mixtures added on suitable sites for game range restoration purposes.

#### Seed Cleaning and Quality

Collect ripe seed by hand or by using a vacuum harvester. Run dry achenes through a hammermill equipped with a 3/16-inch screen at 1,120 rpm to remove hair and styles and clean in a fanning mill (5). Seed quality not standardized: 20 percent purity acceptable in Utah game range work; germination 11 to 80 percent (median 46 percent); 9 percent PLS; and 93,000 achenes or 315,000 seeds per pound (3,6,7).

#### Germination and Seedling Characteristics

Pretreated seeds germinate rather slowly in 40 to 60 days at 68° F (night) and 86° F (day) temperatures. Ratings of fair initial stand establishment, fair rate of growth, and fair final stands in Utah revegetation work suggests only fair seedling vigor. Moist chill achenes at 33° to 41° F for 2 to 6 months to enhance germination. Achenes retain good viability only for 2 years (6,7). Good growth rate of seedlings reported on southern Idaho big game winter range but low survival (8).

## MANAGEMENT

Species used in seeding mixtures on special game range sites in the mountain brush type in Utah. It naturally invades disturbed sites, displaying potential for rehabilitation of disturbed soils. Wider use of species restricted by limited seed supplies and difficulty in collecting and handling seed. Reduce plant competition and animal populations before and during establishment. Plant's ropelike vines, feathery styles, and yellowish foliage are seasonally attractive, particularly in fall (3).

## ASSOCIATED SPECIES

Common chokecherry (*Prunus virginiana*), cottonwoods (*Populus* spp.), willows (*Salix* spp.), boxelder, Rocky Mountain and bigtooth maples (*Acer negundo*, *A. glabrum*, and *A. grandidentatum*), rubber rabbitbrush (*Chrysothamnus nauseosus*), ponderosa pine (*Pinus ponderosa*), and Douglas-fir (*Pseudotsuga menziesii*) commonly occur in communities with virginsbower. Species is added to complex seed mixtures including several grasses, forbs, and other shrubs for game range improvement purposes. Species shows potential for revegetating upper slopes of cut and fills otherwise revegetated slowly by herbaceous species.

## PESTS AND DISEASES

Seed and seedlings are pilfered and destroyed by small mammals. Leaf spots, in particular, and rusts occur rather commonly on foliage; downy mildew less commonly.

## IMPROVED VARIETIES

None.

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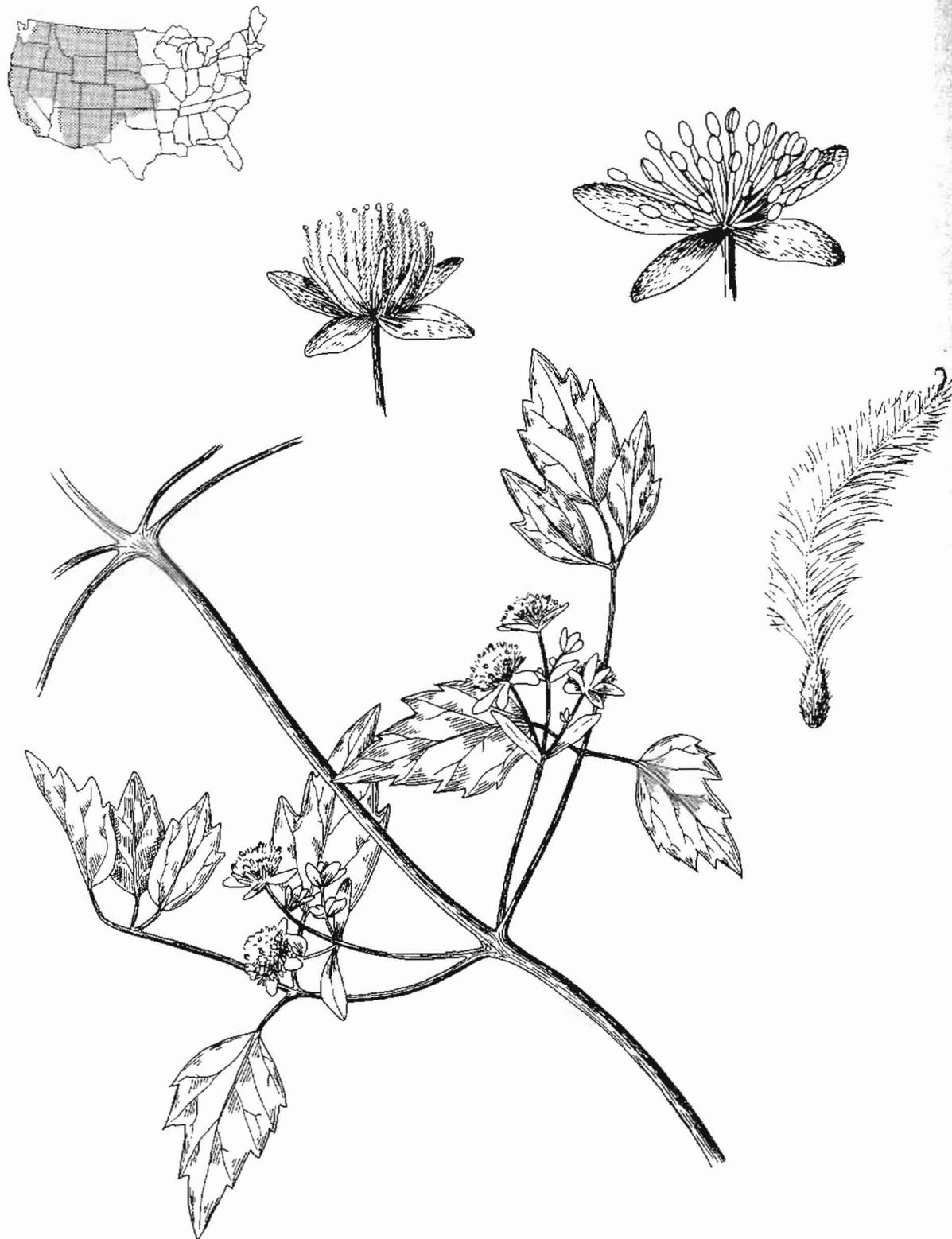


Figure 68. Western virginbower (*Clematis ligusticifolia*). Leaves and flowers x 1; pistillate flower x 2; staminate flower x 2; plumed achene x 2. (After C. L. Hitchcock et al. 1964.)

## MEXICAN CLIFFROSE

*Cowania mexicana* Don.

### ORIGIN

Native of southwestern U.S. and southern Great Basin. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Evergreen, microphyllous, aromatic shrubs or small trees.

Stems rather stiffly erect, branching from gray, shreddy-barked single or multiple base(s), and 3 to 20 feet tall. Leaves clustered on branchlets 1/2 to 1 inch long, revolute-margined and five to seven-lobed, gray to green, gland-dotted, and often whitish beneath. Flowers showy, fragrant, about 3/4 inch across, solitary on branchlets and composed of five persistent sepals and five pale-yellow petals, surrounding several pistils with attached plumelike styles that mature into dry achene-type fruit (1).

Single trunked trees nonsprouting; multistemmed form often sprouting at base. Plants resume active growth in late winter or early spring and after soil moisture recharge; flowering mostly in May to June, sometimes earlier in southern locations, and intermittently two or three times with interrupted precipitation events; maturing mostly in July and August or later. Generally palatable winter browse for livestock and deer but strain unpalatable to livestock in southern Arizona suggests geographic strain differences. Species hybridizes with bitterbrushes (*Purshia* spp.) and, to limited extent, with Apache-plume (*Fallugia paradoxa*) (2).

### ECOLOGICAL RELATIONSHIPS

Species grows on thin, rocky soils of both igneous and sedimentary origin. Thrives in the juniper-pinyon zone, particularly in calcareous soils and on immature limestone rocklands in the 12 to 16 inches MAP zones. Species also found at the edge of the salt desert and on southern exposures in the mountain shrub and ponderosa pine types with lesser and more MAP. Strongly drought-resistant after fully established; less so in seedling stages. Thrives in full sunlight but exhibits fair shade tolerance, especially in the seedling stage. Some variation in frost sensitivity of seedlings to be expected from southern and low altitude strains, also in vigor when introduced from habitats differing much from planting site. Species grows between 4,000 and 8,000 feet in elevation. Species generally killed by wildfire; old one-stemmed specimens readily killed by chaining, dozing, or severing of main trunk. Quite tolerant of winter browsing; removal of 65 percent of current annual twig growth stimulates flowering and reproduction but browsing more than 80 percent causes plants to deteriorate. Competitive beyond the seedling stage and suitable for inclusion in seeding mixtures for exposed rocky slopes within its climatic tolerances (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill achenes 1/4 to 1 inch deep; cover broadcasted fruit with soil to similar depth; chain drag areas after airplane seeding to cover seed. Best rate of seeding unknown. Species rarely seeded or transplanted as sole or dominant element in planting mixtures due to slow rate of stand establishment. More commonly, seeded at 1/2 to 1 pound per acre drill rates in 8 to 10 pounds per acre total seed mixtures or at 1 to 2 pounds per acre rates when broadcasted in complex seed mixtures of 12 to 20 pounds per acre. Plant achenes in the fall or early winter to naturally prechill seed and have seed in place before snowmelt. Prechilled seed probably can be seeded satisfactorily in early spring or later if done just before reliable moisture comes. Satisfactory stands can be established by transplanting seedlings grown in greenhouses or coldframes (3,5,6).

#### Seed Cleaning and Quality

Hand-pick achenes, knock or shake them from bushes into containers or onto canvas. Dry material,

hammermill, or run through Dybvig cleaner and reclean in a fanning mill. Seed quality not standardized: 85 percent purity; 90 percent germination; 76 percent PLS; and 65,000 seed per pound (3,5).

### Germination and Seedling Characteristics

Untreated achenes germinate rather slowly in 60 to 90 days; they germinate 70 percent or better in 28 days when subjected to alternating 50° and 86° F without prechilling and 90 percent in 10 days when prechilled for 1 month at 37° to 41° F and germinated at 50° and 86° F. Another test gave 80 to 100 percent germination in 2 days at constant 70° F temperatures after 30 days prechilling at 57° F. Soaking fruit 1 hour in a 3 percent thiourea solution improved germination in one test. Seedling vigor believed to be only fair, judging from Utah revegetation evaluations (3,5,6,7,8).

### MANAGEMENT

Species seeded for game range improvement purposes in Utah in complex seed mixtures, especially in the juniper-pinyon type and on exposed sites in the mountain brush type. Species has potential for use in controlling roadside and gully erosion. Similar in attractiveness for landscaping to antelope bitterbrush (*P. tridentata*) and apache-plume, but is somewhat more difficult to establish from transplants. Reduction in plant competition and populations during establishment important in stand success. Keeping animal populations in balance with forage/browse supplies helps sustain higher production and cover.

### ASSOCIATED SPECIES

Junipers (*Juniperus* spp.), pinyon pines (*Pinus* spp.), big sagebrush (*Artemisia tridentata*), rabbitbrushes (*Chrysothamnus* spp.), green Mormon-tea (*Ephedra viridis*), blue grama (*Bouteloua gracilis*), galleta (*Hilaria jamesii*), and numerous forbs occur mixed with cliffrose on southwestern rangelands. Species is used in seed mixtures for revegetating game ranges in Utah.

### PESTS AND DISEASES

Small mammals take planted seed; a 1 percent Endrin-2 percent Arasan formulation in a suitable adhesive effective in preventing seed loss without causing loss in germination (5). One minor rust reported on plants.

### IMPROVED VARIETIES

None. Stansbury cliffrose, *C. mexicana stansburiana*, a botanical variety first collected from Stansbury Island in Great Salt Lake, often is used for revegetating and landscaping in the Intermountain West.

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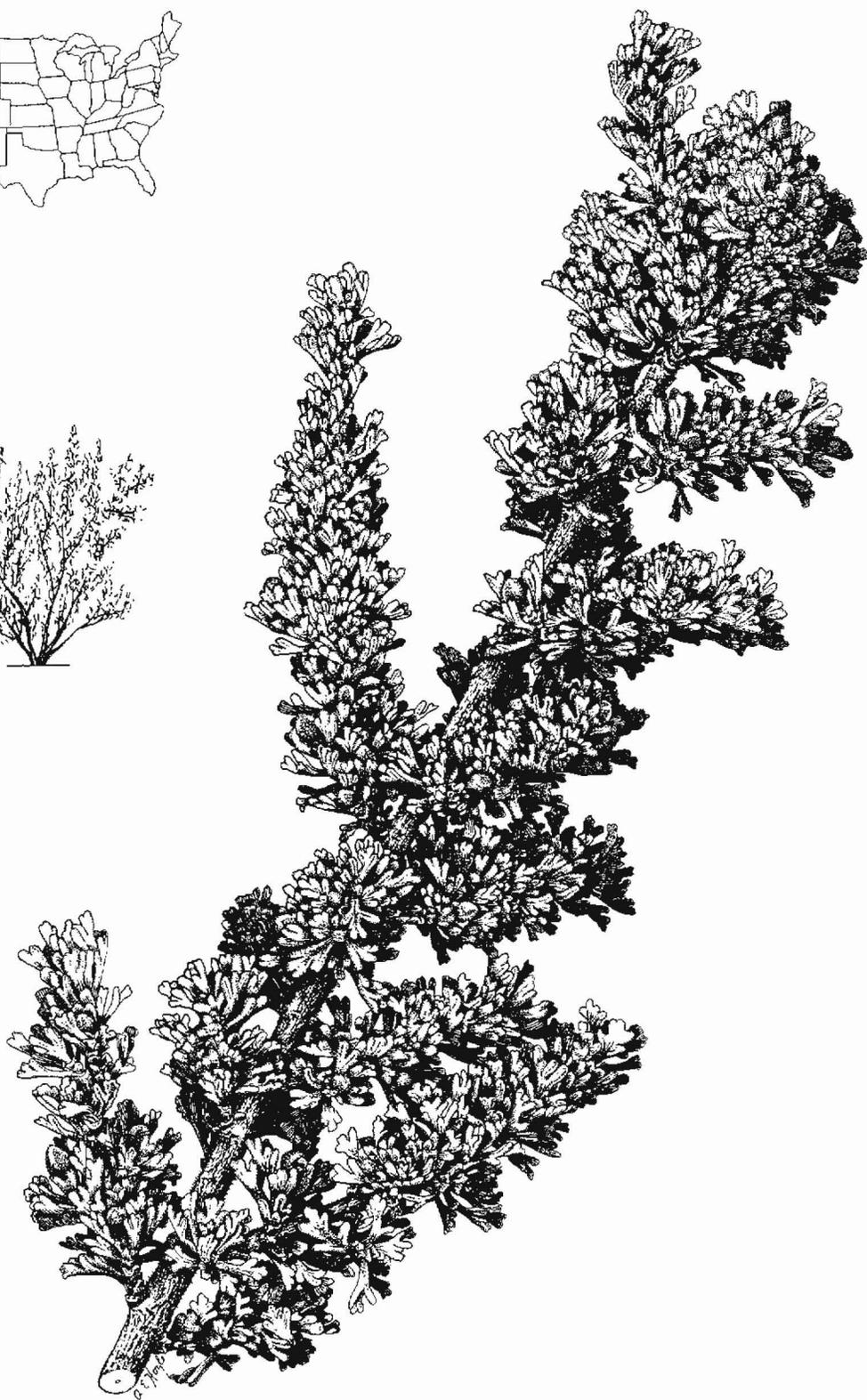
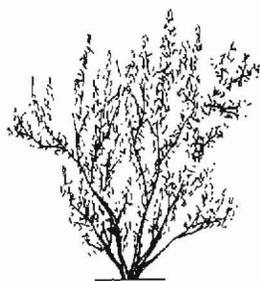


Figure 69. Mexican cliffrose (*Cowania mexicana*). Leafy stem x 1.

## GREEN MORMON-TEA

*Ephedra viridis* Cov.

### ORIGIN

Native to the southern Great Basin and Southwest. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Evergreen-stemmed, deciduous, scale-leaved shrubs.

Plants 2 to 4 feet tall with many green, jointed, and grooved stems; branchlets bright green, clustered at nodes, borne parallel and erect like broom straws and resembling large horsetails (*Equisetum* spp.). Leaves ligulelike scales, opposite at stem nodes, 1/8 inch long, thick-membranous and deciduous, leaving brown persistent bases. Sexes borne in separate plants; male cones spherical, about 1/8 inch diameter with yellow stamens and perianth; ovulate cones ovoid, 1/4 inch long with three to five pair of egg-shaped greenish to pale scales enclosing paired boat-shaped seeds (1).

Plants flower in spring, mature May to July or later, and spread rather quickly by roots. Fair winter browse plant for livestock and deer; less palatable in summer. Green and attractive year-round, contrasting with drab gray vegetation in winter. Planted specimens attain 6 feet in height and 10 feet in width in deep, sandy soils. Trimmed specimens uniquely ornamental (2).

### ECOLOGICAL RELATIONSHIPS

Species common on shallow to medium depth sandy or rocky slopes and in valleys of the salt, southern sagebrush, and higher creosotebush deserts; desert grasslands; and Joshua tree, juniper-pinyon, and oak woodlands. Tolerant of calcareous, weakly saline, and slightly saline-alkaline (sodic) sites; sometimes found growing in clayey soils. Thriving in dry, well-drained sites, mostly in the 6 to 12 inches MAP zones; intolerant of wet sites and poor drainage. Plants drought-resistant, markedly so after initial seedling establishment. Local plant materials winter-hardy; distant southern or lower altitude seed sources may be frost-sensitive, especially in seedling stage. Species commonly occurs between 3,000 and 7,500 feet in elevation. *Ephedra* sites not commonly burned due to sparse, discontinuous fuels but some plants survive wildfire and spread by roots. More vigorous in full sunlight but grows in partial shade of open woodlands. Plants weakly competitive due to slow growth rate; compatible with other shrubs and herbs but more so after seedlings are firmly established (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed 1 to 2 cm (c. 0.4 to 0.8 inch) deep, preferably by drilling in well-prepared, firm seedbed. Always mix with other species when revegetating game ranges to help control weeds and counterbalance slow rates of growth and establishment. One-half to 1 pound per acre of seed used in 17 to 19 and 28 to 30 pounds per acre total seed mixes when drilling and broadcasting, respectively, in Utah game range revegetation. Seedlings can be sown by airplane on disked or plowed lands or such seeded areas can be anchor chained when no site preparation precedes seeding. Plant before the growing season with soil moisture most dependably adequate for good germination and seedling establishment. Seedlings are made in late fall, early winter, or spring in intermountain areas (2,3,4).

#### Seed Cleaning and Quality

Harvest by knocking seeds from bushes into hoppers; dry, clean in fanning mill, then in Crippen EP-26 dewinger, and reclean in fanning mill. Seed quality not standardized: 90 percent purity; about 60 percent germination; 54 percent PLS; and 25,000 seed per pound (3,4).

### Germination and Seedling Characteristics

About half of seed germinate in 5 to 12 days, and most germination is completed in 14 days in lab tests. Alternating 59° to 87°F day and 36° to 41°F night temperatures optimal for germinating Nevada seed. Constant 55°F gave good germination. Germination may be improved by an afterripening period. Results from Utah range revegetation evaluations suggest seedling vigor and growth rate rather weak; plants take 5 to 10 years to attain 2 foot heights. Germination was reduced in -4 to -16 bars osmotic potential solutions; optimum was 0 to -4 bars (3,4,5).

### MANAGEMENT

Species used in seed mixtures for revegetating depleted game ranges in the mountain shrub and juniper-pinyon types and optionally in sagebrush type in Utah. Characteristics and qualities also suited for soil stabilization and highway and park beautification. Reduce plant competition and animal populations, if not already at low levels or excluded, during stand establishment, and balance animal populations with long term conservative usable herbage supply (3).

### ASSOCIATED SPECIES

Common associates include common creosotebush (*Larrea tridentata*), shadscale saltbush (*Atriplex confertifolia*), fourwing saltbush (*A. canescens*), big sagebrush (*Artemisia tridentata*), galleta (*Hilaria jamesii*), sand dropseed (*Sporobolus cryptandrus*), Utah serviceberry (*Amelanchier utahensis*), junipers (*Juniperus* spp.), and pinyons (*Pinus* spp.). Species seeded with a complex mixture of native and exotic grasses, forbs, and native shrubs on Utah game ranges. Where feasible, better stands probably result from planting this species in rows separated from other faster developing species.

### PESTS AND DISEASES

No serious insects or diseases documented. Some loss of seed and seedlings to be expected from small mammals and insects.

### IMPROVED VARIETIES

None. Nevada Mormon-tea, *E. nevadensis*, more tolerant of soil salinity and germinates faster than green form; may be more useful in valley sites. Flowers and fruits in late winter and spring in warmer desert sites.

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### IMPROVED VARIETIES

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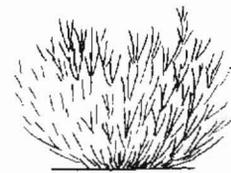
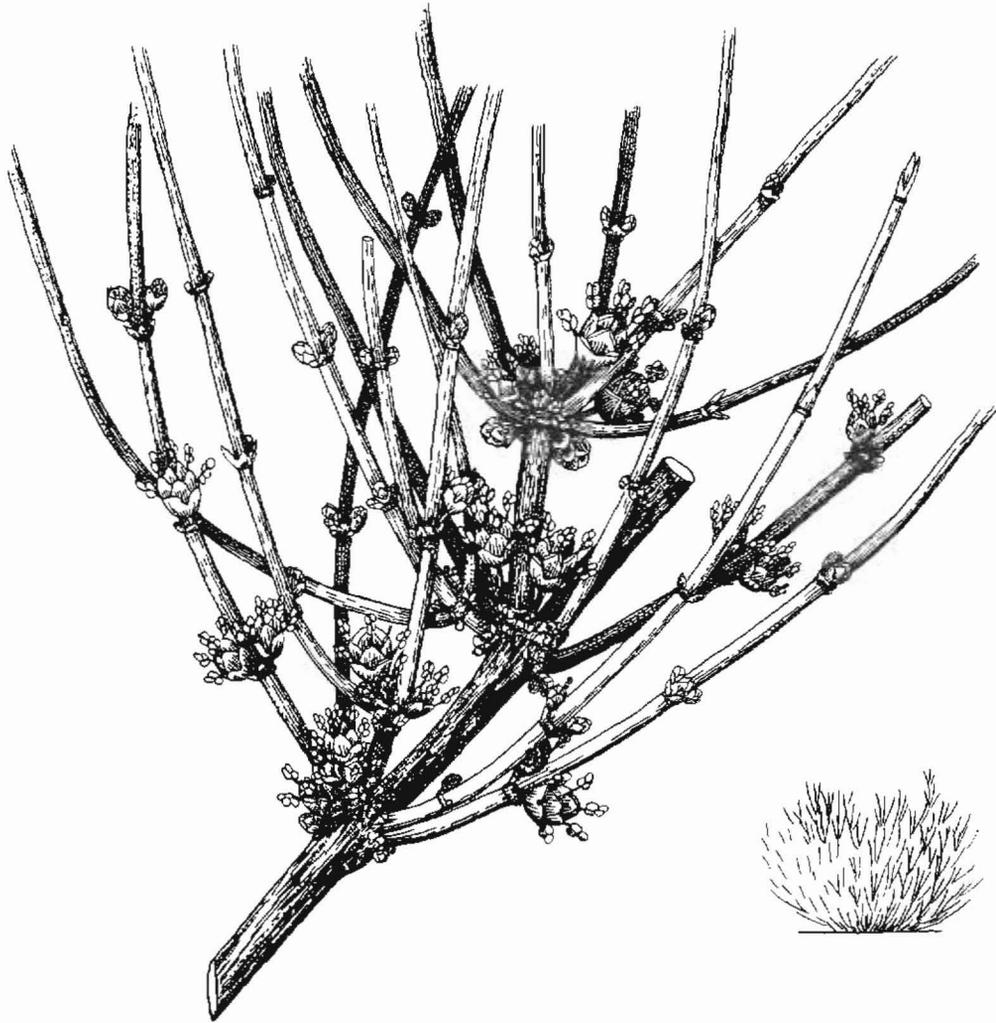


Figure 70. Green Mormon-tea (*Ephedra viridis*). Branch with flowers x 2. (Growth form after Elmore 1976.)

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

**ORIGIN**

Native to Southwestern United States. See map for distribution in the U.S.

**SPECIES CHARACTERISTICS**

Semievergreen, spreading shrubs.

Stems mostly ascending, smooth, white-barked, hairy to hairless and shreddy in age, up to 6 feet tall, branching from decumbent bases, rooting rhizomes, and stolon-like stems. Leaves single or clustered, wedge-shaped in outline, divided into three to seven narrow, round-tipped lobes, often hairy, and revolute margined. Showy applelike flowers 1 to 1 1/2 inches in diameter with 10 narrow bracts, five white petals enveloping numerous hairy achenes equipped with distinctive feathery styles 1 to 2 inches long, turning reddish-purple early and bleaching white when fruit is mature (1).

Leaves evergreen in South and lower altitudes and persistent or deciduous in colder climates. Relatively shallow to moderately deep-rooted but vigorously spreading and with underground rooting stems naturally retarding erosion on sloping land in gullies. New growth evident in early spring and after significant precipitation events, blooms intermittently summer-long but produces most achenes from early blooms. Fair to poor palatability to livestock and game animals, better palatability in winter for goats and deer; provides cover for small mammals and ground dwelling birds (2).

**ECOLOGICAL RELATIONSHIPS**

Common on rocky or gravelly slopes and alluvial fans on medium to coarse-textured, well-drained soils. Tolerant of weakly saline and neutral to moderately basic soils. Sometimes a pioneer plant on raw slopes and lava flows in upper desert grassland and juniper-pinyon zones in Southwest. Common in the 10 to 18 inches MAP zones; more thriftily growing with reduced competition on disturbed sites and in open communities. Cold-tolerant and hardy but be certain of adaptation of seed sources used due to some variability in these characteristics. Species grows between 3,500 and 8,500 feet in elevation. Good drought tolerance although less productive, most evident in less flowering and seed production when stressed. Plants thrive in full sunlight. Spreading rhizomes ensure fair tolerance to fire with quick recovery and miniature thicket formation. Weak seedling and early competitive ability; better sown with quicker developing associates. Good compatibility with most associates and more so after full establishment (2,3).

**CULTURE**

Planting Depth, Rate, and Time

Nurserymen broadcast seed, roll seedbeds, and cover seed with 1/16 inch soil and 1/8 to 1/4 inch sand, indicating 3/16 to 5/16 inch planting depths; up to 1/2 inch depths probably usable on drier rangeland sites. Optimum rate of seeding unknown. Usually used as minor ingredient in seed mixes where adapted at 1/2 to 1 pound per acre drill and broadcast rates in total seedings of 10 to 12 and 18 to 20 pounds per acre, respectively. Plant either in fall or spring; the species germinates without special pretreatment, hence seeding time should precede growing season with most dependable moisture for establishment. Seedlings or larger plants commonly transplanted for ornamental purposes, and wildings have been transplanted for erosion control. Difficult to propagate by root cuttings but can transplant divisions on small projects (4,5).

Seed Cleaning and Quality

Strip fruit or shake them from bushes onto canvas. Chop or rub them to break off styles and reclean to remove debris by fanning and screening. Seed should be cleanable in quantity by hammermilling and fanning, similar to Mexican cliffrose (*Cowania mexicana*) and mountain-mahogany (*Cercocarpus* spp.). Seed quality: minimum of 90 percent purity; 70 percent germination or 63 percent PLS standard in Utah for commercial seed; and an average of 540,000 cleaned seed per pound (3,4,5).

## Germination and Seedling Characteristics

About half of the achenes germinate under favorable temperature conditions in 14 days in seed lab testing but others may take 20 to 60 days to reach germination capacity. Optimum temperature for germination unknown but 60 to 73 percent germination obtained in 60 days at 32° to 38° F. Seedling vigor appears to be rather weak, judging from ratings of only fair germination and poor initial establishment and rate of growth in Utah game range revegetation work. Germination is epigeal (3,4,5).

## MANAGEMENT

Species included as minor ingredient in game range revegetation seed mixtures in the blackbrush, mountain brush, and juniper-pinyon range types in Utah. Considerably used throughout the Southwest, Southern Great Plains, and Southern Great Basin States for ornamental shrub and screen plantings. Plants spread from natural seed sources onto road borrow pits and shoulders and have been transplanted onto erosive areas. Low palatability and spreading habits potentially useful for mined land reclamation. Reduce plant competition and animal populations during establishment and balance grazing/browsing pressure with dependable forage/browse supply. Moderate defoliation by grazing, mowing, and trimming induces denser spreading forms that are more attractive and useful for erosion control (2,3,6).

## ASSOCIATED SPECIES

Naturally occurring with fourwing saltbush (*Atriplex canescens*), blackbrush (*Coleogyne ramosissima*), rubber rabbitbrush (*Chrysothamnus nauseosus*), skunkbush sumac (*Rhus trilobata*), junipers (*Juniperus* spp.), true mountain-mahogany (*Cercocarpus montanus*), and numerous Southwestern and Southern Great Basin grasses and forbs. Commonly sown with complex grass, forb, and shrub mixtures for game range restoration in Utah. Used in mass plantings with tamarix (*Tamarix* spp.), bladder-senna (*Colutea arborescens*), and desert willow (*Chilopsis linearis*) for more attractive summer-long ornamental showings in Southern Great Plains (2,3,6).

## PESTS AND DISEASES

Rodents molest seed and seedlings. No diseases documented. Hornets, bees, and ants are attracted to flowers and may be source of some hybridization with closely related Mexican cliffrose (2).

## IMPROVED VARIETIES

None. Considerable selection and breeding work is underway.

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Figure 71. Apache-plume (*Fallugia paradoxa*). Plant height x 1/4; leaves x 1/2; flowers x 1; feathery fruit x 1/2.

## SPINY HOPSAGE

*Grayia spinosa* (Hook.) Moq.

### ORIGIN

Native of the Intermountain West. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Spinescent, diffusely-branched, evergreen to deciduous shrub.

Plants spreading to erect and 2 to 4 feet tall, with spinescent-tipped branchlets and gray, shredding bark. Leaves alternate, about 1 inch long, oblong to obovate, rather fleshy, round-tipped and scurfy gray. Plants mostly dioecious; male flowers small with four to five-parted perianth. Seed bearing flowers only two flattened and fused round bracts, white or reddish tinged, and winged in fruit. Fruit a nutletlike utricle, closely invested by the two scales (1).

Moderately deep, generalized root systems. Plants resume visible growth in late winter to early spring, flower April to June, and mature fruit June to August. Plants evergreen in southern deserts but leaves deciduous in summer in northern deserts. Fair to good palatability to sheep, goats, and deer, especially late fall, winter, and spring; fair to poor palatability for cattle and horses; browsed some by antelope and rabbits; provides cover for small mammals (2,3).

### ECOLOGICAL RELATIONSHIPS

Species occurs in sandy to clayey and shallow, rocky soil sites in the Great Basin, Mojave, and Colorado deserts; Columbia River Basin sagebrush, salt, and upper creosotebush deserts; and adjacent foothill juniper-pinyon woodlands. It is tolerant of alkaline soils, less commonly found in saline soils, but also grows on near-neutral soils. It is strongly drought-tolerant and grows in the about 5 to 12 inches MAP zones. Strains and ecotypes show variation in cold tolerance; the species is found from near sea level to 7,500 feet in elevation in California and through a great range of latitude from Arizona to Washington. Species thrives in full sunlight but grows mixed in shrublands and open woodlands. Recovery from fires is better than the response of big sagebrush (*Artemisia tridentata*). Fairly good tolerance to grazing, possibly due to early dropping of leaves, especially in northern part of its range; observations in California indicate that moderate browsing stimulates twig and leaf production. Compatible with other species and competitive when fully established (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Optimal planting depth appears to be 0.5 to 1.0 centimeters (0.2 to 0.4 inch) in few tests reported. Broadcasting threshed seed on any surface or bracted seed on smooth or packed surfaces generally has given poor results. Slow developing species of woody plants usually are not seeded alone but in mixtures; hopsage is used as an optional species, usually seeded in mixed seedings at 1 to 2 pounds per acre on Utah game ranges. Native sources of seed exhibit frost hardiness and are recommended for seeding either in early fall or early to late spring (3,4,5,6).

#### Seed Cleaning and Quality

Strip fruits or knock them from branches into containers or onto canvas, run them through hammermill to remove papery scales, and clean product in a fanning mill. Seed quality not standardized: 90 percent purity; variable 25 to 88 percent germination; and seed average 161,000 per pound bracted seed to 402,000 per pound dewinged, pure seed (5,6).

#### Germination and Seedling Characteristics

Most stratified seed complete germination in 8 to 10 days but unstratified seed require 30 days or longer in lab tests. Moist chilling "stratification" period decreases with age of seed from 60 to 80 days for fresh or

year-old seed to 14 days for 6-year old seed. Good germination reported at moisture stresses as low as -12 and -16 bars using bracted seed but not with threshed seed, suggesting that bracts may help regulate osmotic potential of germinating seed. Germination response to temperature appears to vary with seed source or ecotype; one lot from Mojave Desert germinated at 104° F while another from Nevada did not. Constant temperatures of 50° F and 59° F appeared to be near optimum in two tests. Utah evaluations of poor initial establishment, rate of growth, and final establishment suggest only poor or fair seedling vigor (3,4,5,6).

#### MANAGEMENT

Species rated rather low overall in 20 characteristics used to evaluate suitability for revegetating Utah game ranges but recommended for special use in the sagebrush and juniper-pinyon types. Reduce plant competition and animal stocking during the establishment of seedlings. Probably better to plant species in separate rows when sown in mixtures when feasible. Control of animal populations is chief requisite for maintenance of improved cover and production on reclaimed areas.

#### ASSOCIATED SPECIES

Naturally occurs in mixtures with big sagebrush (*Artemisia tridentata*), rabbitbrushes (*Chrysothamnus* spp.), shadscale saltbush (*Atriplex confertifolia*), winterfat (*Ceratoides lanata*), fourwing and other saltbushes (*Atriplex canescens*, A. spp.), galleta (*Hilaria jamesii*), and other semidesert grasses, forbs, and shrubs. Infrequently seeded with mixtures of grasses, forbs, and other shrubs adapted in the sagebrush deserts, salt and Mojave deserts, and juniper-pinyon woodlands and to restore native covers to disturbed lands.

#### PESTS AND DISEASES

Rodent and small mammal removal of seed and browsing of developing stands sometimes needs control. No diseases reported.

#### IMPROVED VARIETIES

None. *G. brandegei*, spineless hopsage, slightly shorter, nonspinescent branched shrubs, slightly longer leaved and containing smaller keel-bracted fruit, occurs in Western Colorado, Utah, and Nevada. It has been rated markedly better for revegetation purposes on Utah game ranges (3).

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Figure 72. Spiny hopsage (*Grayia spinosa*). Vegetative, flowering and fruiting twigs x 3/4; utricle fruit x 5.  
(After C. L. Hitchcock et al. 1964).

## PROSTRATE SUMMERCYPRESS

*Kochia prostrata* (L.) Shrad.

### ORIGIN

Recent introduction from U.S.S.R., widely distributed in arid and semiarid areas there and westward to Central Europe and Mediterranean Sea (1). See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Cool season and warm season perennial half-shrub.

Annual branched stems gray-green to green, ascending to erect from a decumbent woody base and stout and deeply branched root system. Leaves succulent, silky, filiform to linear, mostly 1/8 to 1/2 inch, occasionally shorter ones clustered in lower axils. Inconspicuous flowers borne singly or several, often clustered, in axils of reduced leaves on upper branches. Fruit subglobose, surrounded by winged and hooded fuzzy perianth (2).

Polymorphic species; some plants decumbent, others upright; some gray, others green; similar variation in pubescence. Palatable to livestock in U.S.S.R. and interseeded into grasslands; reported to be palatable to big game as well as livestock in Utah but palatability variable among strains. Nutritionally similar to fourwing saltbush and winterfat with lower, safe oxalate content and nontoxic. Rather weak regrowth after defoliation (1,2,3,4).

### ECOLOGICAL RELATIONSHIPS

Some strains thrive on sands and sandy and stoney soils; others grow on saline and sodic soils. Strain differences exist in production with varying salinity levels; tested strains were tolerant to strong salinity. Tolerant of poor soils and mined soils of low fertility. Good stands produced in Lower Sonoran Zone in southwestern Utah and in sagebrush and open shrubland sites. Apparently thrives in intermediate 12 to 18 inches MAP zones but may grow in 8 to 12 inches or lower precipitation zones. Strains tested in some of the Utah studies did not tolerate close clipping and declined in production in a 1 to 2-inch multicut regime. Preliminary clipping studies in Oregon suggest it may be sensitive to fall defoliation (5). Species may be shade-intolerant. Resprouts after fires. Some strains may be too competitive for use with other desirable, less aggressive species. Species readily self-seeds and spreads, often growing out of crested wheatgrass (*Agropyron cristatum*) tufts (1,3,6,7). Reported tolerant of normal levels of 2,4-D (5).

### CULTURE

#### Planting Depth, Rate, and Time

Drill or broadcast seeds and cover with soil only to 1/4 inch depths. Drill 3 to 4 pounds PLS per acre for range revegetation purposes. Increase rate when broadcasting and for harsh or critical sites. Some airplane seeding being done, because small seed is adapted for broadcasting. Plant seed in late fall to help overcome dormancy in seed and to take advantage of late winter-early spring moisture (3). Studies indicate germination is sensitive to fluctuating surface soil temperatures; germination better at moderate seedbed temperatures (8). Obtaining consistently satisfactory stands is a research problem (5).

#### Seed Cleaning and Quality

Harvest small stands by hand-stripping, run material through a Dybvig seed cleaner to remove fuzzy bracts, and clean in fanning mill. Field row plantings can be harvested by combining or by swathing and then threshing, followed by use of Dybvig cleaner and fanning mill. Seed quality not standardized: acceptable purity 90 percent; germination only about 50 percent with much dormant seed; PLS about 45 percent; and 500,000 seed per pound (3,6).

#### Germination and Seedling Characteristics

Satisfactory germination, variable field emergence, either good or poor, and good seedling vigor reported from recent testing in Utah. Stands may head out by end of first growing season under favorable growing

conditions (1,3). One study reported best germination from November harvest, air drying, and storing at 4°C for 3 months and higher germination from var. *canescens* than from var. *virescens* (9).

## MANAGEMENT

Species is being used for reclaiming strip mined soils and for game range restoration in intermountain region. It is used for interseeding into grasslands in U.S.S.R. Reduction in competition, particularly from overstory vegetation, is usually necessary before, or as part of, seedbed preparation. Reduced animal stocking and suppression of aggressive weeds is helpful in obtaining better stand establishment where practicable. Sound range and game management should ensure some longevity of stands after establishment. Soviet scientists recommend a rotation grazing scheme with periodic rests or deferment during growing season.

## ASSOCIATED SPECIES

Species occurs in native stands mixed with sagebrush (*Artemisia tridentata*) and crested wheatgrass (*Agropyron cristatum*) on solonchic soils and with steppe grasses, forbs, and shrubs in sandy and stoney soils in U.S.S.R. Experimentally being tested with crested wheatgrass and other species for use in restoring big game ranges and for soil stabilization purposes.

## PESTS AND DISEASES

None known but some insect and rodent damage and game concentration and injury of small stands to be expected.

## IMPROVED VARIETIES

None. Several accessions being evaluated. Consult with plant materials specialists for approved or released strains.

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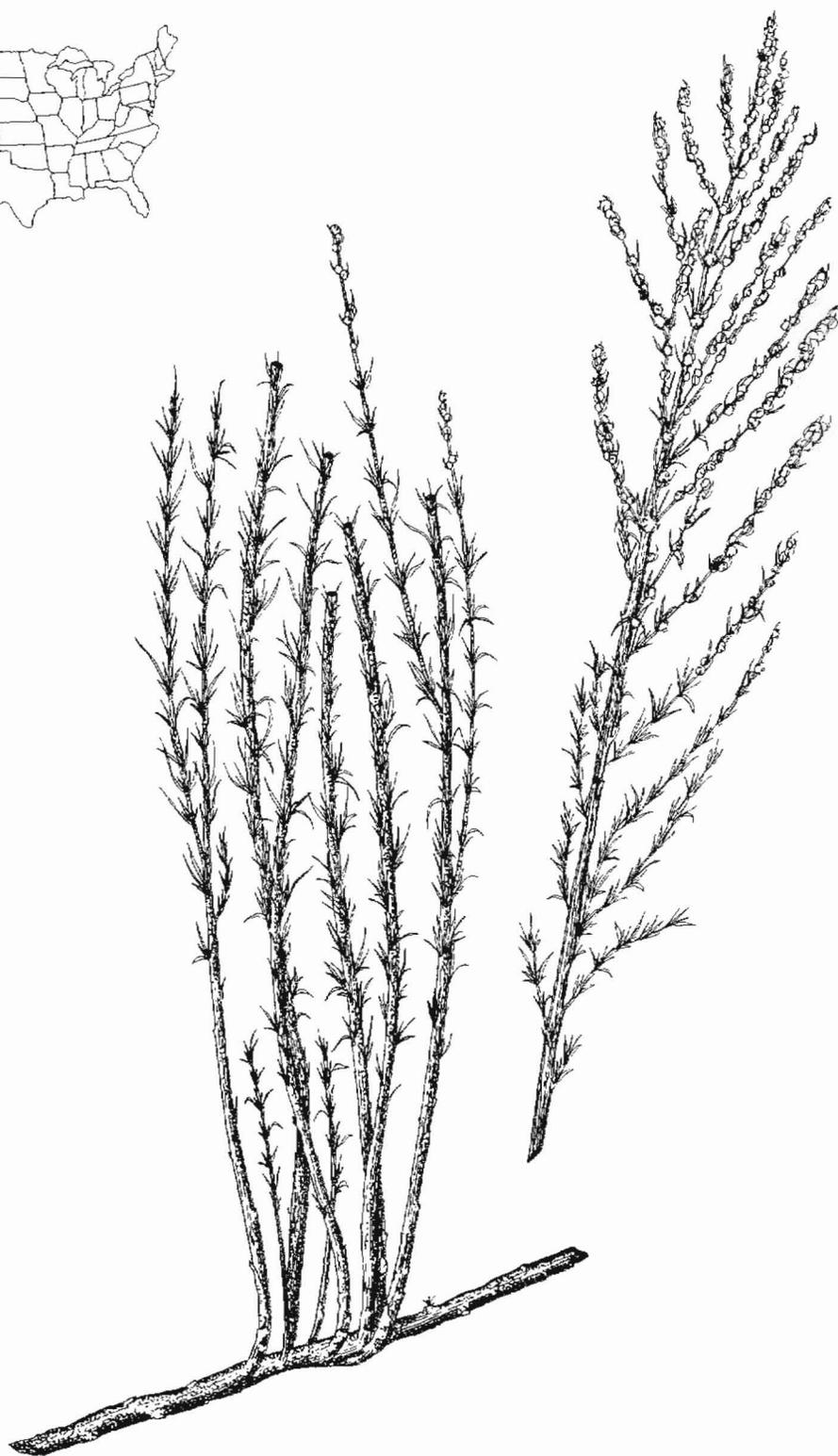


Figure 73. Prostrate summercypress (*Kochia prostrata*). Plant x 1/3.

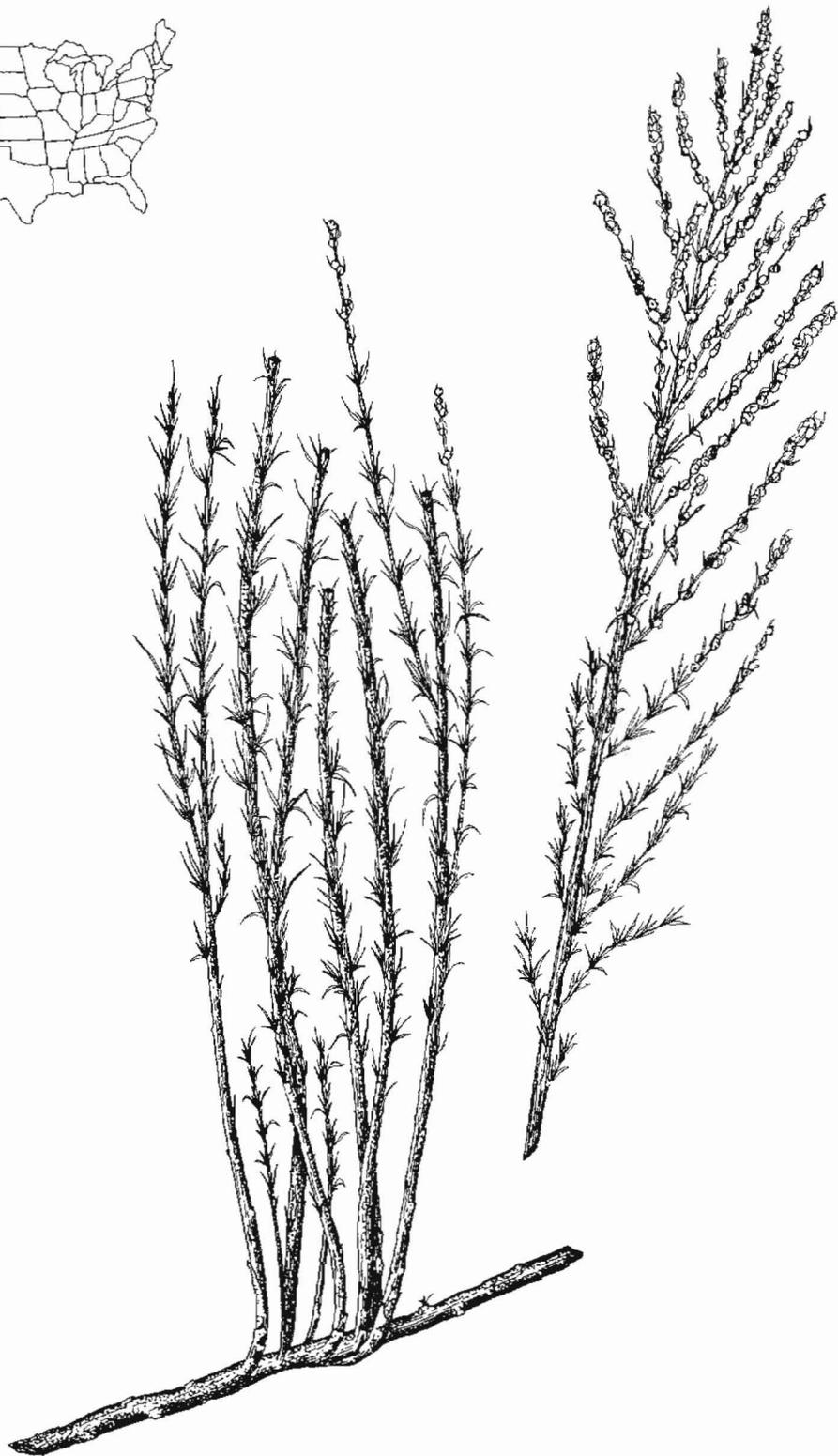


Figure 73. Prostrate summercypress (*Kochia prostrata*). Plant x 1/3.

## SHRUBBY CINQUEFOIL

*Potentilla fruticosa* L.

### ORIGIN

Native to cool, moist areas of western and northern United States. Circumboreal. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small, long blooming, deciduous or persistent-leaved shrub.

Stems erect to ascending from shreddy-barked, reddish-brown branches 1 to 4 feet tall. Leaves pinnate with three to seven, typically five, entire, narrowly oblong leaflets, somewhat whitish beneath and weakly revolute-margined. Inflorescence cymose or solitary flowered; flowers with five bright yellow, round, roselike petals bearing numerous, fuzzy hairy, dry achenes with very short deciduous styles (1).

Shallow to moderately deep, generalized root system; capable of sprouting from root crown. Plants resume growth early spring to early summer, bloom late May until fall or killing frosts, and mature fruit late summer until fall. Low palatability to livestock and game animals; soil stabilizing and highly ornamental. Polymorphic with several horticultural varieties (2).

### ECOLOGICAL RELATIONSHIPS

Adapted to wide range of soils and grows well in most soil textural classes except dense clay and loose sand. Tolerant to moderately acid to moderately basic and weakly saline soils. Only fair to weakly moderate drought tolerance and definitely thriving in mesic to semihydric, meadowlike habitats. Present in 16 to over 20 inches MAP zones but more vigorous in moister or irrigated sites. Thrives under irrigation in drier western and northern regions. Cold-tolerant and winter-hardy, evidenced by occurrence in boreal regions and from moist northern Great Plains to alpine areas. Grows in habitats usually too moist for fires to spread, greatly damaged when intensely burned but sometimes fair recovery by sprouting after spring fires. Moderate shade tolerance, growing in willow thickets but flowers more abundantly in nearly full sunlight. Tolerant of moderate defoliation by grazing, browsing, or shearing; injured by intense, repeated defoliation, especially when coupled with dry site or drought conditions. Weakly moderate competitor and compatible with herbaceous vegetation, more so after establishment or if transplanted (3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Optimum depth unknown. Suggest planting achenes 1/4 inch deep or less or cultipack surface sown seed in well prepared seedbeds. Limited use made in revegetation mixtures for restoration of game ranges in Utah, probably at less than 1 pound per acre. Seedings may be made from early spring to early July or from October until ground freezes; latter date takes better advantage of early spring snowmelt moisture. Some seedings made by airplane in fall on either plowed or disked areas, relying on natural soil sloughing to cover seed or covering seed by pulling a light anchor chain across seeded area. Drilling in spring and late fall is recommended whenever possible. Areas must be rather moist for successful direct seeding. Most landscaping and some disturbed soils vegetated by planting bare-footed or container stock or transplanting wildlings (3,5).

#### Seed Cleaning and Quality

Harvest small lots of seed by hand-stripping or larger lots by hand-operated metal or plastic seed-strippers. Should be amenable to vacuum harvesting. No cleaning records; suggest fanning once or twice if necessary. Seed quality: purity unknown, probably low; germination 55 to 82 percent; and about 1 million seed per pound (3,5,6).

### Germination and Seedling Characteristics

Ratings in Utah of poor germination and initial establishment, average growth rate, and good final establishment suggests possibly weak seedling vigor. May take over 5 years for full stands to develop from seed. Rather difficult seed handling also reported (3,5).

### MANAGEMENT

Minor component of seeding mixtures used on depleted game ranges in aspen openings and subalpine range types in Utah. Should be useful in mountain meadows, both wet and dry. Rated moderate priority for alpine and subalpine land revegetation and for roadside and critical site stabilization and beautification for development of planting materials at Upper Colorado Environmental Plant Center at Meeker, Colorado. Commonly planted as landscaping for homes, building sites, and parks. Reduce plant competition and animal populations to minimum during establishment and balance grazing/browsing pressure with forage and browse supply for stand establishment and maintenance (3).

### ASSOCIATED SPECIES

Species occurs along drainages with willows (*Salix* spp.), alders (*Alnus* spp.), and birches (*Betula* spp.); at edges of meadows and aspen groves with sedges (*Carex* spp.), rushes (*Juncus* spp.), tufted hairgrass (*Deschampsia caespitosa*), and a great variety of other grasses, forbs, and woody plants. Seeded in complex mixtures of browse and herbaceous species for game range restoration.

### PESTS AND DISEASES

Seeds eaten and removed by small animals; succulent seedlings browsed and older ones barked. Spider mites sometimes damage ornamental plantings (2).

### IMPROVED VARIETIES

None for wildland purposes. At least seven horticultural varieties exist. Candidate for selection and breeding improvement when seed production and handling limitations are overcome.

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Figure 74. Shubby cinquefoil (*Potentilla fruticosa*). Branch with leaves x 1; leaf x 1 1/2.

## COMMON CHOKECHERRY

*Prunus virginiana* L.

### ORIGIN

Native to eastern and cooler western regions of the United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, loose thicket-forming shrubs or small trees.

Plants 5 to 30 feet tall, sometimes dwarfed or more treelike. Stems numerous, slender, reddish-brown, ascending to erect with prominent lenticels, loosely branching from base, and from upright to spreading main branches. Leaves alternate, mostly oblong with serrate margins and abruptly pointed apexes, dark green above and pale below. Inflorescence of clustered, many flowered racemes. Flowers white petaled, cup-shaped, and bearing lustrous red to purplish-black, round, berrylike drupes (stone fruit) (1).

Rhizomatous with extensive, shallow roots and few deep feeder roots. Sprouts readily from stump and root and tends to form thickets, particularly after fire or severing of stems. Plants leaf out in spring to early summer, flower 1 to 3 weeks later, and mature fruit in late summer to fall, varying regionally and environmentally. Palatable browse for large domestic and game mammals and provides food and cover for birds, small mammals, and large, omnivorous mammals. Plants naturally arrest soil erosion (2).

### ECOLOGICAL RELATIONSHIPS

Common in moist sites like drainages, ditches, and road shoulders and in cool and moist foothill, montane, and canyon habitats. Adapted to wide range of soil textures except dense clay; intolerant of poor drainage and prolonged spring flooding and high water tables. More common in silty or sandy soils with good depth, fertility, and drainage. Tolerant of moderately acidic (to pH of 5.0), moderately basic, and weakly saline soils. Present in 12 to over 30 inches MAP zones; selectively more abundant in moist or seasonally moist sites in semiarid zones and in open communities and disturbed moist sites of subhumid zones. Fair drought tolerance, but sexual reproduction and vegetative growth noticeably reduced. Drought, coupled with diseases, shortens life of plants. Generally winter-hardy and cold-tolerant; likely to be variations in thriftiness of plant materials from habitats greatly differing from planting site. Strongly moderate shade tolerance but more productive of fruit and blossoms in full sunlight or light shade. Aggressive root and sucker sprouting after fire and moderately tolerant of grazing. Sometimes dwarfed and thinned by concentrations of game in winter. Compatible with many woody nonevergreens and strongly competitive with herbaceous vegetation (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed (stones) about 1/2 inch deep in moist, firm seedbeds or up to 1 inch deep in coarser soils and looser seedbeds or when seeding in fall. Optimum seeding rate on rangelands not known. Nurserymen plant 25 seeds per square foot which result in 3 to 34 percent established plants. Only fractional rates of 1 to 2 pounds per acre drill and broadcast seeding rates, respectively, used in total seed mixtures of 10 to 30 pounds per acre in Utah game range restoration. Sow unstratified seed in fall before ground freezes and stratified seed in early spring; former practice more common on rangelands. Sow stratified seed when most seeds have just cracked stones but before radicles have elongated to avoid breaking radicles. Better establishment reported from planting 1 or 2-year old stock; also when supplementary water given to seedlings during first year. Variable results reported from direct seeding due to seed source variations. Fair results reported from transplanting bare-rooted stock in Black Hills of South Dakota but plants showed periodic die back from tips on open ponderosa pine and burned-over sites (2,3,5,6,7).

## Seed Cleaning and Quality

Hand-pick, strip, or beat fruit from bushes into containers or onto canvas. Run fruit through a Dybvig cleaner with water to remove fleshy parts and dry. Seed quality not standardized: 98 percent purity; 77 percent germination; 73 percent PLS; and cleaned seed averages 4,790 per pound (3,5,6).

## Germination and Seedling Characteristics

About half of unstratified seed germinate in 60 days. Some seed may germinate as late as 120 days after planting. Stratified seed germinate in 40 days under alternating 50° F night and 77° F day temperatures in seed labs. "Stratification" consists of moist chilling seed at 36 to 41°F for 120 to 160 days. Germination is epigeal. Slow germination and only average growth rate in Utah investigations and height growth of plantings in Black Hills indicate variable but probably only fair seedling vigor there. Better vigor should be expected in moist sites and from using improved seed or planting stock (5,6,7).

## MANAGEMENT

Species used in seed or planting mixtures for revegetating game ranges in Utah. Planted for windbreaks, hedges, and low maintenance landscaping in prairie-plains and western mountains and planted on coal minesoils in Kentucky and Tennessee. To establish good stands, reduce plant competition and animal populations. Balance herds with forage supply to sustain improved cover and production (3).

## ASSOCIATED SPECIES

Common chokecherry commonly associates with cottonwoods (*Populus* spp.), boxelder maple (*Acer negundo*), serviceberries (*Amelanchier* spp.), Rocky Mountain and bigtooth maples (*Acer glabrum*, *A. grandidentatum*), pinyon (*Pinus edulis*), Rocky Mountain juniper (*Juniperus scopulorum*), and ponderosa pine (*Pinus ponderosa*). It is seeded or planted with some of the more useful shrubs, grasses, and forbs that are adapted in the mountain brush, pinyon-juniper, and ponderosa pine types in the West.

## PESTS AND DISEASES

Rodents may need to be controlled to establish seedlings on wooded or brushy rangelands. Species is susceptible to a black knot fungous disease which shortens life of plants unless removed by pruning. Vulnerable to the virus X disease of stone fruits so do not plant or seed near orchards. Susceptible to fireblight and tent caterpillar damage. Plants contain hydrocyanic acid, which may be deadly when consumed by all animal life, particularly after plants are stressed by drought or frost.

## IMPROVED VARIETIES

None. Two forms of the species, western (*P. demissa*) and black (*P. melanocarpa*), sometimes recognized. American plum (*P. americana*) and sand plum (*P. besseyi*) sometimes used for conservation and wildlife stabilization purposes.

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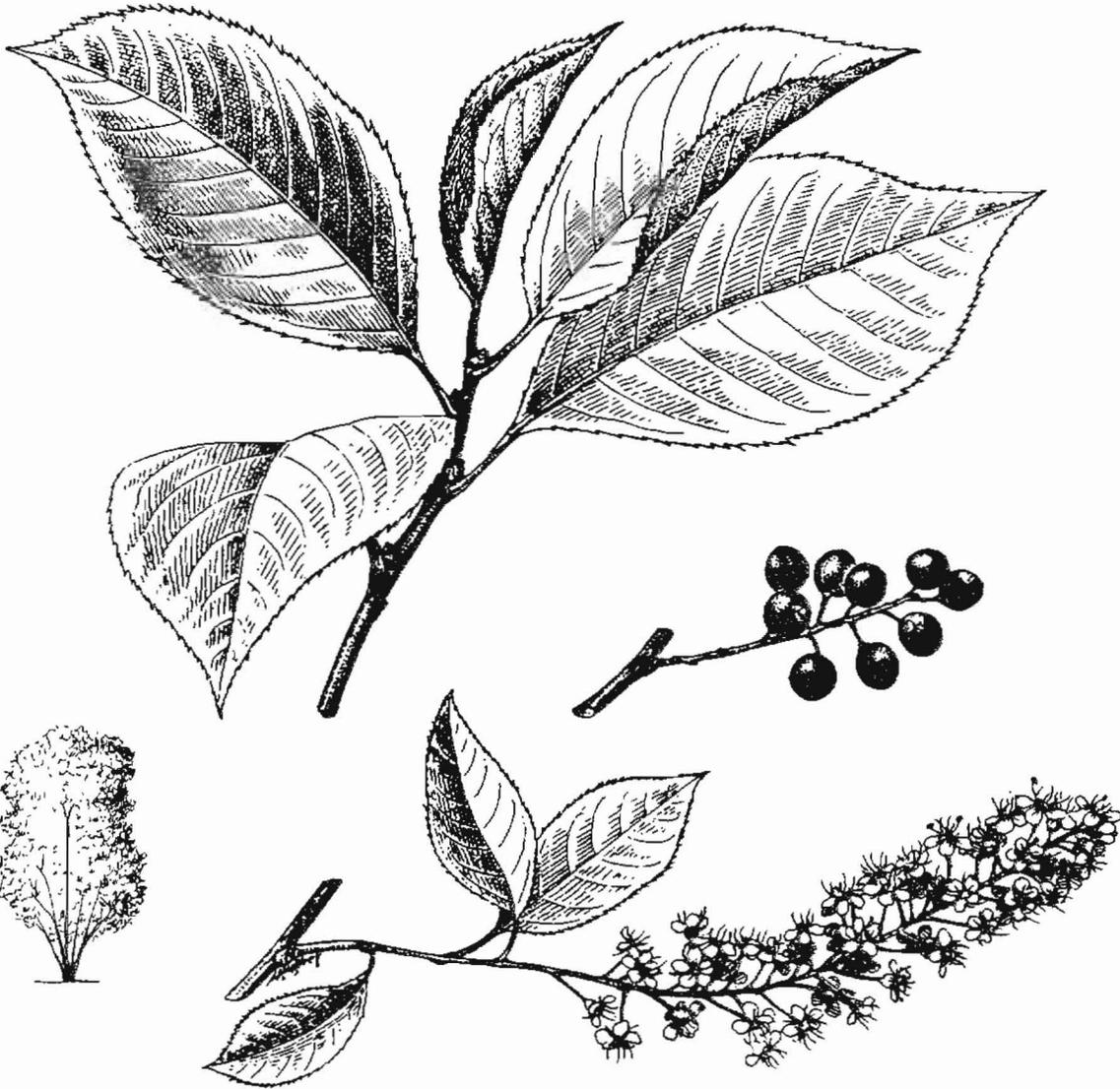


Figure 75. Common chokecherry (*Prunus virginiana*). Leafy twig x 1; fruit x 4/5; flowering twig x 1.

## ANTELOPE BITTERBRUSH

*Purshia tridentata* (Pursh) DC.

### ORIGIN

Native to Intermountain West and adjacent areas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small to medium-sized, deciduous-leaved shrub.

Plants 2 to 6 feet tall, with numerous smooth reddish twigs growing erect from intricately branched stems, arising from spreading main branches which sometimes layer. Leaves small, 1/4 to 1/2 inch long, wedge-shaped and with three-lobed tips similar to big sagebrush (*Artemisia tridentata*) in shape but dark green above, weakly revolute-margined, and often clustered. Flowers borne singly on short, lateral branchlets composed of five-lobed, top-shaped calyx tube; five yellow to white petals, early deciduous, and one to two short styles persistent to hairy, grooved, spindle-shaped achene fruit (1).

Plants polymorphic with prostrate and upright rooting and nonrooting forms. Finely-branched, fibrous root system varying widely in depth. Plants resume growth with leaf emergence in early spring to early summer, flower soon afterward, and ripen fruit about 2 months later, varying geographically as to date. Twig elongation is rather rapid between flowering and seed ripening but slower thereafter. Fairly palatable to livestock; more so to sheep and during spring and fall. Highly palatable to most big game animals, especially in winter; provides cover, protection, and some food for small mammals and birds (2,3).

### ECOLOGICAL RELATIONSHIPS

Species adapted to a wide range of soils; tolerant to most textures but thrives in moderate to deep, well-drained, medium to coarse-textured soils. Tolerant of moderately acid to moderately basic but nonsaline soils. Present on soils of either igneous or sedimentary origin and rather common on granitic soils. Plants adapted to semiarid to subhumid habitats, usually in the 8 to about 20 inches MAP zones. Good drought tolerance and survival but twig growth and fruiting affected by moisture stress. Species generally cold-tolerant with ecotypic and geographic variations. Use local native or tested sources or strains. Grows up to 11,000 feet in elevation in California but is more common between 4,000 feet and 8,000 feet through much of its range. Weakly shade-tolerant; more thrifty in full sunlight. Burning or wildfire usually very destructive of this mostly nonsprouting shrub, but some survival occurs with sprouting ecotypes, particularly when rain follows quickly. Established plants show moderately strong grazing and browsing tolerance and greater tolerance in winter than during the growing season. They also show good compatibility with a wide variety of herbs and are moderately competitive after establishment (2,3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed in a clean, firm seedbed with a rangeland drill about 1 inch deep, adapt depth slightly deeper or shallower according to moisture, texture, and seedbed firmness. Cover broadcasted seed with soil to similar depth. Optimal rates for pure seedings apparently not critically tested, probably because most seedling are made in mixtures to avoid waiting 5 to 10 years for bitterbrush to develop usable forage supplies. Rates of 1/2 to 1 pound per acre, 1 to 2 pounds per acre, and 2 to 3 pounds per acre, drilled and broadcasted, are prescribed in game range restoration in Utah. Seed are planted most commonly in late fall or early winter to accomplish a natural stratification overwinter but treated seed can be planted in spring or later with adequate moisture. Limited transplanting of nursery grown seedlings or container stock has been done, usually in spring (3,4,5).

#### Seed Cleaning and Quality

Beat or shake ripe seeds from bushes into canvas hoppers of suitable containers. Limited success reported using an experimental vacuum harvester. Fan collections to remove nonseed material, run seed through a

Crippen EP-26 dewinger or barley debearder to separate fruit from husks, and reclean in a fanning mill. Seed quality not generally standardized: 90 percent acceptable purity; 85 percent germination; 76 percent PLS; and 15,400 cleaned seed per pound (3,4,6).

### Germination and Seedling Characteristics

Rate of germination varies greatly in lab testing; about one-third to two-thirds of seeds appear to germinate in 14 or 15 days but many do not complete germination for 30 days unless pretreated by moist chilling at 35°F for 1 to 3 months. Field evaluations rate germination very good, initial establishment good, rate of growth average, and final establishment good in Utah, suggesting at least average seedling vigor. Great variation in growth rate from different seed sources also noted in other tests in which seeds from a Janesville, California, source grew more rapidly than seed from local sources after the first year. Species grown from seed in Ephraim Canyon, Utah, had average maximum terminal shoot lengths of 29 and 48 inches and ranked 6th and 9th, at end of 5th and 10th growing season, respectively, among 19 species in another test. Species ranked first in field germination and transplanting survival among four and six selected species in the ponderosa pine type in western South Dakota. Container stock was superior to bare-rooted stock in this test (6,7,8).

### MANAGEMENT

Few shrubs excel more than bitterbrush in range and big game range seedings in its zones of adaptation in the Intermountain West. Palatability may detract from wide use on disturbed lands, unless grazing and browsing animals are controlled. Competition must be reduced to a tolerable minimum by site preparation (chaining, brushland plowing, or cultivation) or scalping before or at time of seeding or planting. Hansen seeder scalper is recommended when seeding in cheatgrass and annuals. Stand establishment and survival may be better if bitterbrush is sown in rows, strips, or blocks separate from, or alternating with, grass and forbs to reduce competition. Irrigate container plants before setting out and bare-root stock immediately after planting when feasible; where possible, plant in contour or irrigable low grade furrows or provide a small water retaining basin about plants set out by shovel. Fertilization, particularly on disturbed minesoils; control of aggressive weeds; periodic irrigation as needed during initial year; and withholding grazing and keeping wildlife populations, including small mammals, at low levels improve survival, growth rates, and earlier forage supply. Generally avoid removing more than 50 percent of current annual growth during the growing season and 60 percent during dormant fall and winter seasons. Stagnant stands of older-aged plants sometimes may be stimulated to greater twig production by moderate topping, suggesting need for periodic close browsing in winter (4).

### ASSOCIATED SPECIES

Bitterbrush grows with big sagebrush (*Artemisia tridentata*), black sagebrush (*A. nova*), true and curlleaf mountain-mahogany (*Cercocarpus montanus*, *C. ledifolius*), rubber rabbitbrush (*Chrysothamnus nauseosus*), mountain snowberry (*Symphoricarpos oreophilus*), Saskatoon serviceberry (*Amelanchier alnifolia*), Stansbury cliffrose (*Cowania mexicana stansburiana*), golden currant (*Ribes aureum*), and Rocky Mountain and big tooth maple (*Acer glabrum*, *A. grandidentatum*). Seeded in mixtures with other shrubs, herbs, legumes, and grasses on blackbrush, sagebrush, mountain brush, juniper-pinyon, and aspen game range types in Utah.

### PESTS AND DISEASES

Small mammals (including rodents) feed on plants and kill them. Use of Endrin and Arasan mixtures has effectively reduced girdling, loss of seed, and sometimes controls seedling diseases. Great Basin tent caterpillar, mountain mahogany looper, and western tussock moth attack foliage. Thrips, seed midge, and leaf tiers affect seed crops. Cutworms and false wireworms kill seedlings. Crown-dieback, footrots, and damping-off diseases occasionally occur.

### IMPROVED VARIETIES

None. Some crosses with *P. glandulosa*, desert bitterbrush, a sprouting species, and other closely related rosaceous shrub species appear promising.

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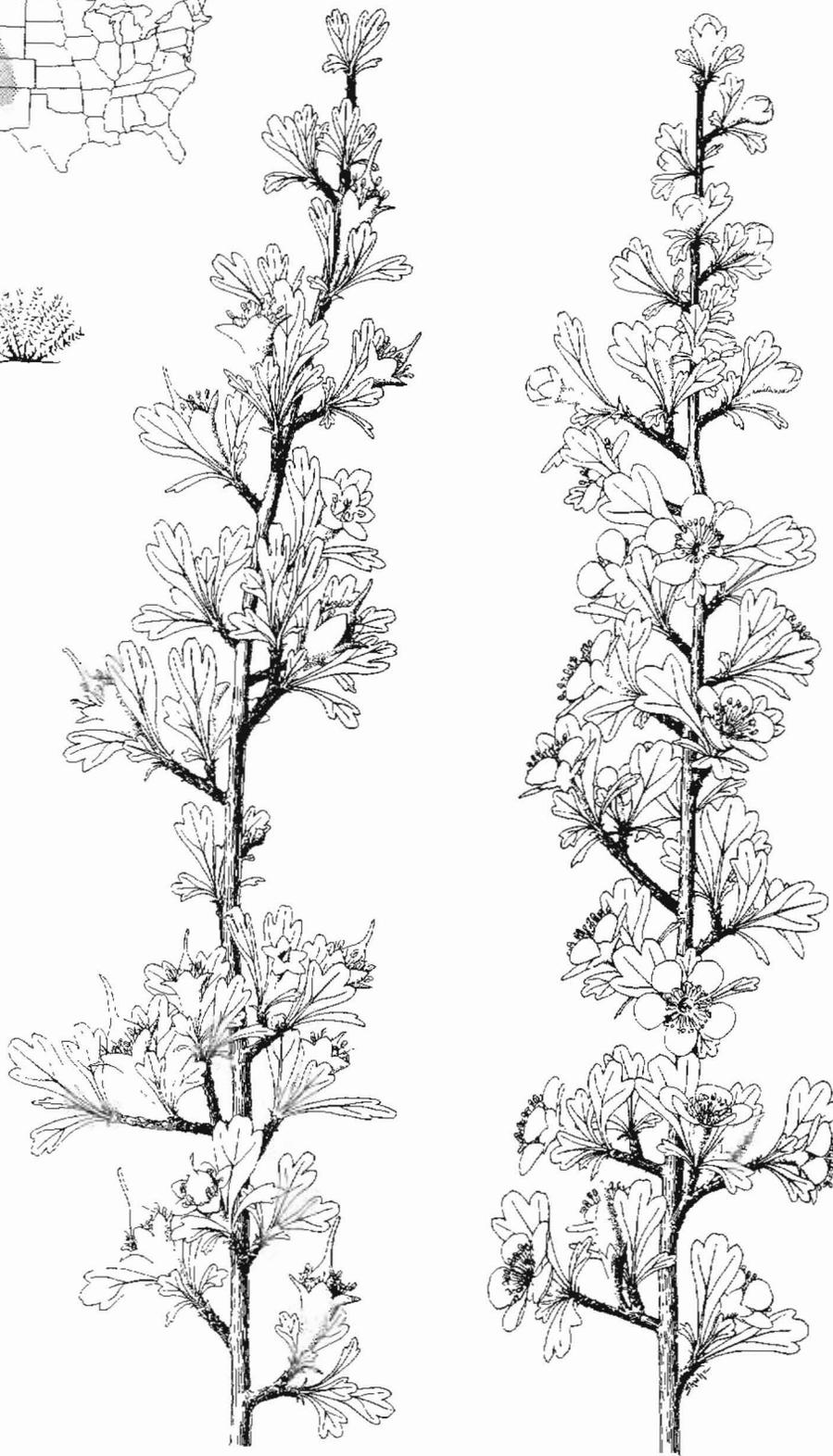


Figure 76. Antelope bitterbrush (*Purshia tridentata*). Flowering branches x 1.

## SKUNKBUSH SUMAC

*Rhus trilobata* Nutt. ex. T. & G.

### ORIGIN

Native to Great Plains, Intermountain, and Southwestern United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, thicket-forming shrubs, 2 to 6 feet tall.

Stems fine hairy and ill-scented, erect to spreading from loosely spreading woody branches. Leaves mostly trifoliate with 1 inch long, obovate leaflets, each with shallowly trilobed apices. Inflorescence spikelike panicles with flowers appearing before leaves. Flowers small, yellow, five-petaled, bearing orangish-red, glandular, hairy, drupelike fruit, containing one boney nutlet seed (1).

Deep and extensively branched roots with somewhat shallow, spreading woody rhizomes, readily root and crown sprouts when tops severed or burned. Plants resume growth in spring, flower 1 to 3 weeks before leafing out, and mature fruit late summer to fall. Low to fair palatability to livestock and game animals; provides emergency food and cover for herbivores, small mammals, and birds (1,2).

### ECOLOGICAL RELATIONSHIPS

Tolerant of most soil textures; often common on hot, dry, shallow rocky foothills, but found as secondary species in plains sandhills and suited for planting as a sand trap barrier in extremely sandy soils. Thrives in well-drained soils; intolerant of flooding and high water tables. Well-adapted in the 10 to 20 inches MAP zones; thrifter in coarse-textured or disturbed soils and somewhat open communities. Moderately strong drought tolerance; acute droughts shorten current twig growth and prevent fruit production. Warm season, generally winter hardy within its native range but apt to be some die-back or frost injury from southern or low altitude ecotypes. Thrifter in full sunlight and only tolerant of partial shade. Good fire and grazing tolerance due to sprouting habit and low palatability. Plants strongly competitive when established, with only fair compatibility with herbs but somewhat better compatibility with shrubs (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed about 1/2 inch deep or 1/4 inch shallower or deeper in moister and fine-textured soils or drier and coarse-textured soils, respectively. Use 1 to 2 pounds per acre in browse-herb mixtures for game range improvement. Not feasible to use at full stand rates except in critical erosive sites where low palatability and spreading habits advantageous. Better to plant seedlings or transplant wildings under those conditions. Plant 25 seed per linear foot of row for growing nursery stock. Plant not stratified or scarified seed in fall or winter and seed moist-prechilled 30 to 90 days in spring or later with adequate moisture and growing season to develop adequate roots for overwintering. Scarify by bleaching in sulphuric acid. Plants are readily reproduced from stem and root cuttings and established by transplanting (4,5).

#### Seed Cleaning and Quality

Harvest by hand-picking fruit or berry clusters into containers. Clean seed by beating fruit in canvas sacks and fanning or running through a Dybvig cleaner with water, drying, and then cleaning in a fanning mill. Seed quality not standardized: 90 percent purity; 75 percent germination; 68 percent PLS; and 8,000 fruit and 20,000 cleaned seed per pound (2,4,5).

#### Germination and Seedling Characteristics

About three-fourths of viable seed germinate in 15 days; others may take 30 days or longer in lab tests. Germination in *Rhus* is epigeal. Utah evaluations rate germination poor, initial establishment poor, growth rate average, and final establishment good, suggesting slow stand development, which may take 10 years or longer to attain maturity. Transplants develop more rapidly (2,5).

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## MANAGEMENT

Species included in game range revegetation mixtures in juniper-pinyon and mountain shrub types in Utah. Promising when transplanted on mineland reclamation sites in Wyoming and Colorado (6). Reported to be among best species for planting on roadsides and disturbed soils in Utah. Reduce plant competition and animal populations to enhance seeding or seedlings establishment. Generally balance grazing/browsing pressure with conservative forage supply, but periodic close use, cabling, or burning where safe and other species mostly resistant, when carefully managed, may improve production and cover (2).

## ASSOCIATED SPECIES

Mountain-mahoganies (*Cercocarpus* spp.), serviceberries (*Amelanchier* spp), junipers (*Juniperus* spp.), Gambel and turbinella oaks (*Quercus gambelii*, *Q. turbinella*), big and sand sagebrushes (*Artemisia tridentata*, *A. filifolia*), rabbitbrushes (*Chrysothamnus* spp.), and many herbs and other shrubs naturally grow in mixtures with skunkbush. Complex mixtures of native and introduced grasses, forbs, and shrubs are seeded with it in Utah.

## PESTS AND DISEASES

Rodents steal planted seeds and may eat and girdle young plants. Plants generally appear to be disease-resistant.

## IMPROVED VARIETIES

'Bighorn', developed in New Mexico from a collection in Bighorn Basin, Wyoming, is a tall form reported to be adapted from New Mexico to North Dakota and Montana. *R. trilobata* is polymorphic with great variation in plant form and size and leaf characteristics; a singleleaf form var. *simplicifolia*, occurs in southern areas.

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Figure 77. Skunkbush sumac (*Rhus trilobata*). Fruiting branch x 1.

## GOLDEN CURRANT

*Ribes aureum* Pursh

### ORIGIN

Native to much of western United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, small to medium-sized, irregular-shaped shrub.

Stems smooth and branching from root crowns and older branches, erect or ascending. Plants spread by underground rhizomes. Leaves round kidney-shaped, three- to five-lobed, with round apexes, toothed-margins, and wedge to heart-shaped bases. Inflorescence a leafy, few to many flowered, raceme. Attractive, spicy-fragrant, bright-yellow tubular flowers with short yellow to red-tipped petals, enclosing a juicy, globe-shaped; red, yellow, or black; many-seeded; berry fruit; varying in color on different plants (1).

Plants resume growth in early spring, bloom in spring, and mature fruit in summer, varying considerably with altitude and environment. Fairly palatable to livestock and good palatability to game animals in spring and summer. Plants provide cover for birds and small mammals and attract birds, which spread seed in droppings (2).

### ECOLOGICAL RELATIONSHIPS

Species widely distributed, but never abundant, in fertile, well-drained, loamy soils. Usually present in moist and often in disturbed soils along roads, ditches, and drainageways. Apparently moisture-demanding for best growth: grows well in moist sites in 12 to over 20 inches MAP zones having at least the equivalence of 20 inches MAP. Moderate drought tolerance, which affects herbage and fruit production, but rarely survival. Tolerant of weakly acid (as low as a pH of 6.0) to weakly basic soils. Cold-tolerant and winter hardy, but varies some among countrywide sources in soil and climatic adaptation. Adapted to all but dense forest shade, taller in shade but with greatly reduced flower and fruit production, probably optimal location in semishade or at edge of shade. Fair tolerance of fire in dormant state; good tolerance of browsing and grazing, and shearing; readily survives by sprouting and spreading. Good competitiveness and compatibility (3,4,5).

### CULTURE

#### Planting Depth, Rate, and Time

Nursery seedlings made 1/8 to 1/4 inch deep and mulched; rangeland seedlings might be made at 1/2 inch depth in drier sites with better survival expected. Nurserymen seed at rate of 40 PLS per linear foot of row. Best rate on rangelands not documented. Many seedlings optionally include currant seed as minor component, perhaps at 1/2 to 1 pound per acre, in range seedings for game range restoration or controlling erosion. Fall preferred seeding time; stratified seed can be sown in spring. Areas also revegetated using nursery or container stock and rooted cuttings (6,7).

#### Seed Cleaning and Quality

Harvest seed by hand-picking, stripping into containers, or knocking fruit onto canvas. Dry collections, fan in fanning mill, and float off unfilled seed. Seed quality not standardized: 95 percent purity; 60 percent germination; 57 percent PLS; and 233,000 seed per pound (3,6,7).

#### Germination and Seedling Characteristics

Germination rather slow in lab testing, usually taking 60 days with some delayed germination after that. Germination is epigeal. Fairly good vigor indicated by good initial establishment, growth rate, and final establishment in Utah game range revegetation evaluations. Moist prechilling for 60 to 90 days enhances germination of spring planted seed (3,6,7).

## MANAGEMENT

Species used for hedges, windbreak windward rows, and landscape plantings in northern and central prairie-plains regions; in seeding and planting mixtures for game range revegetation; and considered excellent for planting to stabilize roadsides and disturbed areas in intermountain areas. Competing vegetation and animal populations need to be reduced to obtain satisfactory stand establishment. Balance grazing and browsing pressures with forage supply; occasional close defoliation (browsing, shearing, or fire, where feasible and safe) improves appearance and may stimulate greater production (3,4,8).

## ASSOCIATED SPECIES

Commonly associated with rabbitbrush (*Chrysothamnus* spp.), Rocky Mountain and bigtooth maples (*Acer glabrum*, *A. grandidentatum*), Saskatoon serviceberry (*Amelanchier alnifolia*), common chokecherry (*Prunus virginiana*), Rocky Mountain juniper (*Juniperus scopulorum*), ponderosa pine (*Pinus ponderosa*), boxelder maple (*Acer negundo*), willows (*Salix* spp.), and cottonwoods (*Populus* spp.). Currant seed is sown or nursery stock planted in mixtures with other herbs and woody plants, most commonly for game range restoration. Species sometime used for outer shrub rows in windbreaks but not recommended for single-row windbreaks.

## PESTS AND DISEASES

Rodents remove seed from new seedlings. Bacterial disease kills canes; use resistant strains and safest to use root cuttings of resistant strains. Species is alternate host of white pine blister rust; do not plant currants where five-needled pines are nearby (2).

## IMPROVED VARIETIES

None. Species readily crosses with other species of *Ribes*. Consult plant material specialists for bacterial-resistant strains.

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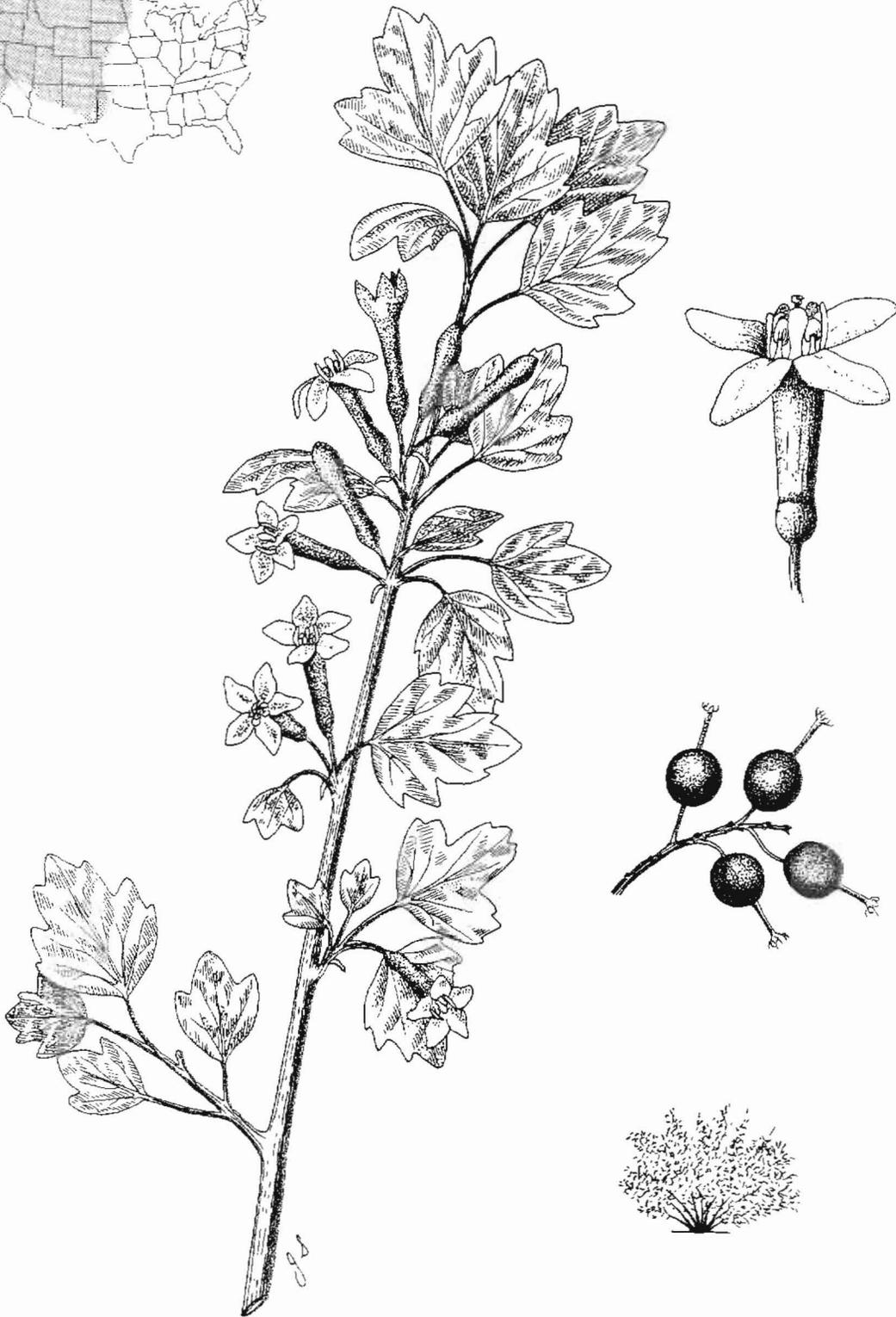


Figure 78. Golden currant (*Ribes aureum*). Branch x 1/2; flower x 3 1/2; fruit x 1. (Flower and fruit after C. L. Hitchcock et al. 1961; growth form after Elmore 1976).

## WOODS ROSE

*Rosa woodsii* Lindl.

### ORIGIN

Native to intermountain West and adjacent Great Plains. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, prickly, briar patch-forming shrub.

Stems woody and perennial, 2 to 6 feet tall, rarely taller, often with prominent nodal prickles and bristly stems but variable and sometimes smooth. Leaves odd-pinnate with 5 to 11 elliptic or broader leaflets, up to 1 inch wide and 2 inches long, serrate-margined and with fused basal stipules. Flowers rarely single, usually 4 to 15, borne in flat or convex-topped clusters on lateral shoots from old wood; each with a shiny green to red, round or urn-shaped, fleshy calyx (hip) with five rose colored petals and containing 15 to 30 dry, bony, and hairy achene seeds (1).

Roots shallow and much branched; plants with spreading rhizomes; readily sprout and sucker. Plants renew growth in spring, flower in late spring and summer, and mature hips from midsummer until fall, varying much with elevation and exposure. Foliage moderately palatable to livestock and big game; provides protective cover in summer; persistent fruit provides winter food for birds and small mammals, which disperse seeds (2).

### ECOLOGICAL RELATIONSHIPS

Species common in well-drained loamy to sandy soils of plains, foothill, and mountain sites. Tolerant of moderately acid to weakly basic but mostly non-saline soils. Intolerant of poor drainage, high water tables, and prolonged flooding. Most abundant in disturbed soils and open communities with reduced competition. Aggressive pioneer in abandoned fields, road borrow pits and shoulders, fence rows, field edges, gullies, and land cuts and fills. Common in 12 to over 20 inches MAP zones, more abundant in 16 to 20 inches zone and along drainages with equivalent of 20 inches MAP, but nearly as dependent on open communities and disturbed soils. Moderately drought-tolerant; markedly less flower and fruit production when stressed but rhizomes drought-resistant. Moderately shade-tolerant, occurring in other than dense forests, but more floriferous in full or nearly full sunlight. Strongly fire-tolerant, except for smoldering fires with heavy volumes of surface fuel. Strong grazing tolerance but dwarfed and thinned by intense grazing, browsing, or defoliation continued summer-long. Only moderately competitive and fairly compatible with herbs (3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed or broadcast and cover with soil 1/2 to 3/4 inch deep, varying depth shallower/deeper with smaller/larger seeds, finer/coarser soils, firmer/looser seedbeds, moister/drier sites or seasons, and with spring/fall seedings, respectively. Best rate of seeding unknown, and species seldom sown alone. Seeded at rates of 1/2 to 1 pound per acre when drilled or broadcasted in complex seed mixtures of 10 to 20 pounds per acre and 20 to 30 pounds per acre for drilling and broadcasting, respectively, on Utah game ranges. Freshly cleaned seed can be sown immediately, warm stratified for late fall sowing, or stratified and sown in spring; optimum date apparently not critically tested and probably dependent on most cost effective seed handling and on seeding before the most consistently moist growing season where irrigation not practiced. Plants are readily propagated from root cuttings and seedlings or wildings sometimes transplanted (3,5,6).

#### Seed Cleaning and Quality

Harvest hips by hand-picking, knocking, or beating into hoopers or containers. Either macerate in water and float off pulp or run hips through Dybvig cleaner with water, dry, and clean in fanning mill; choice dependent on available equipment and whichever method is more efficient. Seed quality not standardized: 95 percent purity; no germination data on record; germination rated poor in Utah revegetation trials; and about 48,000 seed per pound (3,5,6).

## Germination and Seedling Characteristics

Seedcoat dormancy contributes to low and delayed germination in rose seeds. Germination capacity of Woods rose reported to be attained in 30 to 40 days. Stratified seed of many rose species germinate in 15 days. Evaluations show good growth rate and very good final establishment in Utah seedlings of Woods rose; suggests fairly good vigor, despite poor initial establishment associated with poor germination (5,6).

## MANAGEMENT

Species used sparingly in wildlife plantings, for erosion control, and as an ornamental. Rated high potential species for roadside and critical site stabilization and beautification and medium potential for subalpine and alpine revegetation by the Upper Colorado Environmental Plant Center at Meeker, CO. Necessary to reduce plant competition and animal populations on sites during establishment period if seedlings and plantings are to succeed. Balance the grazing/browsing with the conservative forage supply for minimal maintenance and perpetuation of improved cover. Periodic close use, mowing, or burning under safe conditions with enough surface fuel, may improve the appearance and stimulate production of this species (3).

## ASSOCIATED SPECIES

Common chokeberry (*Prunus virginiana*), quaking aspen (*Populus tremuloides*), common Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), mountain snowberry (*Symphoricarpos oreophilus*), russet buffaloberry (*Shepherdia canadensis*), red elderberry (*Sambucus racemosa* var. *pubens*), and lupines (*Lupinus* spp.) are common associates. Species is sown in complex mixtures of grasses, forbs, and shrubs in game range restoration work in Utah. It can be transplanted either as nursery stock or wildings on road cuts and fills and should be used in other disturbed soil situations (3).

## PESTS AND DISEASES

Rodents probably most serious hazard to new seedlings by consuming seeds and girdling seedlings. Roses affected by quite a variety of mostly fungal diseases: leaf spots; rusts; downy mildews; blights; and cankers, but seldom serious.

## IMPROVED VARIETIES

None. Two taxonomic varieties recognized: *Rosa ultramontana* most common in intermountain region and *R. woodsii*, smaller leaved and shorter plants, common in Rocky Mountains and adjacent plains (2). Hansen hedgerose (*R. rugosa*) often used in conservation, windbreak, and wildlife plantings in Colorado and Wyoming.

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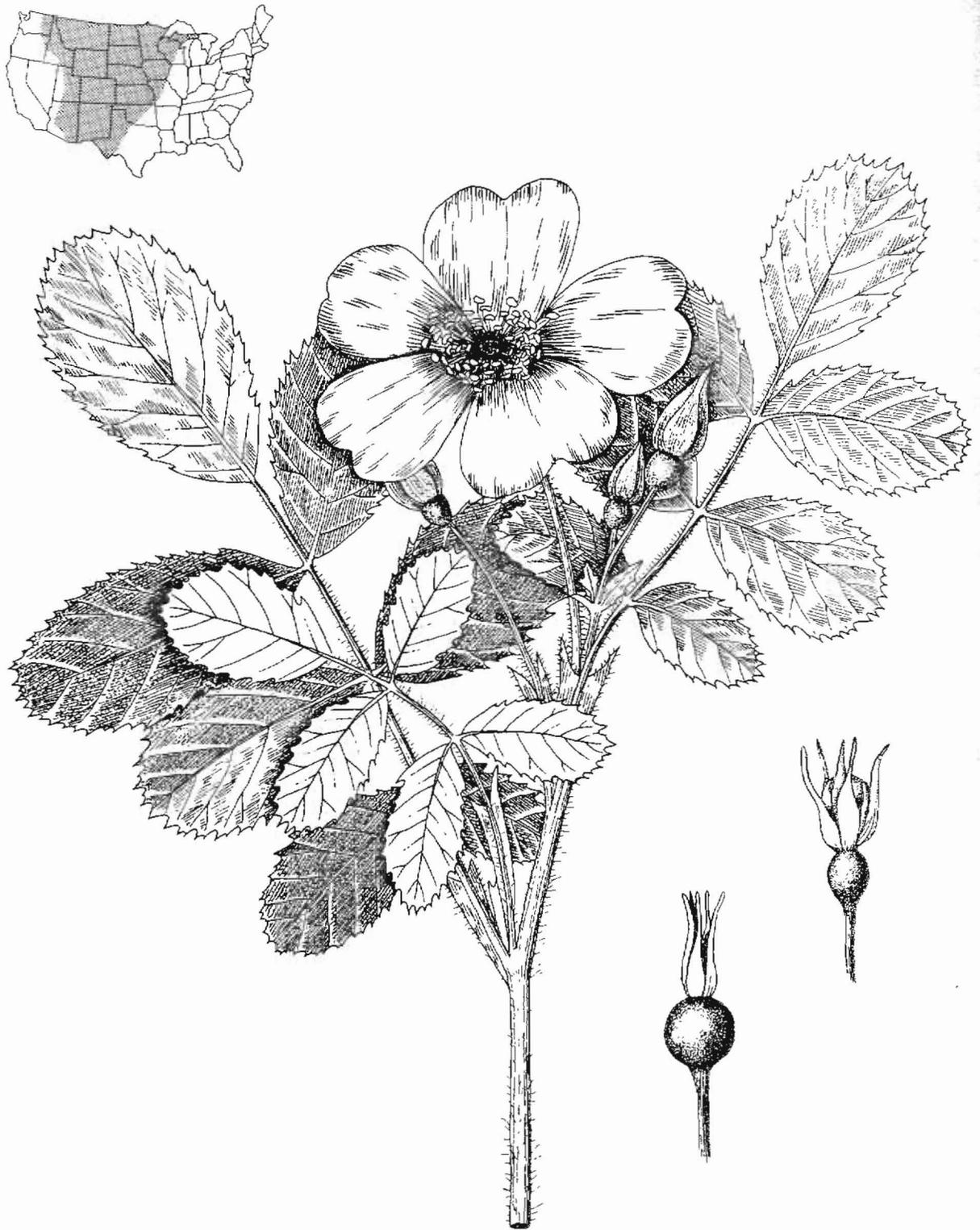


Figure 79. Woods rose (*Rosa woodsii*). Flowering twig  $\times 2\frac{1}{2}$ ; fruit of var. 'ultramontana' (above)  $\times 2$ ; fruit of var. 'woodsii' (below)  $\times 2$ . (Fruit after C. L. Hitchcock et al. 1961).

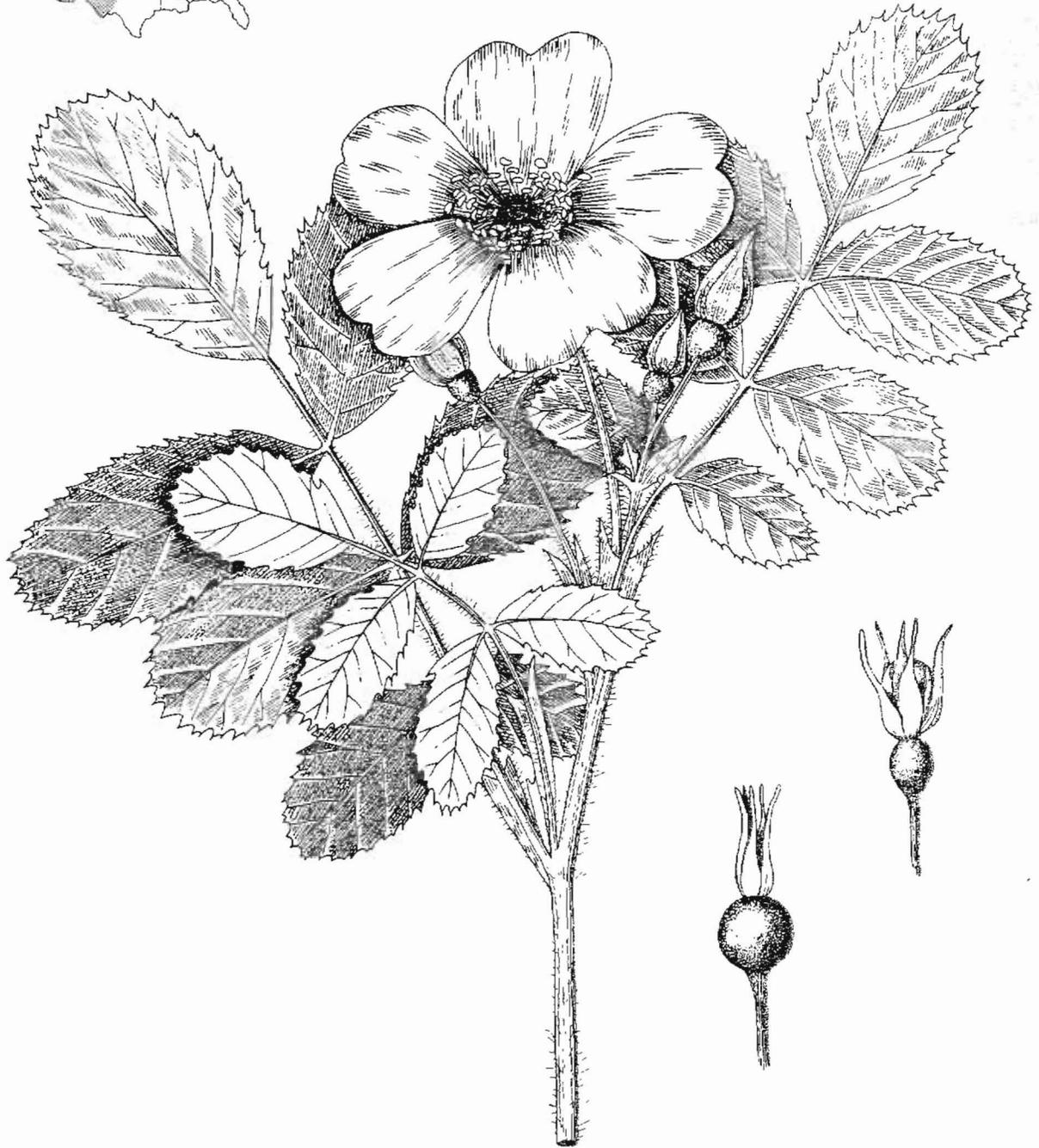


Figure 79. Woods rose (*Rosa woodsii*). Flowering twig  $\times 2 \frac{1}{2}$ ; fruit of var. 'ultramontana' (above)  $\times 2$ ; fruit of var. 'woodsii' (below)  $\times 2$ . (Fruit after C. L. Hitchcock et al. 1961).

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## SILVER BUFFALOBERRY

*Shepherdia argentea* (Pursh) Greene.

### ORIGIN

Native to western United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Thorny, deciduous shrub or small trees, often thicket-forming.

Plants with dense, ascending to erect, thorny branches, silvery when young, up to 13 feet tall. Leaves silvery scurfy, oblong, 1 to 2 inches long. Flowers borne single or clustered at nodes, the two sexes in different plants (dioecious); pistillate flowers small, yellow, and petalless; the four-lobed calyx closely investing the juicy, red, tasty, drupelike, one-seeded fruit (1).

Roots shallow, extensive, well-branched, and capable of fixing nitrogen. Plant spread by underground stems and readily sucker sprout. Plants resume growth in very early spring, usually soon after snowmelt; flower in spring to early summer, very soon after leaves start; and mature fruit in late summer and fall, varying with environment and source of planting stock. Generally poor palatability to cattle, poor to fair palatability to sheep and deer, attractive to bees and insects, and furnishes fair food and cover for birds and mammals; not commonly spread much by animal droppings (2,3).

### ECOLOGICAL RELATIONSHIPS

Species rather indifferent to soil texture; more commonly growing in well-drained medium to coarse soils; found in slightly acid to mostly basic, saline soils. Common on moist to seasonally wet sites in semiarid zones and in more exposed sites in subhumid and colder edges of its range. Fairly common in 12 to 20 inches MAP zones or with equivalent moisture; rather weak drought tolerance, appearing weaker and shorterlived on the southern edge of its range, probably variable by source and ecotype. Generally winter hardy, but probably variable by source when imported. Rather intolerant of shade but sometimes grows in semiwooded bottoms. Fair fire-tolerance in dormant state due to sprouting rootstocks. Strong grazing resistance, aided by thorny branches and root sprouting, make it suitable for a barrier-type hedge or screen. Strongly competitive except with taller woody plants; rather incompatible except with equally competitive and grazing-resistant species (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

In nursery practice, seeds are planted 1/4 inch deep and covered with up to 1 inch of mulch; suggests that seed could be planted, perhaps to advantage, at depths up to 3/4 inch in coarse, dry, and loose soil or in fall under wildland conditions. About 50 percent seedling establishment is expected in the nursery bed while 5 to 15 percent establishment would be good survival from seeding under dryland field conditions. Species is used as a minor addition to game range revegetation mixtures in Utah at unspecified rates; most similar species are added at 1 to 2 pounds per acre rates in total seeding mixtures of 10 to 30 pounds per acre. Seed can be sown in the fall or seed moist-prechilled ("stratified") for 3 months can be sown in spring or probably later where late summer moisture is more reliable or with irrigation. Buffaloberry can be transplanted by digging root sprouts from wildings or from nursery-grown stock. Older stock is often used for landscaping; 2-0 planting stock is used in reclaiming eastern coal minesoils (3,5,6).

#### Seed Cleaning and Quality

Harvest by stripping or by flailing fruit onto canvas after they turn yellow or red. Sift out light debris and run fruit through a macerator or Dybvig cleaner with water, float off pulp, dry, and fan. Seed quality not standardized: 90 percent purity; about 60 percent germination; 54 percent PLS; and 41,000 cleaned seed per pound.

### Germination and Seedling Characteristics

The majority of viable seed germinate in 20 days, but some delay germination up to 60 days in lab tests. Ratings of fair initial establishment, rate of growth, and final establishment suggest fair seedling vigor. Germination is epigeal. Bare-rooted stock planted in ponderosa pine forest and on an old burn in the Black Hills of South Dakota made slightly greater height growth in a 10-year period than antelope bitterbrush (*Purshia tridentata*) and true mountain-mahogany (*Cercocarpus montanus*) (5,6,7).

### MANAGEMENT

Species used for a variety of purposes to reclaim eastern mine spoils, as outer row in multirow windbreaks with supplemental water, for wildlife plantings, hedges, barriers, and low maintenance landscaping. Remove competing vegetation from planting sites for better establishment; water plants when set out if soil moisture inadequate. Transplanting of root cuttings of 2-0 stock, fencing off areas, and irrigation suggested for critical site reclamation (2,3).

### ASSOCIATED SPECIES

Species tend to grow in small colonies or thickets without much undercover; associated vegetation may be grasslands, mountain shrubs, or woodlands either of mountain slopes or commonly along riparian areas or floodplains. Species is planted in separate rows, strips, or blocks, usually with associated species widely spaced. Sometimes used as a special ingredient in seed mixtures for unique sites in the mountain brush type in Utah.

### PESTS AND DISEASES

Rodents may steal planted seed and girdle young plants. An oystershell scale and heart rot sometimes weaken or kill plants.

### IMPROVED VARIETIES

None. Russet buffaloberry (*S. canadensis*) rarely used in mountainous West.

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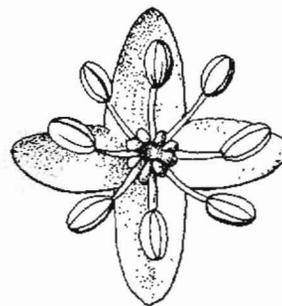


Figure 80. Silver buffaloberry (*Shepherdia argentea*). Branch x 2; fruit x 6; flower x 5 3/4. (Fruit and flower after C. L. Hitchcock et al. 1961; growth form after Elmore 1976).

**WESTERN SNOWBERRY**  
*Symphoricarpos occidentalis* Hook.

**ORIGIN**

Native to the Great Plains and Rocky Mountains. See map for distribution in the U.S.

**SPECIES CHARACTERISTICS**

Deciduous, short, dense colony-forming shrub.

Plants with erect to spreading, perennial stems, weakly branching from woody base and short main branches, usually 2 to 4 feet tall. Leaves opposite, thick, oval, and entire to irregularly-lobed. Flowers in axillary or terminal, spikelike clusters of small bell-shaped corollas, with pink or rose petallike lobes, slightly exserted, hairy styles, and mature into greenish-white, two-seeded, berrylike drupes (1).

Roots densely branched, mostly in surface soil, and intermixed with stout, spreading rhizomes, forming thicketlike patches, often excluding other vegetation. Plants resume growth in spring, flower late spring to early summer, and ripen fruit summer to fall, not until October in parts of Montana. Palatability low to fair for cattle and sheep, good for deer; provides good cover for birds and small mammals (2).

**ECOLOGICAL RELATIONSHIPS**

Species adapted to most soil textures; least common in loose sand. Tolerant of imperfectly drained soils and considerable flooding, but not of prolonged flooding and permanent high water tables. Fairly common in both weakly basic and weakly acid soils. Plants grow in the 12 to over 20 inches MAP zones; more prevalent in bottomlands, draws, swalelike depressions, and flood plains. More conspicuous in disturbed sites of hillsides, roadsides, fencerows, and overgrazed and thin prairie-plains sod. Remarkably drought-tolerant but shortened in height, growth, and fruiting by acute moisture stress. Local plant material winter hardy. Species occurs in Canada and up to 8,500 feet in elevation in Rocky Mountains. Tolerant of open woodland shade and thrives in nearly full sunlight. Grazing and fire-tolerant; injured by fire but usually sprouts and becomes thicker afterward. Strongly competitive, particularly in dense colonies, and probably not very compatible with herbs unless planted at very sparse rates and managed (2).

**CULTURE**

Planting Depth, Rate, and Time

Plant seed 1/4 inch deep or up to 1/2 inch deep; use deeper depth for seeding in drier, coarser textured, and looser seedbeds and when sowing in fall. Nurserymen may need to plant 150 to 200 pure seed per square foot to obtain 30 seedlings per square foot. Optimum rate for seeding rangelands is unknown; one established plant per square yard should provide an adequate stand in 3 to 5 years or 1 plant per square foot by end of first or second season. Most wildlife and range usages should use sparse rates in mixtures with faster developing and germinating grasses, forbs, and other shrubs adapted to sites and purposes. Species is readily propagated by cuttings; it may be more economic to transplant cuttings or wildings into critical and disturbed sites, such as mined lands, and to irrigate until plants are established. Plant warm-stratified seed in fall or seeds moist-prechilled for 9 months in spring or later with adequate moisture (3,4,5,6).

Seed Cleaning and Quality

Hand-pick or strip fruit into containers or flail from bushes onto canvas. Dry collections, sift out the light, nonfruit material, extract seed by moving fruit through a macerator or Dybvig cleaner with water, then dry and fan. Seed quality not standardized: 90 percent purity; no precise germination data, one lot with cutting test of 84 percent and 52,000 cleaned seed per pound produced 8,600 usable plants per pound of seed. Of several lots stratified in moist sand at room temperature, followed by 150 days at 36° to 40° F, the best lot produced only 10 plants from 6 grams of seed (about 1 percent germination if seeds of average size) (7). Average cleaned seed per pound, 74,400 (3,4,5).

## Germination and Seedling Characteristics

No germination data reported in usable form in the literature. Recent Montana tests showed no germination after 2 years of testing. Nutletlike seed have hard, impermeable endocarps and incompletely developed embryos at harvest time making germination difficult. Warm stratification at 86° F for 3 to 4 months is reported to be adequate pretreatment for fall planting, but such seeds need 6 months of moist-prechilling treatment for spring planting. "Practical quantities" of seedlings reportedly obtained by placing nutlets in soil in flats left outdoors for one summer and the next winter (8). Germination is epigeal. Plants 5 years old grew 3 1/2 feet tall and had a spread of about 4 feet at Woodward, Oklahoma (3,4,6).

## MANAGEMENT

Dense colony stand pattern makes species suitable for disturbed land stabilization. Species rated as high priority plant material for oil shale restoration and wildlife habitat improvement at the Upper Colorado Environmental Plant Center at Meeker, CO.. Due to seed collection, processing, and germination problems, a need for research and smallscale trials in transplanting stem cuttings and sprigging rhizome pieces is suggested. Cutting should be irrigated when set out and as needed afterward until well established. Plant competition needs to be reduced to minimum during the first season. Seedlings of the species should be mixed with other adapted browse and forage plants and preferably planted in rows, strips, or blocks separately from grasses. Critical, erosive sites need complete exclusion of grazing during establishment, and animal populations and stocking should be balanced with forage supply on noncritical sites after establishment.

## ASSOCIATED SPECIES

Cottonwoods (*Populus* spp.), boxelder maple (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), true and mixed prairie grasses and forbs, and eastern Rocky Mountain foothill shrub and ponderosa pine community members occur in natural assemblages with western snowberry. Its use is rather rare and probably is safer when planted alone on critically disturbed soils.

## PESTS AND DISEASES

Rodent chewing of stems and some girdling is probably chief hazard. Only minor rusts and leaf spots occur on foliage.

## IMPROVED VARIETIES

None. Coralberry (*S. orbiculatus*), a prairie-plains species, similar to *S. occidentalis*, but with a red, berrylike fruit, is called coralberry or indiancurrant.

Common snowberry  
*S. albus*

Widely distributed intermountain and Pacific Northwest species, somewhat similar, but has hairless styles shorter than corolla, hairy twigs, and lower leaf surfaces. Fair germination of 30 to 80 percent reported after sulphuric acid treatment and cold stratification for 6 months.

Mountain snowberry  
*S. oreophilus*

An upright shrub with longer, tubular flowers and elongated, egg-shaped, white, berrylike, drupe fruit; very common in aspen-fir and spruce-fir forest types of Intermountain West. Satisfactory germination reported when planted in fall in seed mixtures for big game ranges in Utah. Transplanting of pulled-up wildings and pieces of stem with roots reported to be especially successful when done in early spring. Field mice help scatter in their caches.

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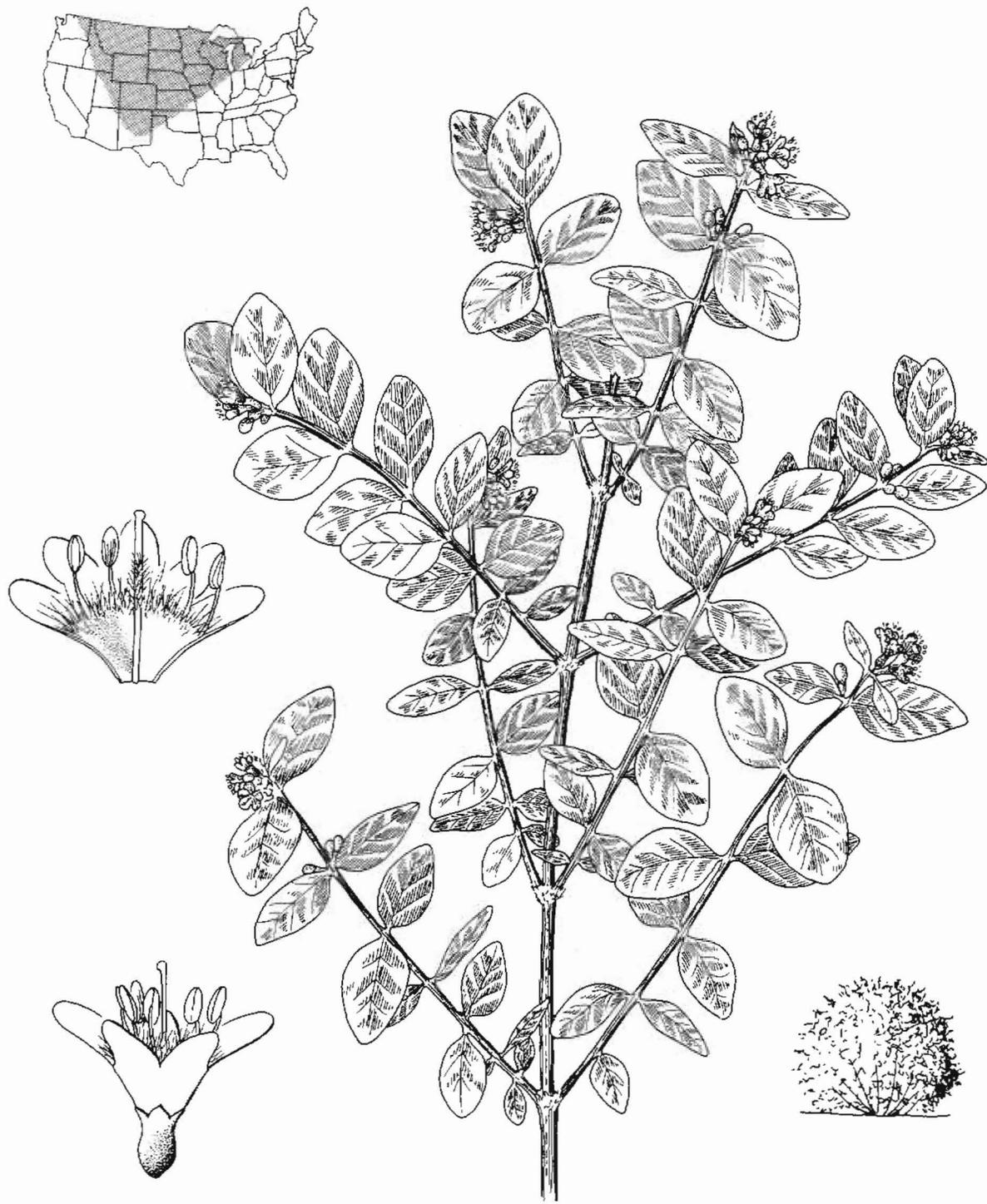


Figure 81. Western snowberry (*Symphoricarpos occidentalis*). Branch  $\times 1/2$ ; flower  $\times 23/4$ ; within corolla  $\times 23/4$ . (After C. L. Hitchcock et al. 1959).

## ROCKY MOUNTAIN MAPLE

*Acer glabrum* Torr.

### ORIGIN

Native to Western United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, bushy shrub or small tree.

Usually 5 to 15 feet tall but rarely 20 to 30 feet tall, with a narrow crown and short multiple trunk up to 12 inches in diameter. Branches ascending to erect and somewhat short. Bark smooth, reddish-brown, and thin. Leaves opposite three to five-lobed, rarely with three distinct leaflets, doubly serrate, dark green above and shining gray below, contrasting with reddish petioles. Small dioecious flowers in clusters; pistillate produces broad winged, colorful double samaras, each containing a round, brown "seed." Species variable in stature, leaf form, and fruit. Variety *douglasii*, a northwestern form, has leaves with shallow sinuses, lobes sharply serrate to base, wings of fruit erect and sinuses round between wings, and sometimes up to 40 feet tall with 18 inch diameter trunks (1).

Roots woody, extensive, and variable in depth. Plants moderately suckering at base. Plants leaf out in early to midspring; leaves faintly streaked with red in summer and turn pale golden-yellow in fall. Plants flower April to June and mature fruit August to October. Poor to fair palatability to livestock, varying geographically, used more by sheep and goats; fairly good palatability to deer and elk, particularly var. *douglasii*. Lower palatability in winter; provides considerable cover for birds, small mammals, and for watershed protection (2,3,4).

### ECOLOGICAL RELATIONSHIPS

Commonly grows along stream banks, canyons, and moist mountain slopes; mostly in silty to sandy or gravelly and rocky soils; and mostly in moderately acidic to neutral or slightly basic, well-drained soils. Tolerant of imperfectly drained soils, however, and periodic flooding and seasonally moderately high water tables. Adapted to specific sites in the 12 to over 25 inches MAP zones, more closely tied to drainage in more arid zones, but on drier exposures northward and in higher elevations. Species occurs up to 6,000 feet in elevation in North and to 9,000 feet in elevation in South. Good winter hardiness generally but considerable variability to be expected among regional sources of seed or planting stock. Weakly to moderately drought-tolerant, varying considerably by geographic strain and probably ecotype. Moderate shade tolerance but growing and fruiting more vigorously in nearly full sunlight. Good tolerance of fires and usually sprouts afterward; may be invigorated by light intensity fires. Competitive after seedling establishment but not very compatible with many herbaceous species (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Drill seed 1/4 to 1 inch deep, adapting depth to soil texture and moisture, looseness of seedbed, and season of planting. Vigorous seedlings produced in nurseries from seeding rates that result in 15 to 30 seedlings per square foot but precise seeding rate for direct seeding under wildland conditions not documented, if known. Species probably usable like bigtooth maple where latter not native; as minor ingredient, probably at about 1 pound per acre rates, in game range revegetation mixtures in upper mountain shrub, open conifer, and aspen types. Plant unstratified seed in fall and stratified seed in spring or later with irrigation or adequate moisture. Poor results reported with transplanting in Utah. Better survival reported from using older (2-0 or 2-2) plants instead of seedlings for planting stock (3,4,5).

#### Seed Cleaning and Quality

Pick samaras from trees or collect them by whipping or shaking them from trees onto canvas or plastic sheets. Fruit can be dewinged in mechanical dewingers and cleaned by fanning, if necessary, before

planting. Seed quality not standardized: 90 percent purity should be possible; 40 percent germination; 36 percent PLS; and 13,000 seed per pound (4,5).

### Germination and Seedling Characteristics

After stratification, germination occurs in about 30 days in the seed lab. "Stratification" treatment recommended: warm stratify at 68 to 86° F for 6 months; then moist chill at 37 to 41° F for 6 months. Optimal temperatures for germination in lab are 50° to 60° F. Germination is epigeal. Performance in Utah rated poor for germination, rate of growth, final establishment, and ease of planting and very poor initial establishment suggests inferior seedling vigor, as well as field germination (3,4,5).

### MANAGEMENT

Species used to limited extent for wildlife planting and native landscaping in mountain or adjacent areas. Considerable attractiveness of foliage and watershed protection potential, in addition to wildlife food and cover values. Necessary to reduce plant competition and grazing and browsing pressure to obtain stand establishment. Seeding or planting maple in rows, strips, or blocks, separate from other species. may increase stands and persistence. Balance animal stocking with forage/browse supplies for minimum maintenance (3).

### ASSOCIATED SPECIES

Douglas-fir (*Pseudotsuga menziesii*), common chokecherry (*Prunus virginiana*), Saskatoon serviceberry (*Amelanchier alnifolia*), boxelder maple (*Acer negundo*), quaking aspen (*Populus tremuloides*), and innumerable herbs and other shrubs grow with this maple. It can be seeded with other adapted species with proper precautions during planting and establishment. Species probably better established by planting 2-year old or older stock in small patches on specific sites. either for wildlife and aesthetics or for critical site stabilization.

### PESTS AND DISEASES

Rodents expected to depredate seeds and seedlings. A pathogen attacks leaves and turns them partly red during growing season (2,3).

### IMPROVED VARIETIES

None.

Bigtooth maple  
*Acer grandidentatum* Nutt.

Similar to *A. glabrum*, shrubs to trees up to 40 feet tall and 10 inches in diameter, platey-scaly trunks. Leaves simple with shallow sinuses and rounded, nonserrate lobes. Leaves turn scarlet, at least partially, in fall and strikingly aesthetic. Probably much more useful than *A. glabrum* (rated 21 points higher in 20 characteristics of usefulness in Utah) within zones of adaptation from southwestern Montana and adjacent Idaho south through western Wyoming and Utah to northern Arizona, New Mexico, and west Texas.

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Figure 82. Rocky Mountain maple (*Acer glabrum*). Branch x 1/2; flower x 9. (Flower after C. L. Hitchcock et al. 1961; growth form after Elmore 1976).

## PECAN

*Carya illinoensis* (Wang.) K. Koch.

### ORIGIN

Native to lower Mississippi and Ohio River valleys and tributaries. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, medium to very large trees.

Trees up to 180 feet tall and occasionally up to 6 feet in diameter; long trunks with gray, shallow-furrowed and flat-ridged bark; ascending to spreading branches; and irregular round crowns. Twigs gray-brown and hairy when young. Leaves alternate; pinnately compound; 9 to 20 inches long; with 7 to 13 narrow, pointed, and curve-tipped leaflets, with toothed margins yellow-green above and paler below. Sexes on same plant (monecious); male catkins in threes, bearing small green flowers; seedbearing flowers single or few at end of new growth, small and green, developing distinctive brown, cylindrical, thin-shelled, nut streaked with black and enveloped in a four-winged husk (1).

Plants moderately sprouting at base from seedling to small-stump sizes; ability to stump sprout decreases with age. Spreading root system with tap root particularly deep for seedlings. Plants flower March to May, starting about 1 week after leaves begin to develop; nuts mature September to October. Plants not used much by large mammals, although sucker growth and saplings browsed; provides cover for certain birds and mammals (2,3).

### ECOLOGICAL RELATIONSHIPS

Species grows most commonly on well-drained loam soils not flooded for extended periods; also occurs on heavy-textured soils. Limited mostly to alluvial soils on first bottoms and thrives on "river front ridges and well-drained flats" (2). Soils moderately acid (to a pH of 5.0) to neutral or mildly basic; some improved varieties commercially grown on weakly saline soils. Adapted to warm temperate climates in 30 to 60 inches MAP zones with 25 or more inches during 5 to 9 month growing season. Exceptionally dry weather affects seedling survival and growth. Seedlings and flowers expected to be frost-sensitive, especially out of their natural range. Pecan is susceptible to fire damage. Intense fires kill small saplings and trees 10 to 12 inches in diameter; some sprouting and survival of younger age classes occurs after light intensity fires. Some tolerance of grazing and browsing expected due to sprouting habit. Moderately competitive but adversely affected by high densities of trees and vines; compatible with moderate density of lower growing vegetation (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

In nursery practice, nuts are drilled 3/4 to 1 1/2 inches deep, six to eight nuts per linear foot, in rows 8 to 12 inches apart. Unstratified nuts planted in fall and stratified ones in spring. Spring is a safer time because pecan nuts have no dormancy and can germinate in warm spells during winter and often winter kill later. Some direct seeding may still exist but many field plantings are made using seedlings or nursery stock. Seedlings reported somewhat difficult to transplant due to long tap roots. Growing nursery stock 2 years and root pruning first year recommended to overcome problems (4,5).

#### Seed Cleaning and Quality

Collect nuts from ground after natural seed fall, flailing the branches, or shaking trees. Remove tough husks by hand, trampling, or running them through a corn sheller. Seed quality not standardized: purity nearly 100 percent; germination capacity 50 to 90 percent for nuts cold-stratified 30 to 90 days; and 100 "seed" per pound (4).

## Germination and Seedling Characteristics

The majority of viable pecans germinate in 33 days in lab tests. Seeds lack dormancy; place them in cold storage at higher humidity over winter to avoid their becoming rancid and losing viability. Good germination occurs at alternating 68° to 70° F night and 86° to 90° F day temperatures. Plants exhibit good seedling vigor in full sunlight without much competition, often making 3 feet of height growth per year during early seedling years under favorable growing conditions (2,4).

## MANAGEMENT

Tree used to some extent for planting on Kansas, Oklahoma, Missouri, and Indiana mine soils, suggesting potential for use throughout its natural range. Fence out livestock and reduce plant competition around planting site. Balance tops to roots before planting seedlings and provide water retaining furrow or basins around planted stock in subhumid to semiarid zones. Fertilization, control of weedy competition during first several years, and, possibly, irrigation may be needed for good survival, particularly in semiarid zone. Wildlife, if abundant, may need to be controlled or discouraged by repellants during establishment. Long term conservation and land use planning and management necessary to optimize improved cover and crop benefits (3,4).

## ASSOCIATED SPECIES

Species commonly occurs in mixed stands with American sycamore (*Platanus occidentalis*), American elm (*Ulmus americana*), eastern cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), swamp privet (*Forestiera accuminata*), and roughleaf dogwood (*Cornus drummondii*). Planted in mixed plantings with other nurse or crop trees, usually in separate rows, strips, or blocks (2,3).

## PESTS AND DISEASES

Small mammals pilfer seed and girdle seedlings. Deer sometimes browse older plantings heavily. Several insects attack species but rarely become epidemic: pecan caterpillar worm; walnut caterpillar; twig girdler; and bark beetles. Die-back disease and root rots sometimes occur (2,3).

## IMPROVED VARIETIES

Numerous improved varieties have been developed, mostly for improved yield and quality of nut. Such varieties are propagated by budding or grafting. Consult with local or regional plant materials specialists for superior strains or sources of seed or planting stock.

Black hickory  
*Carya texana* Buckl.

A smaller, medium-sized tree that typically grows on bottomlands but tolerant of sandy uplands. Species has only five to seven leaflets, weeping branches, thicker reddish-brown shells, and smaller kernels that are difficult to remove. Bark is dark gray to black and deeply fissured; plants have rusty, pubescent, terminal buds and leaf undersides. Species may be better suited to poorer sandy sites within its restricted natural range in Texas, Louisiana, and Arkansas.

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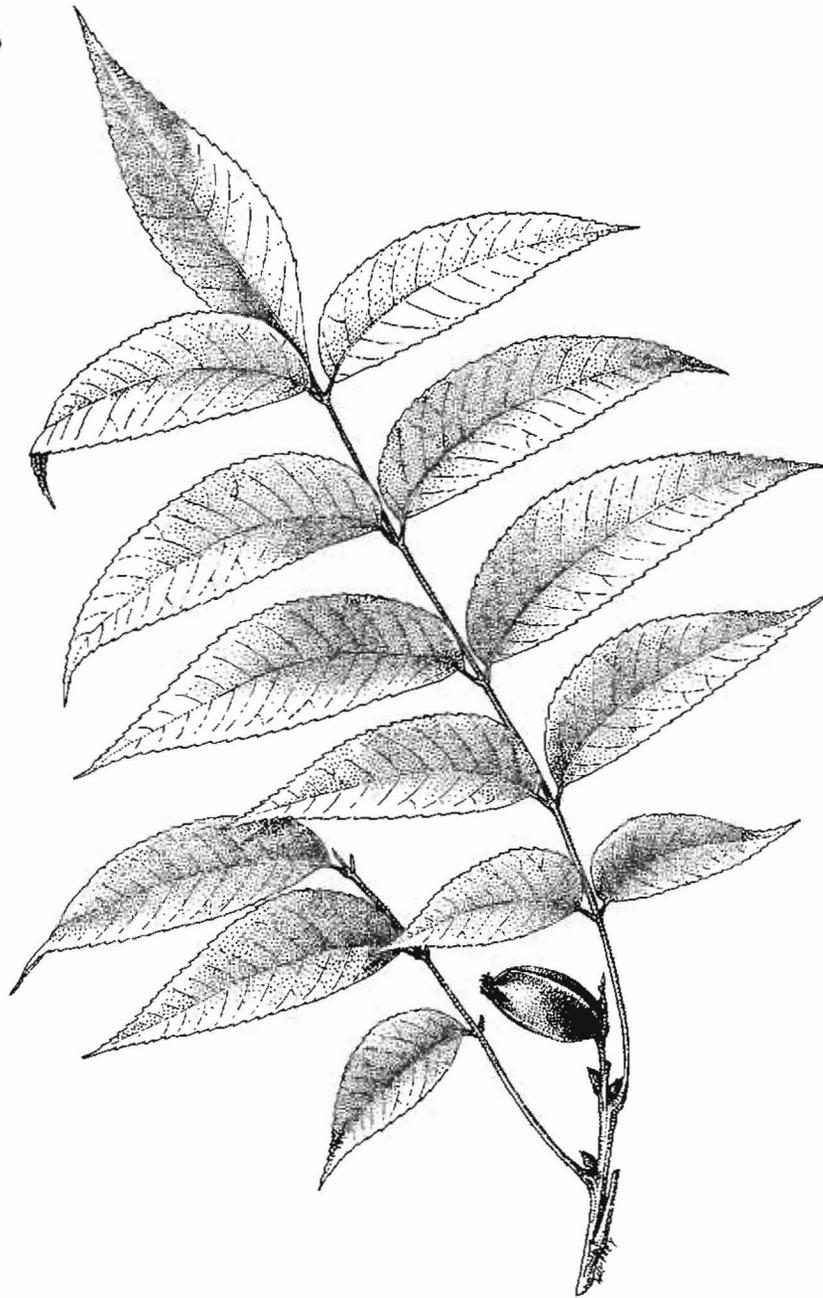


Figure 83. Pecan (*Carya illinoensis*). Twig with leaves and fruit x 1/2.

## DESERTWILLOW

*Chilopsis linearis* (Cav.) Sweet.

### ORIGIN

Native to Southwestern United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Short-lived, large shrub or small tree.

Plants 10 to 25 feet tall with central trunk and narrow, graceful crown. Leaves willowlike, alternate, linear, entire, and untoothed, up to 6 inches long. Flowers showy, large, long-tubular and catalpalike. two-lipped, fragrant corollas, white-tinged or lavender-lined, four to six inches long and bearing narrow, elongated two-celled, podlike capsules, 4 to 12 inches long, containing cottony, winged seeds. Capsules persist overwinter (1).

Variable species, particularly in shape, width, stickiness, and venation of leaves, but also in aesthetic characteristics. Rooting characteristics not described. Plants leafing out in spring or later with available moisture, blooming May to August, and maturing fruit September to late fall. Mostly unpalatable to livestock; browsing usually indicates overuse of range. Plants furnish some cover for birds and wildlife, watershed protection, and landscape aesthetics in arid lands.

### ECOLOGICAL RELATIONSHIPS

Species common along desert washes below 5,000 feet in elevation, in sandy to gravelly alluvium. Sites mostly well-drained, neutral to basic, and mildly saline. Good drought tolerance, naturally occurring along drainage channels periodically flooded; survives fairly well on drier roadway shoulders without irrigation after transplants firmly established. Variable but somewhat frost sensitive and intolerant of subzero weather. Intolerant of more than weak shade when in mixtures with other woody plants. Sites rarely burned but plants usually killed by fire. Moderate grazing tolerance, mostly due to low palatability. Moderately competitive in native habitats and not very compatible with other species (1,2).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed 1/4 inch deep when raising nursery stock; seeds can be planted up to 1 inch deep in drier or unirrigated sites with better survival expected. Plant seven times as many seed as the desired nursery seedling density (often about 25 seedlings per square foot). Seed in spring when soil has warmed to germination temperature. Species rarely direct-seeded on rangelands. Readily propagated by cuttings; cuttings are usually planted directly into nursery beds in spring. Mostly planted as seedlings or older stock for landscaping purposes; 1-1 planting stock considered optimum for transplanting in the Southern Great Plains (3,4).

#### Seed Cleaning and Quality

Hand-pick seed any time after they ripen. Spread, dry, beat lightly and shake pods, then screen out seeds. Seed quality not standardized: 90 percent purity; germination varies between 26 and 100 percent; and seeds average 86,000 per pound (3).

#### Germination and Seedling Characteristics

About half of seeds germinate in the seed lab in 9 to 30 days. Seeds lack dormancy but storing in wet sand several days speeds germination (3).

### MANAGEMENT

Species mostly used for ornamental purposes; e.g., for roadside beautification, border rows in hedges, screening, and less commonly for mass plantings; possibly rarely used on wildlands to restore native

vegetation on disturbed lands. Natural occurrence along drainages susceptible to erosion suggests potential for stabilization of eroding or disturbed lands. Remove plant competition from around plantings, irrigate nursery stock when setting out and during at least the first season. Fence out livestock. Provide irrigation furrows or basins where feasible and control competing growth until plants well established (4,5).

#### ASSOCIATED SPECIES

Plants occur in native mixtures with honey mesquite (*Prosopis glandulosa*), palo verde (*Cercidium microphyllum*), netleaf hackberry (*Celtis reticulata*), cottontop (*Digitaria californica*), and other herbs and woody plants.

#### PESTS AND DISEASES

Some rodent damage to be expected to seedlings and younger plants. Rather susceptible to damping off in nursery plantings. More resistant to cotton root rot than most species planted in the Southern Great Plains.

#### IMPROVED VARIETIES

'Barranco', an improved variety with superior aesthetic qualities, has been released from the Los Lunas, New Mexico SCS Plant Materials Center. Two taxonomic varieties are recognized, indicating the variability within the species and possibilities for improved strains.

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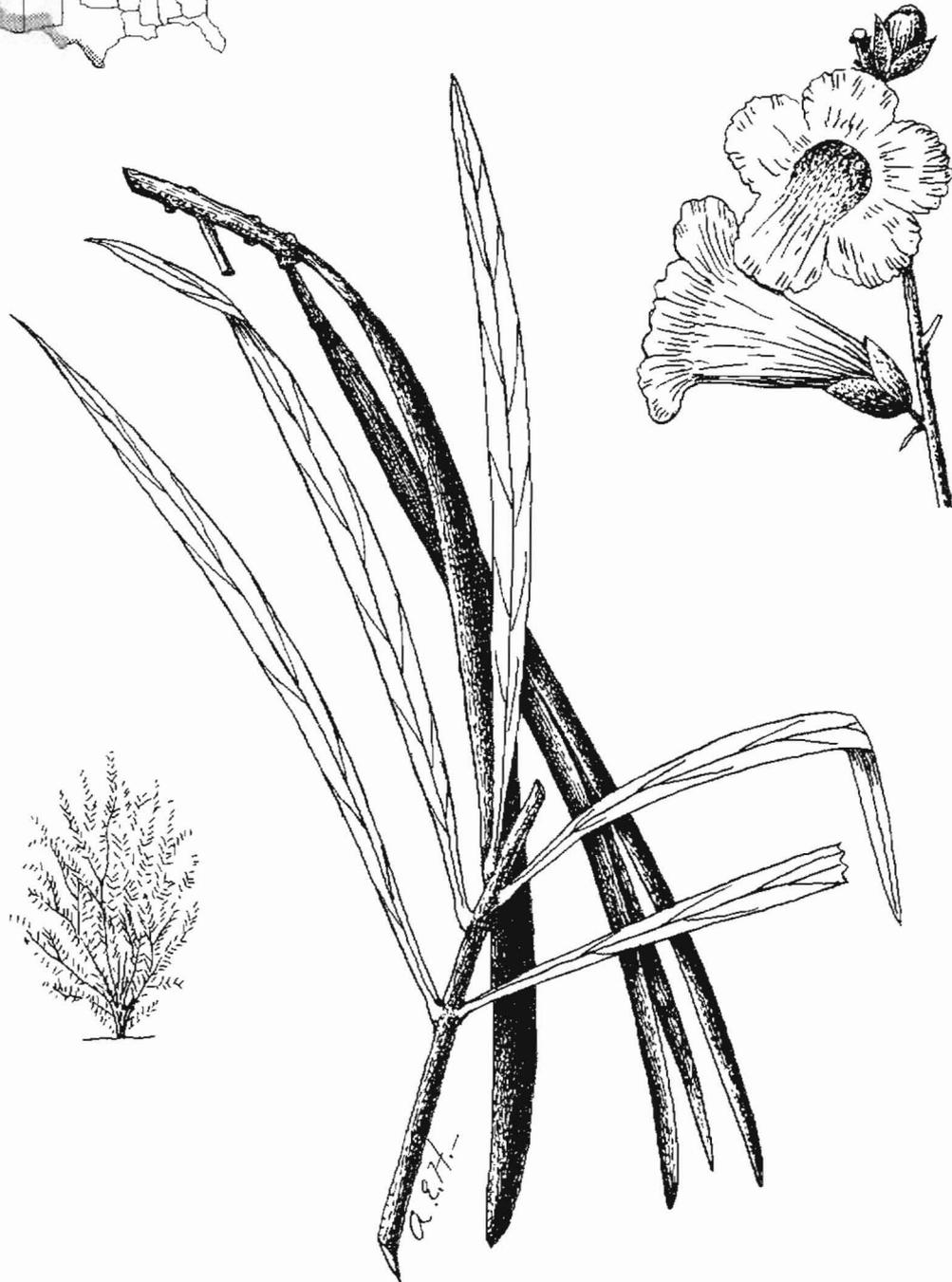


Figure 84. Desertwillow (*Chilopsis linearis*). Leaves and pods x 1; flowers x 1 1/3.

## RED (GREEN) ASH

*Fraxinus pennsylvanica* Marsh

### ORIGIN

Native to eastern U.S., west to eastern Montana and south to eastern Texas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small to medium-sized, deciduous trees.

Trees up to 60 feet tall and 2 feet in diameter, with thin brown fissured and shallowly-ridged bark and an irregular broad crown. Twigs rounded, often hairy, gray to reddish-gray. Leaves opposite, odd-pinnate, 8 to 12 inches long with five to nine (usually seven) oblong-lanceolate or elliptic leaflets, serrate or entire, yellow-green above, paler below. Plants dioecious; flowers inconspicuous in panicles; pistillate-producing, oblanceolate, samara-type fruit with winged terminal section gradually merging into round, slender, seed cavity (1).

Roots moderately shallow but among most extensive and windfirm. Trees develop coppice sprouts and plants stump sprout and form new crowns after being beheaded. Plants flower March to May, with leaf buds unfolding a little later; fruit matures September to October. Low palatability to livestock but often overbrowsed by livestock in small woodlots or around farmsteads and by deer; furnishes cover for birds and small mammals. Plants produce economic wood products and furnish shade and landscape beautification. Leaves turn golden yellow in fall but some trees exhibit poor form, such as crooked growth and very open tops (1,2).

### ECOLOGICAL RELATIONSHIPS

Species most commonly grows on alluvial soils of river valleys and along drainages, particularly in its western geographic range. Plantings thrive on upland soils of medium to coarse texture with adequate moisture in shelterbelts throughout the Great Plains. Trees thrive in areas more semiarid than its natural range with infrequent irrigation. Tolerant of frequent flooding and of moderately strong acid (to a pH of 4.0) to moderately basic reacting soils. Green ash naturally grows in subhumid to humid temperate climates in the 15 to 60 inches MAP zones with 10 to 35 inches coming during the growing season. Species is moderately drought-tolerant but with variation among ecotypes. Growth rate is related to fertility and can be improved by N fertilization when moisture is adequate. Ecotypes show marked differences in winter killing; species is frost-sensitive in flowering and early seed development stages. Growing well and shade-tolerant but often produces poorer form in shade. Good tolerance of fire when burned in dormant states. Species compatible and often seeded with other woody species (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Nurserymen drill 25 to 30 seeds per linear foot of row in rows 6 to 12 inches apart at 1/2 to 3/4 inch depths or broadcast seeds and cover with soil to similar depths with a goal of obtaining 10 to 15 seedlings per square foot. Unstratified seed can be sown in the fall and/or stratified seed planted in spring. Most trees are established by transplanting seedlings (1-0) or older nursery grown stock (5,6).

#### Seed Cleaning and Quality

Pick samaras in the fall when their color turns brown and seed within is white, crisp, firm, and fully elongated; pick seed clusters by hand, by pruning or using seed hooks, or by shaking or beating them from branches onto canvas or plastic sheets on the ground. In cities, they can be swept up from the streets. Seed quality not standardized: purity nearly 100 percent; germination about 75 percent with stratified seed; and seeds average 17,000 per pound (6).

### Germination and Seedling Characteristics

Most of the stratified seed germinate in 20 days in seed labs. Germination is epigeal. Most successful treatments to enhance germination couple 2 months of warm (68° F) exposure or storage with 7 months of cold (32° to 41° F) storage. Seedlings elongate 1 to 2 feet per year in earlier years under nursery conditions but only a few inches with intense weed competition. Rated rather slow grower in prairie-plains region (6,7).

### MANAGEMENT

Green ash is commonly planted using 1-0 seedling stock on surface mined soils in eastern U.S. Growth is reported to be slow and tree form often poor, leading to recommendation that it be planted in mixtures with other hardwood species. Plan reclamation by considering total land uses, wildlife habitat needs, size of area, edge, interspersions of cover types, nurse trees, and fencing from grazing on mined lands. Species is planted in central rows of windbreaks and often used in Northern and Central Great Plains windbreaks. Control plant competition around each plant during establishment; this is often more economically accomplished by planting in a pattern that permits cultivation. Generally better establishment, growth, and survival is experienced by planting grass, herbs, shrubs, and trees in separate rows, blocks, or strips to minimize competition and accommodate cultural practices.

### ASSOCIATED SPECIES

Species naturally grows in mixtures with sugar maple (*Acer saccharum*); American linden (*Tilia americana*); bur, white, and red oaks (*Quercus macrocarpa*, *Q. alba*, and *Q. rubra*); hickories (*Carya* spp.); American elm (*Ulmus americana*); and cottonwoods (*Populus* spp.). Can be planted with some of these hardwood species and other hardy species better able to grow on disturbed mined lands or with shrubs and evergreens, such as eastern redcedar (*Juniperus virginiana*), Rocky Mountain juniper (*J. scopulorum*), and/or ponderosa pine (*Pinus ponderosa*) in certain areas of the Great Plains (2).

### PESTS AND DISEASES

Several insects feed on ash trees: oyster scale; carpenter worm; two ash saw flies; and unspecified borers particularly affect shade trees and windbreak plantings. Rabbits and cattle may injure unfenced plantings. Leaf spots, anthracnose, rusts, and root rot sometimes damage trees and wood (2,6,7).

### IMPROVED VARIETIES

Several horticultural varieties are recognized. Green ash, the glabrous form of the species, formerly called var. *lanceolata*, has bright green upper and lower leaf surfaces, naturally grows further south and west, and is more commonly used in the Northern Great Plains and in western plantings. Arizona ash (*F. velutina*) similar and used with irrigation in the desert Southwest.

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Figure 85. Red (Green) ash (*Fraxinus pennsylvanica*). Leaves and leaflets x 1; flowers and fruit x 1.

## BLACK WALNUT

*Juglans nigra* L.

### ORIGIN

Native to eastern and central United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Deciduous, medium-sized tree, up to 90 feet tall and 3 feet in diameter, with irregular rounded crown and straight clear trunk and brown to blackish, deeply furrowed, and broadly-ridged, thick bark. Twigs stout, gray hairy, with round, hairy, terminal bud and several smaller lateral buds. Leaves alternate, up to 2 feet long, pinnately compound with 13 to 23 ovate, lanceolate, serrate, pointed leaflets, hairy below. Flowers monoecious, yellowish-green; pistillate bearing, round, blackish-shelled nuts in yellow-green, hairy husks (1).

Meat of nut nutritious; furnishes food for variety of wildlife. Well-developed deep, extensive, root systems; plants windfirm. Wood of high commercial value. Stumps readily sprout after trunks damaged, severed, or burned. Seedlings are tap-rooted; nursery stock improved by midsummer root pruning. Plants resume growth in spring, flower April to June, and ripen fruit September to October. Low palatability to livestock but sprouts and seedlings consumed in heavily-stocked woodlots (1,2). Primary value of species related to its high quality wood.

### ECOLOGICAL RELATIONSHIPS

Species sensitive to soil environment; thrives on deep, well-drained, near-neutral, moist, fertile soils. Relatively intolerant of dry and infertile soils; slower growing on dry, sandy ridges and slopes and in wet bottomlands. Responds with faster growth on deep, loamy, loessal and fertile alluvial soils; also present on limestone soils. Tolerant of mildly acid soils (to a pH of 5.5). Adapted to slightly less than 25 to 60 inches MAP zones. Generally larger trees found along drainages near western edge of range and on north- and east-facing slopes. Limited to elevations below 4,000 feet in Appalachians. Not drought-tolerant; growth rate and wood quality markedly affected by moisture stress. Adapted seed and planting stock sources important to stand success and growth due to racial variations in length of growing season and individual tree variation in growth rate and quality. Some fire tolerance afforded by durable heartwood and thick, relatively damage and decay-resistant bark. Moderately grazing/browsing-tolerant but seedlings and sprouts damaged and stunted by overuse, particularly in small, closely-grazed woodlots. Strongly competitive, partly due to roots containing a toxic substance, juglone, that is antagonistic to roots of some plants that come in contact with walnut roots (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Nurserymen sow nuts 1 to 2 inches deep in well-prepared seedbeds that are mulched; planted in furrows at rate of 15 "seed" per square foot. Some broadcast seed on rototilled beds and press them into soil by using a roller. Nursery objective is a density of 8 seedlings per square foot. Unstratified seed are sown in fall and stratified seed in spring. Revegetate disturbed, mined forest lands either by planting 1-0 seedlings or stratified nuts in spring. Common field practice is to sow at rate of 3 nuts per seed-spot. Use of container stock, when available, should improve survival on semiarid and subhumid mined lands and critical sites (4,5).

#### Seed Cleaning and Quality

Harvest nuts as soon as they are ripe (husks brown to black) by handpicking off ground or after shaking or felling limbs. Remove husks when firm to slightly soft by hand or by running fruit through a corn sheller. Use mechanical hullers for large quantities of fruit. Float off unfilled seed. Hulling not always necessary but aids regulating seedling density and essential when seed treated with fungicide. Seed quality not standardized: 87 percent purity; 50 percent average germination; 43 percent PLS; and average of 40 nuts per pound (5).

## Germination and Seedling Characteristics

Most viable stratified seed germinate in 24 days under controlled seed lab conditions. Early growth rates of black walnut seedlings are moderately fast in the nursery, particularly on fertile soils. Plants begin to reproduce in 12 to 15 years but not in commercial quantity until 20 to 30 years of age. Natural reproduction is largely dependent on small mammals caching nuts, surplus of which germinate in following spring. *Juglans* spp. have hard shells and dormant seeds. Dormancy is broken by stratifying seed at 34° to 41° F overwinter in moist sand covered with 2 feet or more of soil or mulch and screened against rodents; small lots can be placed in plastic bags, moist sand, or peat at same temperatures for 3 to 4 months. Planting in fall naturally accomplishes about the same results (5).

## MANAGEMENT

Both planting seedlings and direct sowing establish satisfactory stands for wood, nuts, and wildlife cover in moist, near-neutral soils of Midwestern mined lands. In some areas, liming and fertilization may be needed to correct soil-test deficiencies. Species probably is better used in mixed hardwood stands and interspersed with other cover types and crops suited to overall land use objectives. Better growth may be possible by planting with leguminous nurse trees. Remove competing vegetation from around planting or seeding spots and fence out livestock. Practice good forest and land use management for sustained benefits (4).

## ASSOCIATED SPECIES

Species commonly grows in mixed stands with yellow-poplar (*Liriodendron tulipifera*), sugar maple (*Acer saccharum*), oaks (*Quercus* spp.), and hickories (*Carya* spp.). In western areas, commonly associated with American elm (*Ulmus americana*), common hackberry (*Celtis occidentalis*), green ash (*Fraxinus pennsylvanica*), boxelder maple (*Acer negundo*), American linden (*Tilia americana*), and red oak (*Quercus rubra*). Kentucky coffeetree (*Gymnocladus dioica*), yellow-poplar, and white ash (*Fraxinus americana*) are fairly good indicators of good sites for black walnut.

## PESTS AND DISEASES

Walnut caterpillar defoliates and reduces growth rate. Flatheaded apple tree borers, the twig pruner, and scurfy scale sometimes cause problems in Central Great Plains and weak or damaged trees are susceptible to European canker. Small mammals, particularly squirrels, molest planted nuts but also plant some in hoards that later germinate (2).

## IMPROVED VARIETIES

Numerable named varieties exist that have been selected mostly for large nuts and easily extractable meats. They are propagated by budding and grafting. Consult nurseries and State specialists for improved materials for planting stock.

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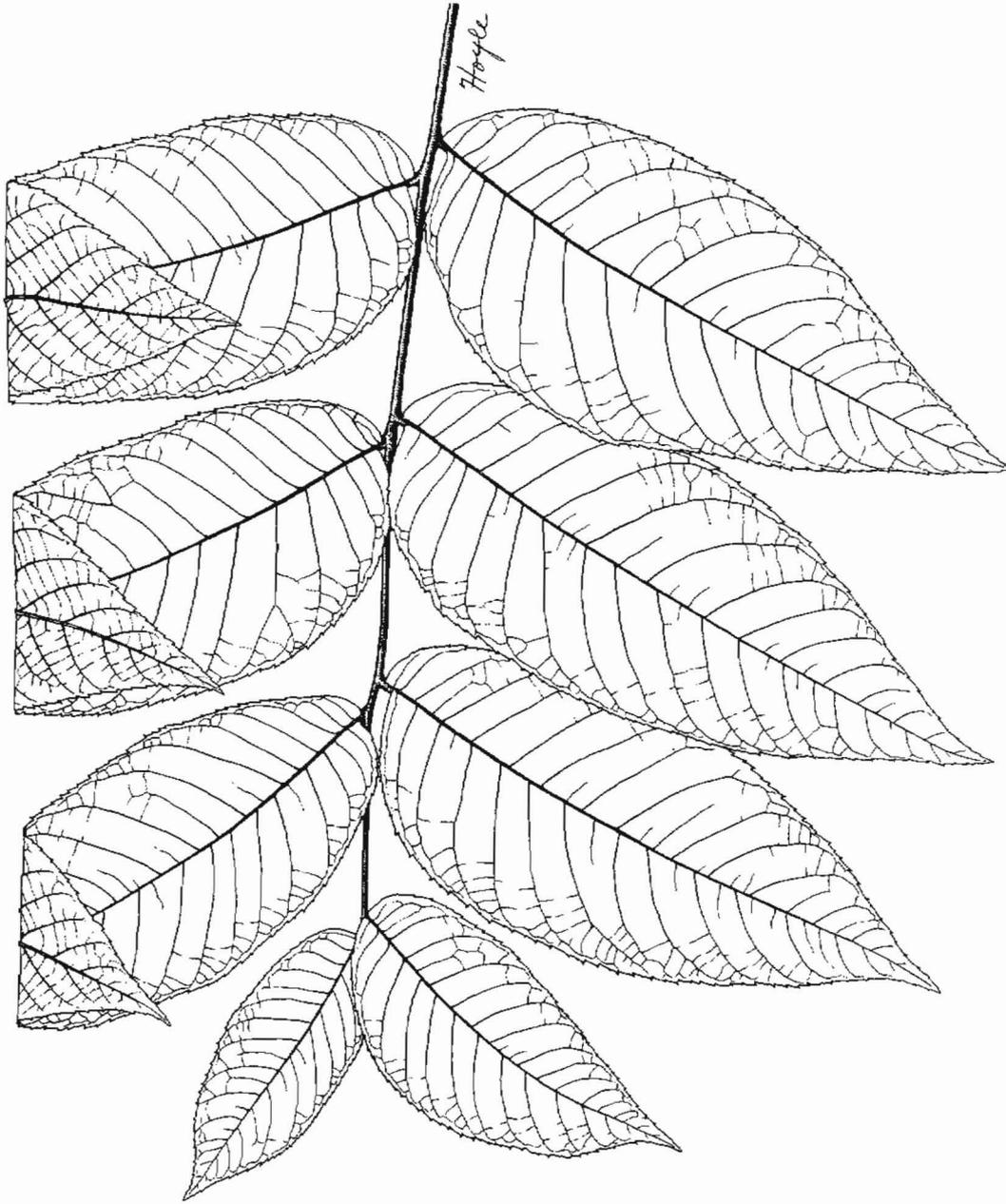


Figure 86. Black walnut (*Juglans nigra*). Leaf with leaflets x 1.

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## EASTERN REDCEDAR

*Juniperus virginiana* L.

### ORIGIN

Native to the Eastern United States and much of the Great Plains. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small to medium-sized, evergreen trees.

Plants up to 40 feet tall and 2 feet in diameter with dense, irregular, pyramidal or conical crowns and thin, reddish-brown bark, exfoliating in broad ribbons. Leaves opposite, scalelike, dark green, sharp-pointed with juvenile forms often ternate. Twigs four-angled, slender, and scale-leaf covered. Flowers mostly dioecious; staminate in miniature brown cones at ends of branches, inconspicuous but often dense enough to give branches reddish-brown cast; pistillate developing subglobose, berrylike, glaucous cone, containing one or two seed and sometimes more (1).

Deep, early, taproot, replaced by extensive, shallow root system with age. Not reproducing naturally by sprouting or suckering but artificially propagatable by stem cuttings or layering. Plants flower March to May and mature fruit September to November. Species not very palatable to livestock but young plants in pastures often grazed enough to suppress invasion, particularly in Great Plains. Plants provide effective cover and some food for large and small mammals and birds; animals spread seeds and aid natural reproduction (1,2).

### ECOLOGICAL RELATIONSHIPS

Species can grow in such varied habitats as thin, rocky soils to finer textured, saturated soils of swamps. Its competitive abilities and tolerance result in it occurring on drier sites on thin limestone-derived soils or rocky sites and secondarily in fertile alluvial and moist soils. Does well on mildly acid (to a pH of 5.0) to calcareous soils in Midwest but more dependent on reduced competition and stable soil medium, evidenced by its intolerance of unstable sandy surfaces in Illinois. Responses to sites vary; it grows on upland ridges, flats, and dry, exposed sites with adequate moisture in East; more frequently found on north slopes and along streambanks in semiarid western range. Less tolerant of flooding than loblolly pine (*Pinus taeda*). Moderately to strongly drought-tolerant, particularly during seedling stages, due to deep tap roots. Very weak alkali tolerance. Generally winter hardy, but some damage reported in severe winter of 1948-1949 in northwestern part of its range, indicating need to consider adapted sources of seed and planting stock. Fair shade tolerance; about equal growth rate in full sunlight and one-third shade. Fires very destructive and even light fires are injurious. Moderately grazing-tolerant but juveniles kept in check by moderate grazing. Species competitive with herbaceous species but often succeeded by more shade-tolerant hardwood species (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Nurserymen plant seed 1/2 inch deep in firm soil or sand or broadcast seed and cover with sand; most plantings are then covered with mulch. Mulch usually is held in place by snow fencing material, carefully supported over the beds. Mulch is removed at start of germination and seedlings are provided with light shade, usually by covering them with slatwire snow fences. Precise rates of seeding unreported; most seedlings in nursery beds strive for a density of about 50 seedlings per square foot. Seedlings held beyond 1 year can be transplanted into nursery rows at 6 by 1 inch or 8 by 2 inch plant spacings. Because some seed may have dormant embryos, seeds are either planted in late summer to fall or are stratified and then planted either in early spring or in fall. Most junipers are planted instead of being sown for reforestation or shelterbelt-windbreaks and 2-0, 3-0, 1-1, 1-2, 2-1, or 2-2 stock are commonly transplanted in spring. Mostly 1-0 or 2-0 stock are used in minesoil reclamation in the Western Interior and Lignite coalmining regions (Illinois-Oklahoma, E. Texas) (4,5,6).

## Seed Cleaning and Quality

Harvest seed (cones) by stripping or picking into containers or shaking/flailing the fruit from plants onto canvas or plastic sheets placed on ground. Cut fruit to test ripeness, and fill and collect them as soon as ripe to avoid losses. Remove nonfruit material by fanning; clean by running fruit through a macerator (or Dybvig cleaner) with water and floating off unfilled seed and pulp; dry and reclean by fanning. Seed quality not standardized: purity nearly 100 percent; germination 75 percent; about 75 percent PLS; and 43,000 seed per pound (2).

## Germination and Seedling Characteristics

Germination should begin 6 to 10 days after sowing stratified seed and be completed in 4 to 5 weeks. Treatment to enhance germination usually consists of prechilling at 41°F for 1 to 4 months. Germination is epigeal. Seedlings have rapid tap root development but slow top growth and continue to grow slowly during sapling to maturity stages (2).

## MANAGEMENT

Well suited to use in coal minesoil reclamation, particularly in the Western Interior and Lignite regions. Commonly used for windbreaks and shelterbelts in Midwest and Great Plains regions and generally within its range for landscaping, hedges, and screening material. Wood useful and tree used for Christmas trees. Species ranks high in survival among Great Plains shelterbelt plantings. Necessary to reduce plant competition drastically at planting sites and fence out livestock, at least during establishment period, to obtain good stand establishment and survival. Water transplants when set out in semiarid zones or dry soil and provide water-retaining furrows or basins. Cultivation during first few years greatly enhances survival and growth. Planting designs need to consider total land use, cropping, and forestry, as well as watershed and wildlife values and needs. Good management and utilization practices are essential for sustained benefits from improvement practices (4,7).

## ASSOCIATED SPECIES

Species commonly occurs in mixed stands with shortleaf (*Pinus echinata*) and Virginia pines (*Pinus virginiana*); red (*Quercus rubra*), white (*Q. alba*), black (*Q. velutina*), and blackjack oaks (*Q. marilandica*); and hickories (*Carya* spp.) and black walnut (*Juglans nigra*). Used commonly as outside rows in multirow windbreak/shelterbelt planting; can be planted alone for hedges and for one-row windbreaks. A faster developing crop grown in alternate strips may help control an erosion problem during early establishment (6).

## PESTS AND DISEASES

Mice and rabbits sometimes attack seed and seedlings. Species is alternate host to cedar-apple rust, which affects some fruits but has little effect on juniper. *Fomes annosus* sometimes destroys sapwood in South. Boring insects, bagworms, juniper webworm, and seed-corn maggot cause occasional problems (2).

## IMPROVED VARIETIES

Numerous varieties have been developed, primarily for ornamental or landscaping purposes. Great variations within the species are amenable to further planting stock improvement by selection, breeding, and grafting.

Rocky Mountain juniper.  
*Juniperus scopulorum* Sarg.

Very similar to *J. virginiana*; many plants branching near ground level or have short trunk, especially on exposed sites. Scale leaves slightly longer, more commonly with glaucous foliage; and glaucous blue cone fruit, taking 2 years to mature. Heartwood light to dark red and streaked. Common in upper juniper-pinyon and Douglas fir zones; most extensively occurring western juniper; found from 5,000 to 9,000 feet in

elevation in Rocky Mountains. Widely planted in windbreaks and for wildlife plantings and landscaping, particularly in the Rocky Mountains; also suitable for shelterbelt and windbreak plantings in adjacent central and northern Rocky Mountain and Great Plains. Better survival than for *J. virginiana* reported in plantings on Wyoming/Colorado minesoil reclamation sites (7). Great variability in ecotypes.

Oneseed juniper  
*Juniperus monosperma*

Oneseed juniper (*J. monosperma*), a coarser, bushy Southwestern species, often branches at or below ground, has rough-margined scale leaves, concentrated toward the tip of ascending branches, and irregular crowns. Very slow growing with dense, decay-resistant heart wood used for fenceposts. Species occurs from edge of southern desert at 3,500 to 7,500 feet in elevation. Rarely used except where required by law to restore original vegetation.

Utah juniper  
*Juniperus osteosperma*

*J. osteosperma* has tall, grooved trunks and mealy-fruited cones; sometimes monoecious; otherwise similar to *J. monosperma*. Grows in the southern Great Basin and Colorado Plateau Regions. Used some for native landscaping, but is too slow growing for most conservation purposes.

Common juniper  
*Juniperus communis*

*J. communis*, common juniper, is a spreading, evergreen shrub with glaucous-green, awl-shaped, sharp, needle leaves in whorls of three and glaucous green to purplish berrylike cones; grows throughout western North America, mostly at middle elevations in undercover of coniferous or aspen forests. Planted less commonly, despite good cover and ornamental values. Requires cool, moist habitats. Birds naturally spread the seed in droppings.

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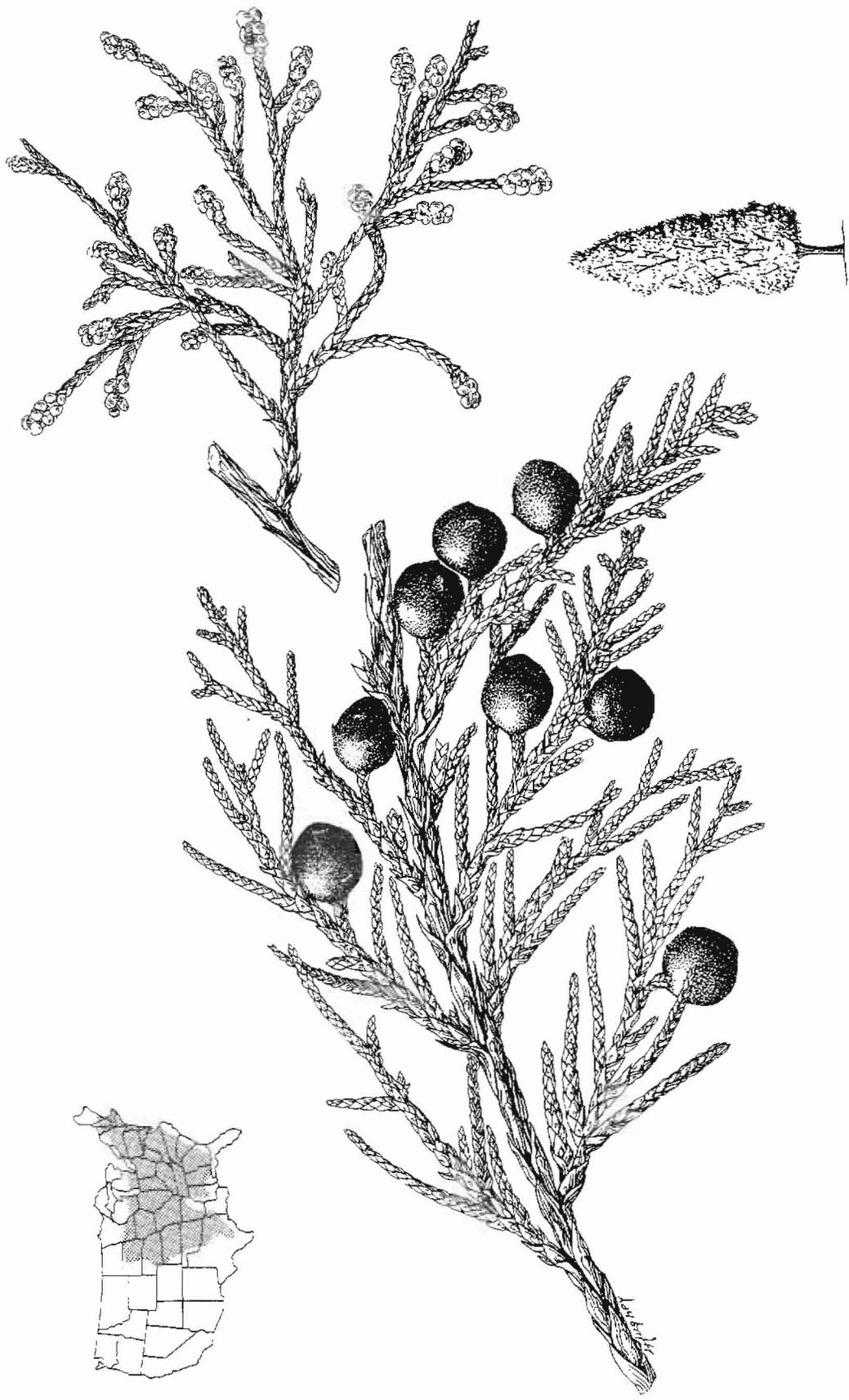


Figure 87. Eastern redcedar (*Juniperus virginiana*). Staminate and pistillate twigs x 2.

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## OSAGE-ORANGE

*Maclura pomifera* (Raf.) Schneid.

### ORIGIN

Native to Oklahoma, Arkansas, and Texas but naturalized in many Eastern States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small, thorny, deciduous tree.

Plants with open, rounded crowns, up to 25 feet tall, with a short trunk up to 2 feet in diameter, curved branches, and milky sap. Leaves simple, entire, alternate, egg-shaped to broadly lanceolate, shiny green above, paler below, about 4 inches long. Twigs orangish, stout, and with straight axillary thorns about 1/2 inch long. Flowers inconspicuous, sexes either on different or same tree(s); male flowers densely clustered on drooping stalks; pistillate in round, bristly, axillary heads. Fruit a multiple fruit, composed of many drupes, resembling a small, pale green grapefruit or orange (1).

Roots deep and extensive and plants readily stump and root sprout, particularly after tops cut or injured. Plants flower April to June, fruit ripen September to October, and good seed crops are produced annually. Not very palatable to livestock and big game but occasionally browsed; provides valuable watershed and wildlife cover, especially for smaller forms of wildlife (1,2).

### ECOLOGICAL RELATIONSHIPS

Initially very restricted in distribution and apparent adaptation. Plantings reveal much broader amplitude of tolerance. Best performance in well-drained, deep, fertile, silty, alluvial soils. Tolerant of moderately acid (to a pH of 4.5), moderately basic, and slightly saline soils. Naturally thrives in 25 to 40 inches MAP zones or equivalent but tolerant of about 15 inches minimum. Not hardy to dry, cold weather in the Dakotas and dies back almost annually at Cheyenne Horticulture Station, WY; some old plantings persist in southeastern Colorado; sometimes grown in Denver and eastern Colorado, but survives better with some irrigation. By contrast, well-adapted to most of eastern United States as far north as New England; used some in eastern Oregon and Washington. Nursery stock in prairie-plains region ripens slowly and is subject to early frost injury, indicating problems to be expected with southern natives. Intolerant of much shade and generally thrives in full sunlight. Some tolerance of fires and grazing due to vigorous sprouting habit. Apparently strongly competitive and not very compatible with other species, particularly taller woody plants; nearly always planted in separate rows. Many old hedgerows of this species have been removed in modern times (2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Seeds are planted 1/4 to 1/2 inch deep or broadcast and covered with soil or sand to similar depth. Plant untreated seed in fall and pretreated seed in spring. Rate of seeding varies with quality of seed, seedbed conditions, and desired seedling stand density. Most small stands are probably established by transplanting rooted sprouts from existing stands or by planting nursery stock. Seedling (1-0) stock is planted for minesoil reclamation in the Midwestern and Eastern States; it probably would be advantageous to plant older stock in northern and western regions with shorter growing seasons and more difficult sites (3,4,5).

#### Seed Cleaning and Quality

Pick ripe fruit in fall or winter as they begin to fall. Extract seed by macerating fruit in water and floating off or screening out the pulp. Extracting is easier after letting fruit ferment for several months in moist storage or buried. Seed quality not standardized: 95 percent purity; 58 percent germination; 55 percent PLS; and 7,000 clean seed per pound (5).

### Germination and Seedling Characteristics

About one-third of pretreated seeds germinate in 14 days and most do in 40 days in the lab or in sand flats at 68° night and 86° F day temperatures. Either subject seed to 41° F moist chilling for 1 month or soak them in water for 48 hours to enhance germination. Plants attain early seed-bearing age in 10 years, indicating fairly good seedling and juvenile rate of growth and development (5).

### MANAGEMENT

Species formerly was very popular for hedgerows and effective barriers for livestock; more recently popular for use in windbreaks, from which fence posts are cut. Species used primarily for its cover values in the midwestern and eastern coalmine areas. Better stands result more quickly if plant competition is controlled and livestock are withheld during establishment. Liming, cultivation, and fertilization may be necessary on more acid and infertile soils for good stand development. Species of little value for forest products so consider planting other crop and nurse trees; consider total land use and conservation for sustained economic benefits (2).

### ASSOCIATED SPECIES

Osage-orange naturally occurs in open stands of mixed hardwoods, such as oaks (*Quercus* spp.), pecan (*Carya illinoensis*), hickories (*Carya* spp.), and eastern redcedar (*Juniperus virginiana*). It is planted alone or in separate rows with evergreens and taller hardwoods for windbreaks and in mixed forest tree stands in farm forestry conservation and utilization programs.

### PESTS AND DISEASES

Small mammals and rabbits molest seeds and seedlings. Species is subject to damping off disease in nurseries and plants are subject to cotton root rot. Generally, however, it is very hardy and tolerant of dry and somewhat poor soil and stressful growing conditions (4).

### IMPROVED VARIETIES

None.

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- (2) Vogel, W. G. 1981. A guide for revegetating coal minesoils in the Eastern United States. U.S. Dept. Agr., For. Serv. Gen. Tech. Rep. INT-103. 190 pp.
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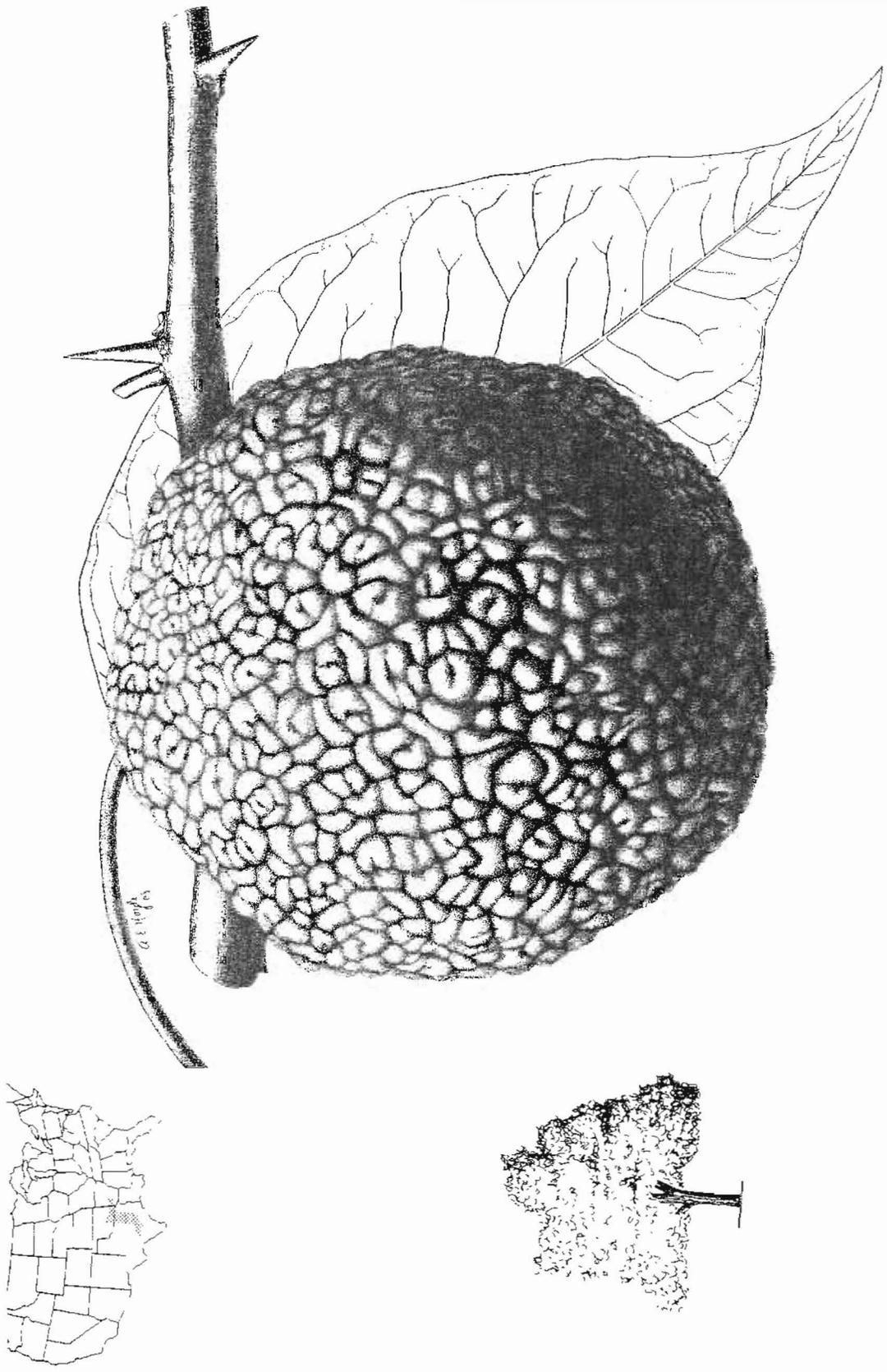


Figure 88. Osage-orange (*Maclura pomifera*). Fruit, leaf, and twig x 1.

## ENGELMANN SPRUCE

*Picea engelmannii*

### ORIGIN

Native to high mountains of western United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium to large-sized, evergreen trees.

Conifer up to 100 feet tall and 3 feet diameter with clear boles, conical crowns of whorled branches, and thin red-purplish brown bark, separating into loose scales. Needle-leaves single, typically blue-green, about 1 inch long, four-sided, crowded on upper side of branchlets, not sharp to touch. Male flowers in small purple stroboli, ovulate in bright red conelets and developing into 1 to 2 inch, oblong, cylindric cones with chestnut brown, irregular-outlined scales subtending blackish, winged, nutlet seeds (1).

Root system shallow and spreading. Stroboli open June to July at lower and higher elevation, respectively; cones mature and seed ripen late September to early October of first year. Palatability low to livestock and big game but sheep and big game browse considerably around bedgrounds and in winter, respectively. Forests provide good wildlife and watershed cover, in addition to valuable wood (1,2).

### ECOLOGICAL RELATIONSHIPS

Species thrives in the cold humid climate of subalpine elevations in western mountains. Generally thrives in deep medium to moderately fine, silty to clay loam soils but present on somewhat rocky medium to shallow depths. Tolerant of moderately acid to mildly basic, but not saline, soils. Somewhat tolerant of imperfectly drained and moderate and high water tables but not of saturated soils. Species thrives in 25 to over 40 inches MAP zones and has rather weak drought tolerance. Established plants are tolerant to full sun but very difficult to establish in full sunlight, particularly on beetle-killed areas in Central Rocky Mountains. Generally quite cold-tolerant but source of seed, ecotype, and provenance very important to adaptation, survival, growth, and quality. Not very grazing-tolerant, and seedlings and advanced reproduction often killed around frequently used sheep bedgrounds; losses were formerly more prevalent with permanent bedgrounds. Fire-sensitive and even light fires that scorch boles are capable of killing. Within its range, very competitive after fully established and usually succeeds in mixed stands, except on exposed south and west exposures or on dense clay soils and ill-suited sites (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

In nursery practice, seeds are planted or covered with nursery soils or sand 1/4 inch to 3/8 inch deep. Seedbeds are rolled and mulched before seed start to germinate. About 120 to 140 seed per square foot are sown to obtain a nurserybed density of 40 seedlings per square foot. Only spring seedings are recommended because fall-sown seed may germinate and winter kill during intermittent warm and freezing fall weather. Nursery or container-grown stock are outplanted during spring and early summer; 2-0, 3-0, or sometimes 2-1 or 3-1 bare-rooted stock can be used. Newer greenhouse or controlled environment operations raise similar sized stock in 1 year and, when properly handled, they result in equal or better survival and growth in outplantings. Direct seeding is not commonly practiced because of much poorer results than with planting (3,4,5).

#### Seed Cleaning and Quality

Harvest cones quickly after ripening to avoid seed loss. Seeds ripen before cones change to typical mature color. Collect cones from standing trees, slash, or squirrel caches. Air dry cones for a few weeks or heat up to 100° F to 120° F in simple convection kiln. Then, shake or tumble cones in mechanical shakers and tumblers to extract seed. Wings and chaff are readily separated by moistening seeds, stirring in round bowl with a soft plastic scraper, and drying and cleaning seed in a seed cleaner. Empty seeds can be separated by flotation in alcohol. Seed quality not standardized: purity varies with cleaning effectiveness, probably 90 percent (4).

## Germination and Seedling Characteristics

Most seeds germinate in 10 days in the seed lab without any "stratification." Standard germination conditions are: 68° F night and 86° F day temperatures with 8 hours of light daily. Germination usually runs 10 to 20 percent below seed soundness determined by cutting tests. Seedling rate of development of spruce is slow and growth from sapling to maturity also is slow, due to short growing season at high altitudes (4).

## MANAGEMENT

Species is used primarily for reforestation at higher elevations in cool, moist sites below upper timberline. It has been used to a limited extent in the reclamation of subalpine mine sites; for example, in the reclamation of the AMAX, Inc. Urad mine tailings in central Colorado. These sites were stabilized using waste rock, waste wood chips, sewage sludge, a sown mixture of grasses and other herbs to stabilize site 1 year prior to planting trees, including Engelmann spruce and shrubs. Irrigation was used in early establishment and some of the trees were inoculated with fungi to increase surface area of roots for better growth and survival. Grazing must be excluded and game and rodent populations controlled for maximum chance of successful planting. Shingles placed to shade seedlings aid better establishment. Shaping and stabilizing spoils, replacement of topsoil and/or fertilization, proper planting, mulching, providing shade, irrigating during first few years where feasible, or planting in contour furrows or trenches, as well as conservative land use management, need to be considered in reclamation plans (5,6).

## ASSOCIATED SPECIES

This spruce occurs most commonly with subalpine fir in the Rocky Mountains; it also occurs with lodgepole pine (*Pinus contorta*), limber pine (*P. flexilis*), bristlecone pine (*P. aristata*), quaking aspen (*Populus tremuloides*), a variety of blueberries (*Vaccinium* spp.) and other shrubs, and numerous high altitude herbs. In reforestation, it is usually seeded alone but sometimes with lodgepole pine in more difficult sites. The Urad mine reclamation included numerous grasses, herbs, and shrubs, with the herbaceous vegetation used to stabilize site and ameliorate the harsh environmental conditions for shrubs and trees.

## PESTS AND DISEASES

Small mammals and sometimes big game and livestock injure seedlings. Spruce bark beetle epidemics occur infrequently but usually are devastating, particularly to older age classes. Spruce budworm is potentially dangerous and wood rotting fungi are most common diseases (2).

## IMPROVED VARIETIES

None. Blue spruce (*Picea pungens*), more attractive native, commonly used for ornamental, screening, and windbreak purposes in Central Rocky Mountains below 10,000 feet; requires irrigation in lower elevation zones; e.g., in Great Plains and Great Basin.

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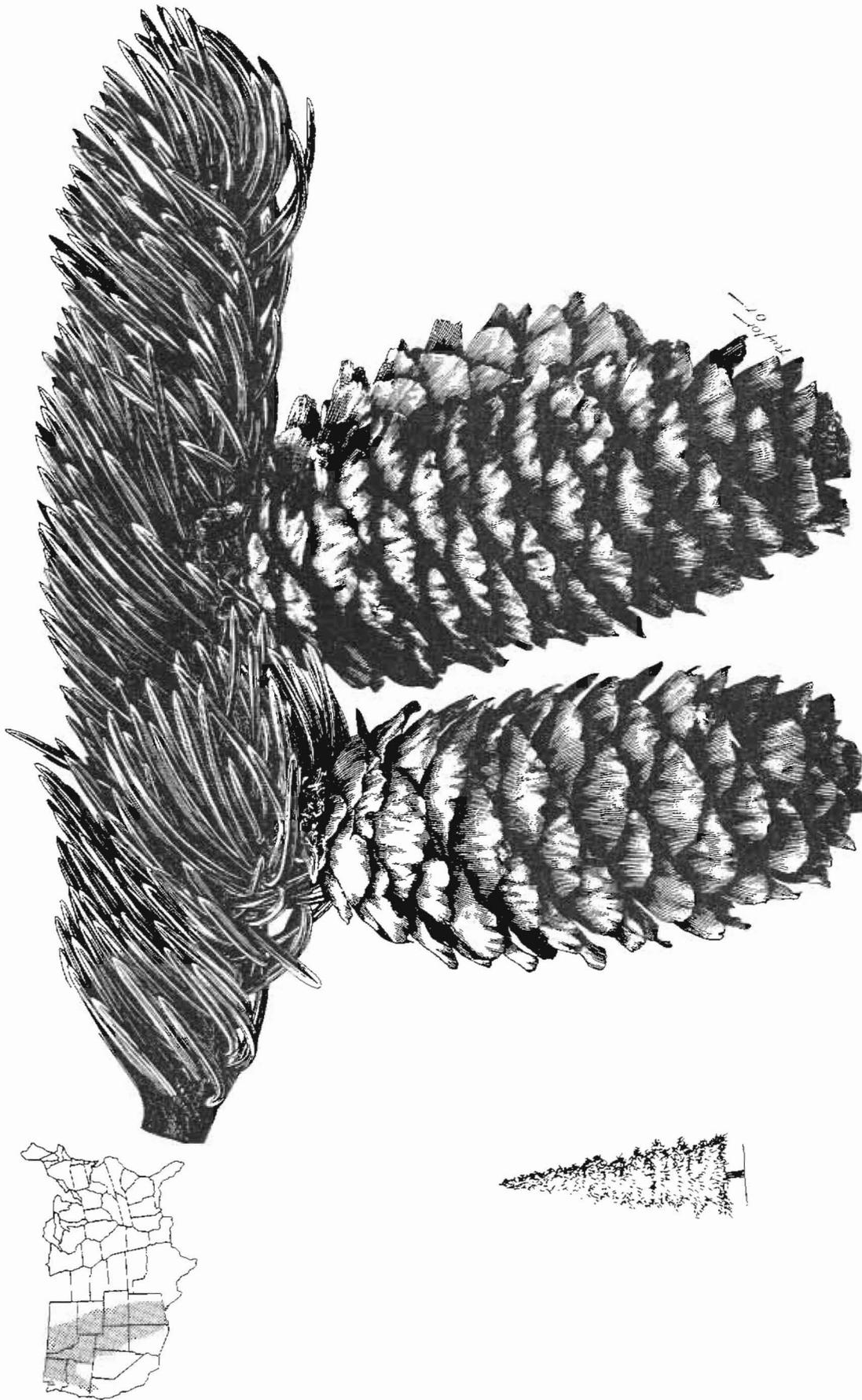


Figure 89. Engelmann spruce (*Picea engelmannii*). Twig, needles, and cones x 2.

## LOGEPOLE PINE

*Pinus contorta* Dougl.

### ORIGIN

Native to Central and Northern Rocky Mountains and to the Sierra-Nevada-Cascade Mountains and North Pacific Coast. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small to medium-sized, evergreen tree.

Conifer typically 30 to 80 feet tall and 0.5 to 2.5 feet in diameter with short, narrow crowns and long, slender boles with thin, orange-brown to gray bark, covered with loose scales. Leaves needlelike, fascicled in twos, 1 to 3 inches long, and yellowish-green. Male flowers in miniature spikelike stroboli, orangish-red; female conelets clustered and develop into ovoid, curved cones 1 to 2 inches long, often closed for years, with scales armed with prickles, nobby at base, containing winged, reddish-brown nutlet seeds (1).

Plants incapable of vegetative reproduction except artificially; reproduce profusely from seed, often forming very dense "doghair" stands after fires; produce straight posts, poles, and timber. Flower June to July and ripen seeds August to September at 6,000 feet in elevation near Lake Tahoe, CA. Not considered palatable to livestock but sometimes browsed by sheep and often used by deer and elk, particularly as winter emergency browse; provide food and cover for some birds and other wildlife; also provide watershed protection. At least two distinct subspecies recognized: var. *contorta*, a short, scrubby tree with twisted cones that grows along North Pacific Coast; and var. *latifoliam*, a taller inland or mountain form. The following discussion is specific of var. *latifolium* (1,2).

### ECOLOGICAL RELATIONSHIPS

Subspecies grows on medium to coarse-textured soils derived from granites, shales, and sandstone geological material or coarse-grained lavas, usually well-drained. It occurs from 1,500 to 11,500 feet in elevation. Lodgepole grows on low fertility sites and on shallow rocky or gravelly sites. It requires more moisture than ponderosa pine (*Pinus ponderosa*) for good growth and is found mostly in the 18 to 25 inches MAP zones in the Central Rocky Mountains. Trees are cold-hardy, although chinook winds sometimes cause red belt injury. Planting generally is recommended above 8,000 feet in elevation in Rocky Mountain-Intermountain areas with suitable sites. Source of seed and planting stock important to survival, growth, and quality due to great variability within the taxon. Species requires high elevation and cool sites and often performs better on east- and north-facing slopes, except at highest elevations. More shade-intolerant than most associates; advanced reproduction to pole-sized plants persist in shade for extended number of years. Trees easily killed by fire but species generally is perpetuated by fire opening serotinous cones. Young trees are rarely damaged along driveways, around sheep bedgrounds, and in areas of extreme game winter concentrations. Less competitive in open stands than ponderosa pine; more competitive in shaded sites. Moderately compatible in not very dense mixed tree plantings but naturally rather incompatible with undercover species due to dense needle-litter, acid soils, and reduced nitrification (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Nurserymen plant seed about 1/8 inch deep by drilling or pressing seed firmly into soil. Rate is adjusted for quality of seed and desired nursery seedlings density. For 50 to 75 seedlings per square foot density, about twice as many seeds would be sown because nursery germination usually is about 10 percent less than average seed lab tests for germinative capacity (60 percent). Seed may be sown either in fall and mulched or sown in spring. Some seed spot direct seeding can be done on the more favorable sites but usually gives unreliable results; most sites which do not naturally regenerate and disturbed and difficult sites can be planted using 2-0 or older stock. Older stock often is used on more difficult sites but stock must have balanced tops and roots, good caliper, and not have too extensive a top or it will dry out too rapidly during dry weather and on exposed sites (4,5,6).

## Seed Cleaning and Quality

Cones should be collected from superior quality trees. They may be collected from standing or felled trees or animal caches after seed-ripening. Hand pick seed with aid of ladders, hand cutter, and/or cutting hooks to sever cones. Dry cones by spreading them on some surface in sun or in well-ventilated rooms or hang in bags inside from overhead hooks. Serotinous (closed) cones can be opened by dipping in boiling water for 10 seconds to 2 minutes. Shake opened and dried cones in a tumbler or shaker to extract seed; run seed through a dewinger machine; then reclean in clipper cleaner, fanning mill, or screens. Seed quality not standardized: purity unrecorded, 90 percent or better if effectively cleaned; germination 70 percent; and seed average 94,000 seed per pound (4,6).

## Germination and Seedling Characteristics

Majority of viable seed germinate, and peak germination rate occurs in about 10 days under controlled lab conditions; some seed germinate as late as 21 days. Cold-moist stratified seed are germinated at fluctuating 68°/86°F temperatures with 8 hours of light daily. Fluctuating 47° and 78°F temperatures, full sunlight, mineral soil or disturbed duff, and weed-free sites favor field germination. Recommended "stratification": 30 to 56 days at 33° to 41°F in a moist medium. Germination is epigeal. Seedling root and top growth rate are slow, and species is a rather slow grower except for some lowland interior Pacific Northwest strains that are fast growing but short-lived (4,6).

## MANAGEMENT

Species widely used for reforestation, mountain windbreaks, Christmas trees, landscaping, and wood products. In much of its range, natural regeneration is preferable and encouraged by small patch or strip clearcutting, slash disposal methods, and site treatment. Unstocked areas or those regenerating poorly can be machine planted on sites with high productivity that are not too steep, rough, rocky, or with down logs and stumps. Only the most favorable sites without much competing vegetation and with good moisture conditions, for example east and north-facing slopes with moderate depth of permeable, fertile soil, might be direct-seeded by hand in carefully chosen microsite spots, taking advantage of available shelter from drying wind and sun behind stumps, down logs, rocks, and slash. Generally, planting old adapted nursery stock gives more reliable stand establishment; hand planting is done using a planting bar or round-pointed shovel. Site preparation, providing contour furrows and control of competing vegetation, exclusion of grazing and control of rodents and larger mammals or use of repellants, careful selection and care of planting material, providing some shade or mulch where feasible, making sure plants are kept cool and moist until planted, using proper planting/seeding techniques, and prudent forest and total land management afterward are important considerations (5).

## ASSOCIATED SPECIES

Lodgepole pine commonly occurs in close association with Englemann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), quaking aspen (*Populus tremuloides*), common juniper (*Juniperus communis*), grouse whortleberry (*Vaccinium scoparium*), russet buffaloberry (*Shepherdia canadensis*), and snowberries (*Symphoricarpos* spp.). Usually planted alone or in solid blocks, but may be used for contrast, as a specimen, or for screening with other species about it in landscaping (2).

## PESTS AND DISEASES

Rodents, porcupine, and deer molest new plantings. Mountain pine beetle is the most serious insect pest; lodgepole needle miner, lodgepole sawfly, and spruce budworm defoliate plants. Dwarf-mistletoe increases mortality rates and causes reduced productivity (2).

## IMPROVED VARIETIES

None.

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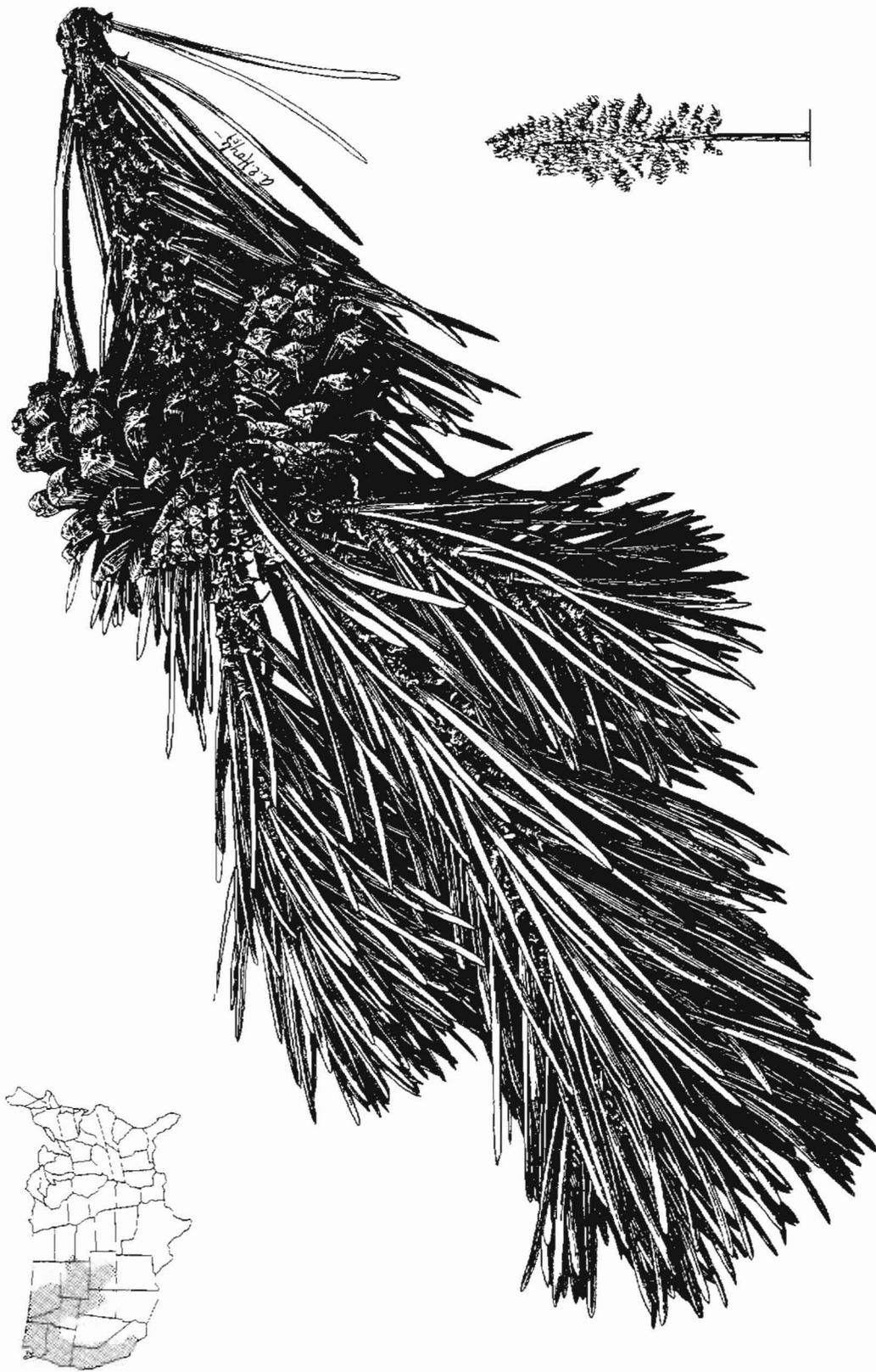


Figure 90. Lodgepole pine (*Pinus contorta*). Twig, needles, and cones x 1.

### Germination and Seedling Characteristics

Most viable seed germinate in 10 to 14 days in the lab. Standard germination conditions used are constant 72° F temperatures and 8 hours of light daily. Fresh seed are sometimes hastened in germination by 15 days cold stratification; 15 to 60 days of such treatment are recommended for stored seed prior to use. Germination is epigeal. Growth is rated rather rapid for better sites and is most evident in pole-sized age classes (3,5).

### MANAGEMENT

Species is widely used in Southeastern U.S. and into Ohio River valley and even west of its natural range in Western Interior coal district due to wide adaptation of species. Direct seeding is common practice on mine spoils in Alabama and Southern States. Planting 1-0 seedling and older 2-0 stock is more common in northern and drier sections within and beyond its range. Total land reclamation and use planning is necessary for successful establishment and good performance. Important considerations include: site preparation; control of plant competition; correcting soil pH and fertility problems; topsoil replacement; grading and stabilizing; selection and care of planting and seed stocks; seeding and planting; control of small mammals and grazing during establishment years; replacement and thinning; insect, disease, and pest control; and conservative total land management and use (4,5).

### ASSOCIATED SPECIES

Shortleaf pine commonly occurs in pure or mixed stands with eastern redcedar (*Juniperus virginiana*); black, post, scarlet, bear, southern red, northern red, and chestnut oaks (*Quercus velutina*, *Q. stellata*, *Q. coccinea*, *Q. ilicifolia*, *Q. falcata*, *Q. rubra*, and *Q. prinus*, respectively); sweetgums (*Liquidambar* spp.); and white, longleaf, Virginia, and loblolly pine (*Pinus strobus*, *P. palustris*, *P. virginiana*, *P. taeda*); and numerous shrubs, forbs, and grasses. It is seeded/planted alone or with loblolly pine or, less commonly, with selected hardwoods and herbaceous species.

### PESTS AND DISEASES

Young plants are susceptible to pine tip moth and littleleaf disease. Rabbits damage seedlings and hogs rarely do some damage. Small mammals and birds consume quite a few seed.

### IMPROVED VARIETIES

None. Improved planting stock exists. Check provenance for better quality.

### REFERENCES

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Shortleaf pine commonly occurs in pure or mixed stands with eastern redcedar (*Juniperus virginiana*); black, post, scarlet, bear, southern red, northern red, and chestnut oaks (*Quercus velutina*, *Q. stellata*, *Q. coccinea*, *Q. ilicifolia*, *Q. falcata*, *Q. rubra*, and *Q. prinus*, respectively); sweetgums (*Liquidambar* spp.); and white, longleaf, Virginia, and loblolly pine (*Pinus strobus*, *P. palustris*, *P. virginiana*, *P. taeda*); and numerous shrubs, forbs, and grasses. It is seeded/planted alone or with loblolly pine or, less commonly, with selected hardwoods and herbaceous species.

### PESTS AND DISEASES

Young plants are susceptible to pine tip moth and littleleaf disease. Rabbits damage seedlings and hogs rarely do some damage. Small mammals and birds consume quite a few seed.

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None. Improved planting stock exists. Check provenance for better quality.

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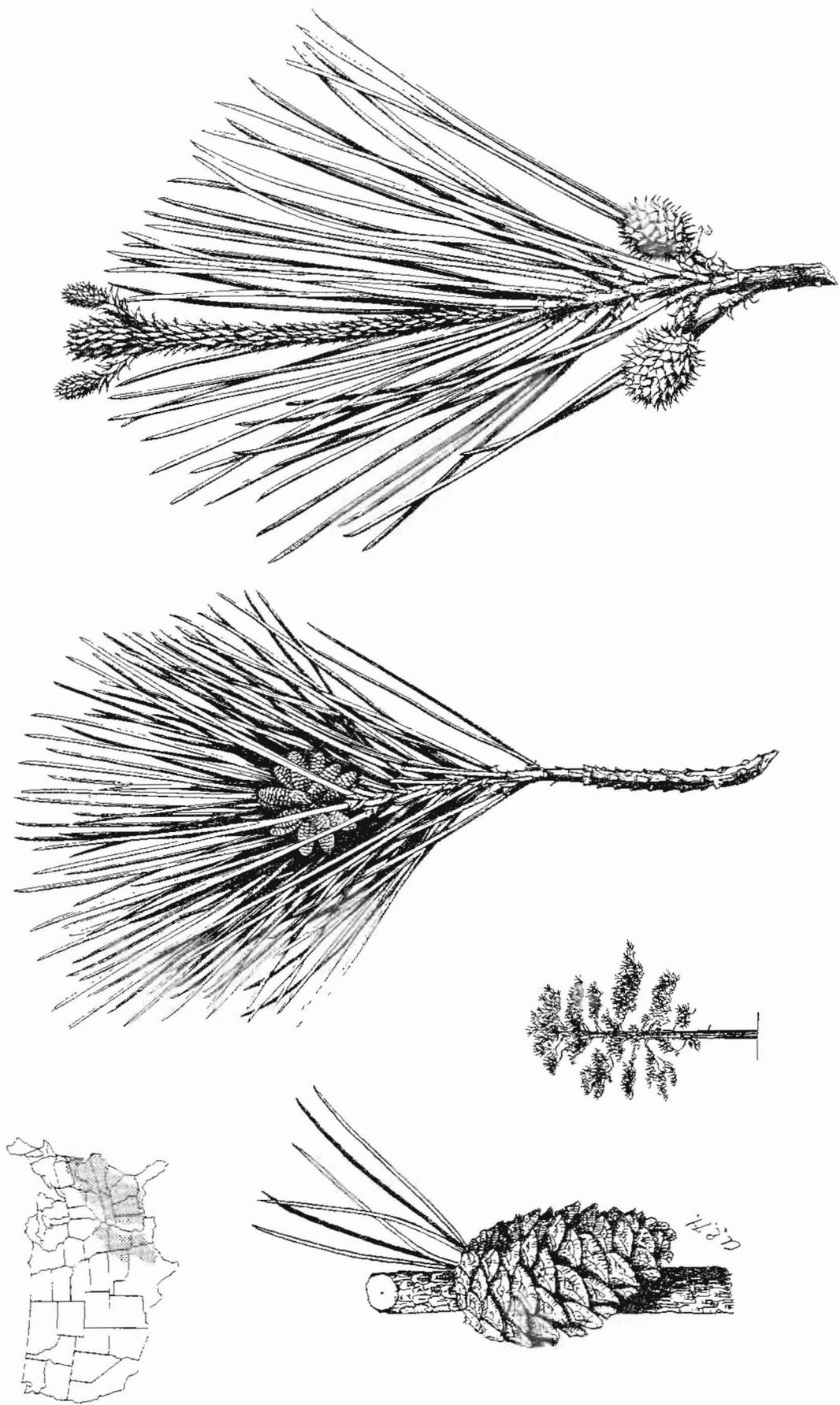


Figure 91. Shortleaf pine (*Pinus echinata*). Staminate twig x 1/2; pistillate twig x 1; cone x 2/3

## LIMBER PINE

*Pinus flexilis* James

### ORIGIN

Native to western foothill and high mountain ridges. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small to medium-sized, evergreen tree.

Commonly 20 to 50 feet tall with irregular round crown; drooping, terminally-leaved branches; and thin, smooth, gray-white bark, turning brownish with age. Leaves needlelike, in fascicles of five, rigid, dark to gray-green. Staminate flowers small, in reddish stroboli; ovulates clustered, purplish, developing into long, narrowly ovate-conic cones, bearing large, wingless, light brown seed on inner surface of slightly reflexed, unarmed scales (1).

Plants with deep tap roots having few branches, later supplemented by several lateral roots; very windfirm and snow-tolerant. Flowering early summer and maturing late summer to fall, varying by latitude and altitude. Palatability low for cattle, fair for sheep; considerably browsed by big game during open spells in fall and winter; provides some food and sparse cover for birds and small mammals (1,2).

### ECOLOGICAL RELATIONSHIPS

Adapted mostly to medium and coarse, mostly shallow soils or raw parent material; typically occurs on exposed ridges and summits from foothills of Idaho and Nebraska to upper timberline. Adapted to moderately basic to moderately acid soils/substrates. Cold and drought-tolerant; growing in 12 to over 20 inches MAP zones and in denser stands in above 20 inches MAP zone. Growing either in open, pure stands or mixed stands; relatively intolerant of shade. Not fire-tolerant but often growing in stands so sparse fires seldom carry. Intolerant of competition from dense stands of shade-tolerant tree species but rather compatible with herbs and shrubs in its native environs (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

Plant seed for nursery purposes in fumigated, well-prepared beds about 1/4 to 3/4 inch deep or up to twice the diameter of seed, using greater depths for coarser textured soils and dry seasons. Rate of seeding is adjusted for seed quality and with the seeding stand density goal, which often varies from 15 to 50 plants per square foot; sparser stands used when seedlings are held beyond 1 year in nursery. Seeds are sown in early spring using stratified seed; unstratified seed can be sown in fall at higher elevations or northern latitudes where little danger of fall/early winter germination exists. Either direct seeding or transplanting of nursery, or rarely wilding, stock can be done for a variety of purposes, including high altitude mineland reclamation. Hand spot seeding/planting requires careful selection of spots where seedlings are apt to survive, usually where ample soil moisture and site stability are assured (3,4).

#### Seed Cleaning and Quality

Cone collecting, seed extraction, and cleaning processes are similar to other pines. Refer to ponderosa pine (*Pinus ponderosa*) for such information. Seed quality not standardized: purity variable, approaching 100 percent, depending on cleaning effectiveness; germination from limited testing 42 percent (untreated) to 82 percent (stratified); and seeds average 4,900 per pound (3).

#### Germination and Seedling Characteristics

Peak germination rate attained in 14 days, and some seed germinate in 27 to 30 days in lab tests. Optimum germination appears to occur by cold stratifying seed for 3 weeks to 3 months and testing under alternating 60°/86°F temperatures. Germination is epigeal. Limber pine is classed as a slow grower, taking 200 to 300

## MANAGEMENT

Limited use made of this species in land reclamation and highway beautification within its unique habitats. Necessary to avoid too large seedlings due to high transpiration loss on windy sites. Seeding/planting spots should be selected in shelter of rocks, downed logs, or bushes, and plants should be provided with shingle or slash on most exposed sides. Mulching and irrigation probably necessary during first year or more for good survival. Grazing should be excluded and small mammals controlled or seeds and plants treated with repellants. Typically fragile sites require conservative land management and constant monitoring of reclamation, particularly during first 5 to 10 years (4).

## ASSOCIATED SPECIES

Limber pine commonly occurs in mixtures with Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), bristlecone pine (*Pinus aristata*), lodgepole pine (*P. contorta*), and a variety of shrubs and herbs. Infrequently seeded/planted alone.

## PESTS AND DISEASES

Seeds are consumed by small mammals and birds. Chief problem is white pine blister rust, which periodically decimates stands where species or currants (*Ribes* spp.) abound. *Ribes* either needs to be controlled or limber pine not used.

## IMPROVED VARIETIES

None.

Whitebark pine  
*Pinus albicaulis*

*Pinus albicaulis*, whitebark pine, distributed in the Northern Rocky, Cascade, and Sierra-Nevada Mountains, is very similar and distinguishable chiefly by its shorter, rounded ovoid cones which remain closed until their central axis disintegrates. It occupies similar exposed subalpine summits but is not found at lower foothills sites. Species could serve a similar role for its attractive foxtaillike evergreen foliage and site stabilizing potential in high altitude mining areas. Bristlecone pine (*Pinus aristata*), sometimes popularly called foxtail pine, is more commonly used for landscaping in urban and suburban areas, has more terminally concentrated needles and purplish ovoid cones, having bristly incurved prickles on scales.

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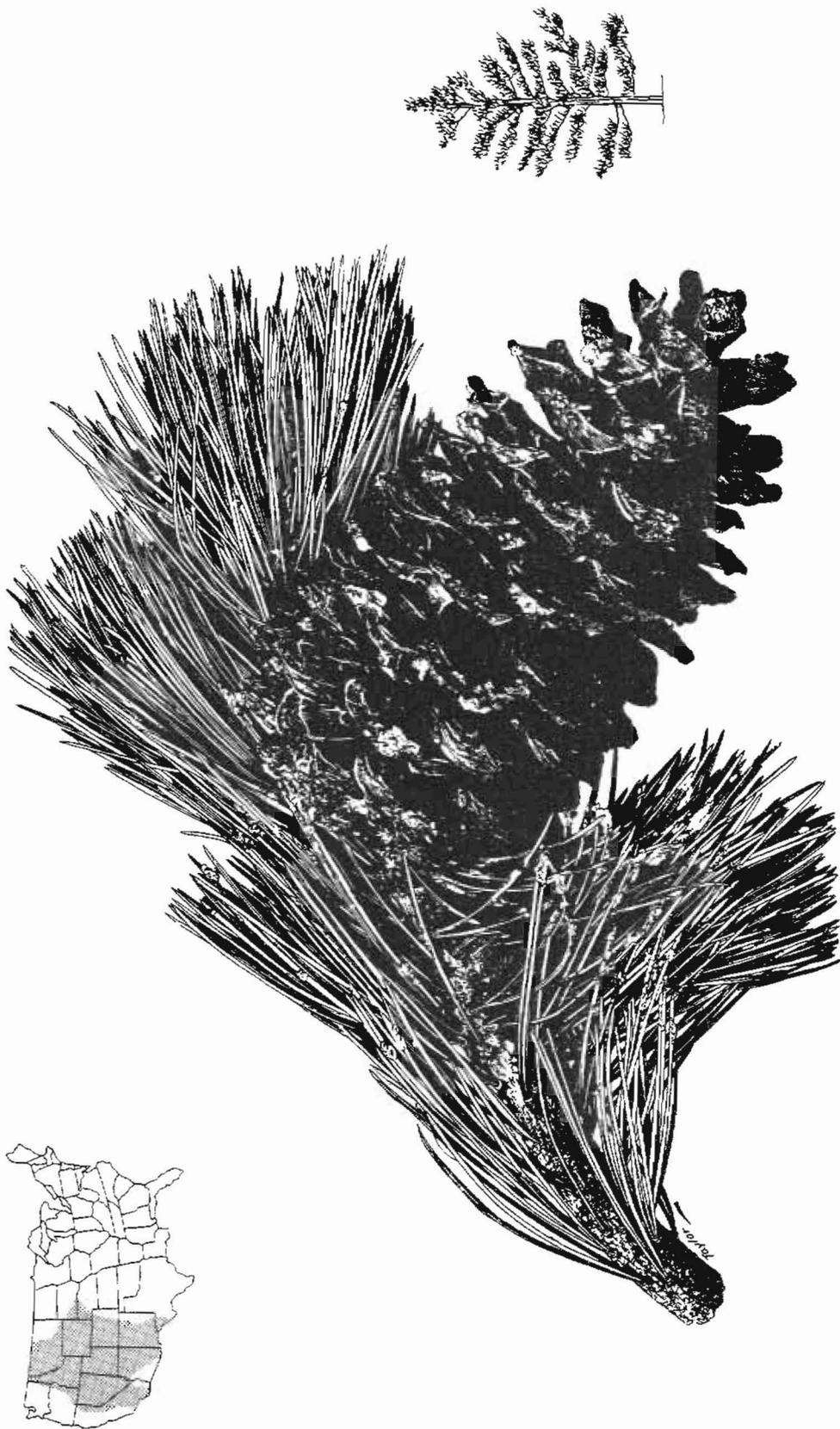


Figure 92. Limber pine (*Pinus flexilis*). Twig, needles, and cone x 1.

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## PONDEROSA PINE

*Pinus ponderosa* Laws.

### ORIGIN

Most extensively distributed pine in North America: from Nebraska and western Dakotas west to Pacific Coast and in all 11 western States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium-sized to very large evergreen trees.

Conifer typically 50 feet to 150 feet tall with medium length conical or round-topped crowns, limby to clear boles in age, 2 to 4 feet in diameter, covered by thick black or cinnamon-brown bark, separating into scales, and large yellowish flat plates. Leaves yellow-green, needlelike, in fascicles of threes or twos, averaging about 6 inches long, and persistent. Male flowers yellow in small conelike stroboli, pistillate in green cones, maturing brown, up to 6 inches long, containing winged, purplish nutlets borne naked on inner face of cone's many recurved prickly scales (1).

Plants not sprouting from base or stump; extensively and moderately deep rooted: seedlings with long tap roots. Plants flower April to June, and seeds ripen August to October, varying environmentally and genetically. Palatability usually low to livestock; sometimes browsed, particularly by big game in winter, often due to shortage of forage or drinking water. Trees provide good wildlife and watershed cover and some food for birds and small mammals, in addition to valuable wood products (2).

### ECOLOGICAL RELATIONSHIPS

Species adapted to wide range of soil textures from clay loams to loamy sands; grows on soils derived from sedimentary, metamorphic, and igneous parent materials, and also on thin parent materials of gravel, cinders, and pumice. Thrives in deep, well-drained soils of good moisture holding capacity; occasionally on sites with imperfect drainage and seasonally high water tables. Better performing on mildly acid to neutral substrates but tolerant of moderately acid (to a pH of 4.5) to moderately basic soils but not to saline or sodic soils. Thrifty stands occur in the 15 to over 25 inches MAP zones in Rocky Mountains; rarely found growing in moisture compensating soils/sites (e.g., pumice) with less than 10 inches MAP. Moderately strong drought tolerance, particularly in seedling stages, due to long tap roots. Species with three recognized subspecies and geographic strains and ecotypes; use care in selecting source of seed and check provenance of planting stock as well. Shade-intolerant and grows most rapidly in nearly full sunlight. Fair to good tolerance of fire in maturer stages due to thick bark; usually only injured if less than half of crown burned, but seedlings and pole size trees killed or thinned by fire. Reproduction fairly tolerant of moderate browsing but malformed trees and seedling mortality result with repetition. Providing adequate drinking water daily to livestock minimizes browsing of pine reproduction in the semiarid Southwest. Trees moderately tolerant of competition past the seedling stage, retaining capacity to respond to release from competition until later age than most species. Dense grass greatly inhibits pine reproduction, particularly in semiarid Southwest (1,2,3)

### CULTURE

#### Planting Depth, Rate, and Time

Seeds are drilled or broadcasted and pressed firmly into prepared nursery seedbeds 1/8 to 1/2 inch deep, the latter depth with fall seedings. Rate of seeding varies with quality of seed and desired seedling density; usual goals vary between 25 and 65 seedlings per square foot, the higher density for 1-0 stock and lower density for 2-0 or older stock. Seedling yield from viable seed ranges from 20 to 80 percent, median 50 percent, suggesting need for 50 to 130 PLS per square foot for seedling density goals listed above. Seed either in fall or spring; use untreated seed in fall but only seeds receiving moist prechilling treatment should be planted in spring. Reforestation or afforestation by direct seeding is unreliable. Sometimes seeds are sown in moist mineral soil, north slopes, weed and brush-free areas, and rodent-controlled. Drill 10,000 to 12,000 PLS per acre or locally more precise rates: use a rangeland drill or improved tree seeder or spot

seeder and 1,700 to 5,000 PLS per acre, varying rate to desired stocking (4). Generally nursery or greenhouse grown seedlings or older stock are planted for reforestation and windbreak purposes; older stock (2-0, 2-1, or older) often used for planting on difficult sites, including minesoil reclamation sites. Newer controlled-environment greenhouse practices raise vigorous container stock in 1 year, equivalent in size to former 3-year old nursery stock. Sample checks indicate as good or better survival and growth than standard planting stock 3-years old (3,5).

#### Seed Cleaning and Quality

Collect cones by hand-picking from trees by climbing trees or ladders, using a cutting hook, or collecting ripe seeds from felled trees or animal caches. Dry cones slowly in sun, ventilated rooms, in sacks suspended from ceilings, or heat in cone kilns at 110°F, 120°F, and 165°F for 60, 3, and 2 hours for var. *arizonica*, *ponderosa*, and *scopulorum*, respectively. Shake dried/heated cones in tumblers or shakers to extract seed. Dewing seed in a dewinger and clean in clipper cleaner or fanning mill. Seed quality not standardized: purity variable, dependent on cleaning effectiveness and purity needed for sowing method, usually should be 90 percent or better; germination capacities average 75 percent, 60 percent, and 64 percent; and 11,400, 12,000, and 13,100 seed per pound for var. *arizonica*, *ponderosa*, and *scopulorum*, respectively (5).

#### Germination and Seedling Characteristics

Fresh seed not stored before testing germinate rather rapidly with more than half to about 90 percent germinating in 10 days under controlled lab conditions; some late germination occurs for 20 to 30 days. Germination is epigeal. Variety *arizonica* requires no pregermination treatment but stored seed of the other two varieties are improved and hastened by moist prechilling ("cold stratification") for 20 or 30 days. Growth rate is rather slow in early years but moderate to fast beyond the advanced reproduction stage, varying greatly with site conditions (2,5).

#### MANAGEMENT

Species very commonly used in Rocky Mountain-Intermountain regions and frequently in northern prairie-plains regions for reforestation, windbreaks, landscaping, wildlife cover, Christmas trees, and watershed protection. It is used to limited extent for planting on coal minesoils in Kansas and Pennsylvania. Prepare planting sites and remove competing vegetation and conserve moisture. Take good care of planting stock, never letting roots dry between lifting and planting, and observe good planting practices. Container stock should be irrigated before being set out and bare-root stock should be irrigated at the time it is set out, whenever feasible. Planting in contour furrows, basins, or irrigable furrows aid growth and survival in arid zones (4). Exclude livestock from new plantings for several years. Plan reclamations, shelterbelts, and reforestation to fit into total land conservation and utilization programs (4,6).

#### ASSOCIATED SPECIES

Ponderosa pine commonly associates with Rocky Mountain juniper (*Juniperus scopulorum*), Douglas-fir (*Pseudotsuga menziesii*), true mountain-mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), and Rocky Mountain maple (*Acer glabrum*). It commonly is planted with eastern redcedar (*Juniperus virginiana*) or Rocky Mountain juniper, shrubs and hardwoods in windbreaks; frequently is planted alone.

#### PESTS AND DISEASES

Small mammals menace new plantings and sometimes large animals destroy them. Three *Dendroctonus* pine beetles are most destructive among 108 species of insects on ponderosa pine. Dwarf mistletoe causes more damage than any other disease, but *Fomes annosus* causes root and butt rot and *Polyporus anceps* rots considerable wood (2).

#### IMPROVED VARIETIES

None. Rocky Mountain variety is *P. ponderosa scopulorum*; *P. ponderosa arizonica*, the Arizona pine, of southern Arizona and New Mexico, has five-needled fascicles and small cones.

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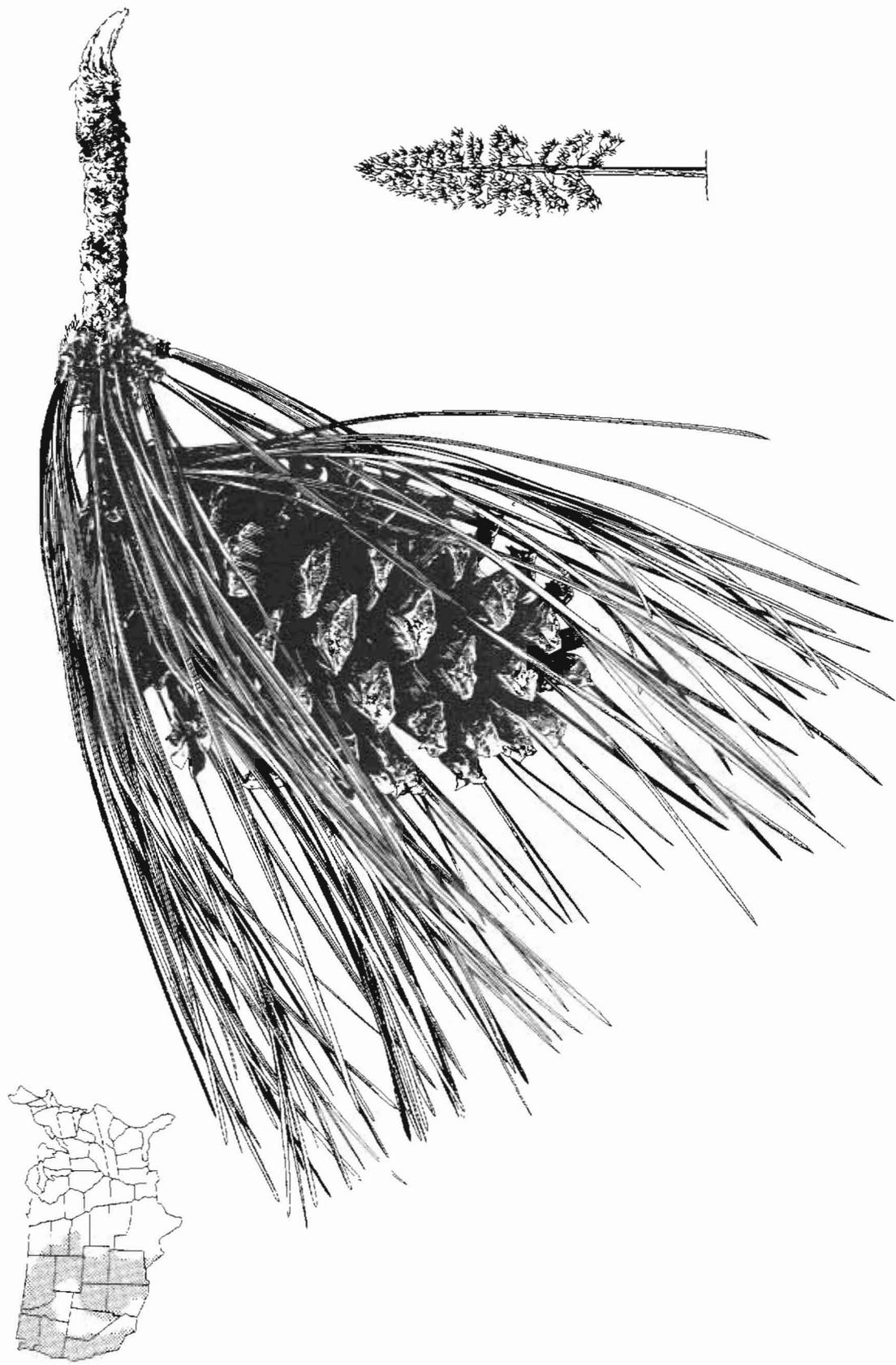


Figure 93. Ponderosa pine (*Pinus ponderosa*). Twig, needles, and cone x 1.

## LOBLOLLY PINE

*Pinus taeda* L.

### ORIGIN

Native to Southeastern United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium to large evergreen tree.

Conifer often 100 feet tall and 3 feet in diameter; with long, clear boles; dense, rounded crown and thin, scaly bark, black in youth and reddish-brown and plated in age. Needlelike leaves in fascicles of three, slender, 6 to 9 inches long, pale green. Yellow male flowers in small stroboli; ovulate yellow flowers in conelets, developing into conic-oblong cones, 2 to 6 inches long, pale reddish-brown, containing 1/4 inch long, winged, brown and black seed, borne on inside of spiny-tipped, reflexed scales (1).

Trees fairly windfirm from an extensive but somewhat shallow root system. Not stump or basally sprouting. Vegetative growth resumes in March and April; flowers about 10 days later; and cones and seeds mature in early October. Palatability low to livestock, infrequently attacked by hogs; provides some food and cover for birds and small mammals, in addition to good watershed and wood values (1,2).

### ECOLOGICAL RELATIONSHIPS

Species adapted to wide variety of soils from residual upper Piedmont soils to poorly drained flatland soils of lower Coastal Plain and river floodplains. More productive on river bottoms and terraces; poor growth with excessive surface drainage or hardpans within root profile. Tolerant of weakly to strongly acid soils (lower pH limit is 4.5). Tolerant of prolonged flooding and fairly high water table. Ill-suited to eroded soils without an A horizon. Generally occurs in the 40 to 60 inches MAP zones with a 6 to 10 month growing season. Weak drought tolerance. Rated intolerant of shade but tolerates partial shade. Moderately cold-tolerant for a southern pine and grown, with better survival from planting nursery stock, several hundred miles north of its native range. Source of seed and provenance of planting stock very important to disease and cold tolerances and growth. Good tolerance of fire after 5-years old. Species responds to fertility: greater growth rates noted when planted with adapted legumes or in alternate rows with European alder (*Alnus glutinosa*). Weakly competitive with shade-tolerant hardwoods and not particularly compatible with herbs, due to heavy smothering needlecast (1,2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Seed is pressed into soil about 1/6 inch deep (one seed diameter in depth) and mulched with pine straw in nursery operations. Plant field sown seed 1/4 to 1/2 inch deep. Use 1 to 1 1/2 pounds PLS per acre for direct seeding loblolly into southern parts of the Eastern and Western Interior (Illinois-Oklahoma) Coal Province sites. Special seedbed preparation to provide weed-free, firm conditions essential if such conservative rates are to yield desired 1,000 trees per acre. More commonly for reforestation, 1-0 seedling stock is planted in late winter or early spring. Unstratified seed are sown in late fall or early winter and stratified seed in spring; they should be treated with bird and rodent repellent before sowing (3,5,6).

#### Seed Cleaning and Quality

Collect mature cones from superior standing or freshly felled trees and from animal caches. Hand-pick from trees with aid of ladders and cutting hooks; sometimes mechanical tree shakers are used to speed the job. Dry cones in sun, well-ventilated rooms, or in cone kiln until scales reflex. Extract seed by shaking in tumbler or shaker; dewing in a dewinger machine and clean in a Clipper cleaner or fanning mill or equivalents. Remove empty seed by floatation in water. Seed quality: minimum purity standard suggested 95 percent; average germination 90 percent; 85 percent PLS; and 18,000 seed per pound (6).

### Germination and Seedling Characteristics

Viable seeds germinate in 17 days under lab conditions. Germination is epigeal. Germination test conditions are constant 72°F temperatures with 16 hours of light daily. Recommend pregermination treatment for fresh and stored seed is 30 to 60 days of cold-moist stratification. Loblolly seedlings and trees are fast growing (6).

### MANAGEMENT

Species typically is planted as 1-0 nursery or container stock north of its natural range in the southern parts of the Appalachian, Eastern Interior, and Western Interior Provinces and in all of the Lignite coal mining Provinces of the Eastern U.S. Commonly direct-seeded on coal mine spoils in Alabama and southern sections, often with herbaceous legumes or in alternate rows with nitrogen-fixing trees. Ultimate uses may be forest products, aesthetics and screening, and wildlife cover and food. Plantings/seedlings require site preparation; removal of plant competition; proper selection and care of planting/seed stocks; seeding/planting; exclusion of grazing for first few years (always on critical sites); soil amendments/fertilizers; topsoil replacement, grading, and stabilization; seedling recruitment/tree thinning; insect/disease/pest control; and total conservation and land use (3,5).

### ASSOCIATED SPECIES

Loblolly pine is often mixed with sweetgum (*Liquidambar* spp.); shortleaf pine (*Pinus echinata*); and southern red, post, blackjack, and water oak (*Quercus falcata*, *Q. stellata*, *Q. marilandica*, and *Q. nigra*); yellow poplar (*Liriodendron tulipifera*); pond and slash pine (*Pinus serotina* and *P. elliottii*); and laurel oak (*Quercus laurifolia*). Commonly seeded alone or with shortleaf pine (*Pinus echinata*) and adapted lespedezas (*Lespedeza* spp.) or European alder (*Alnus glutinosa*), which fix nitrogen and stimulate better growth (2).

### PESTS AND DISEASES

Limited damage by rabbits and hogs; more damage done by rodents consuming seed. Southern pine, black turpentine, and engraver beetles cause serious losses. Tip moths attack young plants. Heart and butt rots major causes of cull timber.

### IMPROVED VARIETIES

None. Seek improved provenance.

Virginia pine  
*Pinus virginiana*

Virginia pine (*Pinus virginiana* Mill.), a small tree 40 feet tall and 1 foot in diameter, has needle-leaves in twos, only 2 inches long, with cones similar to *P. echinata* but flatter-based. Grows on low fertility, dry sites and on old abandoned fields. Abundant producer of high germination seed. Natural range: New York and Pennsylvania to southern Ohio, south to northeast Mississippi, south along Atlantic Coast to South Carolina/Georgia boundary. Most common pine used on minesoils in Eastern U.S. Tolerant of dry and acid minesoil types. More commonly planted as 1-0 seedlings than seeded; plantings in Eastern Interior and Western Interior Coal Provinces permit invasion of hardwoods after 15 to 20 years. Used for pulp and Christmas trees; makes high value wildlife food and cover when planted in strips or blocks alternating with herbaceous or other woody plants.

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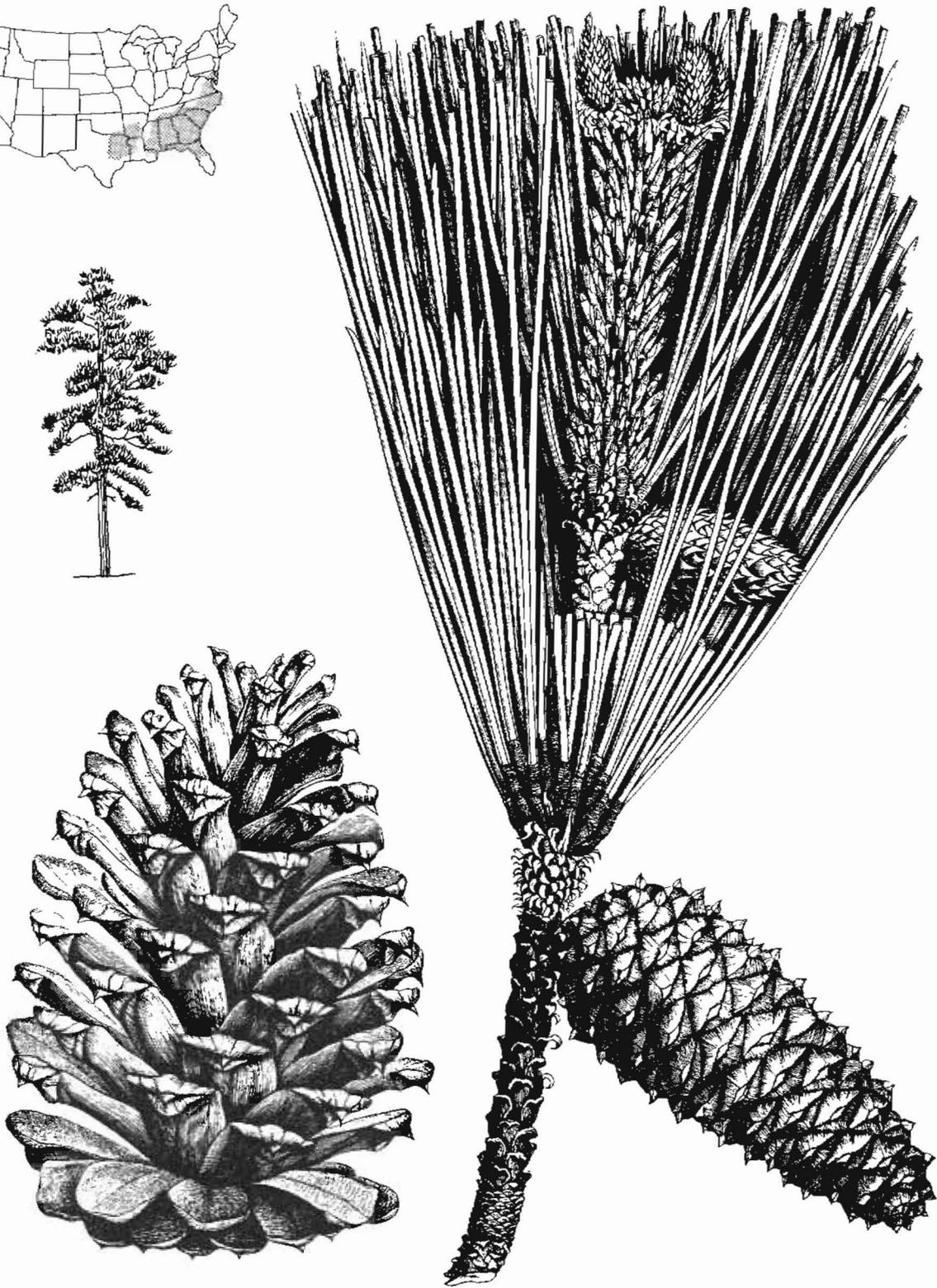


Figure 94. Loblolly pine (*Pinus taeda*). Twig with needles and closed cones x 2/3; cone x 4/5.

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## QUAKING ASPEN

*Populus tremuloides* Michx.

### ORIGIN

Native to cooler, moist, northern and western mountain area. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small to medium-sized, short-lived, deciduous tree.

Trees 20 to 50 feet tall, 0.5 to 2 feet diameter, clear trunks with loosely rounded crown and thin, smooth, chalky white bark, becoming gray and furrowed near base in age. Leaves simple, alternate, suborbicular, with pointed apex and rounded to cordate base, serrate margins attached to flat petiole that causes blade to flutter. Flowers inconspicuous in pendant aments, pistillate longer with red stigmas, maturing gray, hairy seeds in narrow ovate capsules (1).

Plants with extensive and mostly shallow roots, spreading by underground runners and readily root sprouting after cutting or fire. Flowering March to May, before the leaves, and maturing seed May to June or later at highest elevations. Palatable to livestock and big game; wood consumed by beaver; provides excellent watershed and wildlife cover and specialized wood products (1,2).

### ECOLOGICAL RELATIONSHIPS

Species grows in soil of most textural classes; more productive in deep, well-drained, medium-textured sandy loam to silt loams and least well adapted to coarse sands and dense clays. Thrives in sites with water table between 1.5 and 5 feet below surface and with higher calcium, magnesium, potassium, and nitrogen supplies. Grows in moderately basic to weakly acid soils and contributes to increased nitrogen supply by leaf drop. Regional strains and ecotypes adapted to wide moisture range from 7 inches MAP in interior Alaska, to the 25 to 40 inches MAP zones in the Midwest and Northeast, and to about 15 to 30 inches zones in the Rocky Mountains. Tends to occur on south-facing exposures at upper elevation and on north-facing slopes or along drainages at lower elevations. Cold-hardy but inflorescences sometimes killed by late spring freezes, indicating need to seek adapted seed or planting stock. Plants grow near sea level and close to upper timberline in western mountains. Shade-intolerant but a pioneer casting shade for tolerant species to succeed it. Good fire-tolerance; when infrequently burned, sprouts and becomes denser. Fair grazing/browsing tolerance; vegetative reproduction frequently suppressed by grazing/browsing and intense repeated defoliation of sucker sprouts of cutover stands partially kills and thins stands (1,2,3).

### CULTURE

#### Planting Depth, Rate, and Time

In nursery practice, seed is sown on the soil surface, not even rolled or packed in, sprayed with water with fine spray until seed fixed to soil, then shaded and kept moist for 1 month until seedlings well started. Rates of seeding are adjusted by seed quality to produce a prescribed or desired seedling density in the nursery, usually 100 or more per square foot. Seed is either planted fresh due to specialized storage necessary to retain viability or deferred until later fall or spring or just before the start of the moistest growing season. Nursery grown seedlings uncommonly planted in early spring for landscaping or for control of disturbed lands. Young wildings or root cuttings also can be used for small projects but transplanting is considered uneconomical with present state of the art. Rarely, tractor mounted shovels or front end loaders are pushed into edges of aspen groves and young plants thus transplanted for aesthetics and soil stabilization purposes (4).

#### Seed Cleaning and Quality

Branches with nearly mature catkins can be collected and placed in a warm greenhouse or room until capsules open or catkins can be picked from trees when seeds turn a light straw color. Place catkins in screens or pans in thin layers until seed is shed. Seed can be separated from hairs by using an air stream to

force seeds through a set of screens (20, 20, 40, and 60-mesh). Dry seed slowly at 70° F over a 3-day period. Seed quality not standardized: purity approaches 100 percent, depending on thoroughness of cleaning; germination not detailed but isolated tests to 97 percent; and 3,600,000 seed per pound (one test only) (4).

#### Germination and Seedling Characteristics

Best germination reported from 84° F and 89° F temperatures but sturdier seedlings reported from those germinating under 41° F to 84° F regimes. International rules of testing call for alternating 68°/86° F regimes with light, first counts at 3 days and final count at 14 days. Seed retains good viability for at least 1 year when stored at 41° F. Germination is epigeal. Aspen seedling and tree growth is considered rather rapid (4).

#### MANAGEMENT

Chief current use largely for landscaping in near-mountain towns and rest stops and parks. Species considered promising for high altitude revegetation and wildlife habitat improvement and of lower potential for critical site stabilization and roadside planting, probably partly due to its high palatability. Seedlings transplanted in mountain sites may need to be mulched and irrigated until well established. Reduction of plant competition, exclusion of livestock, and control of game and small mammal populations until stands firmly established and subsequent balancing of grazing/browsing pressure with conservative forage supplies are essential management features in a total land-use, sustained yield management program (5).

#### ASSOCIATED SPECIES

Species grows best alone but is mixed with bristlecone pine (*Pinus aristata*), Rocky Mountain Douglas-fir (*Pseudotsuga menziesii glauca*), blue spruce (*Picea pungens*), lodgepole pine (*P. contorta*), Engelmann spruce (*P. engelmannii*), and subalpine fir (*Abies lasiocarpa*) in western mountains and with several firs (*Abies* spp.), spruces (*Picea* spp.), and pines (*Pinus* spp.), as well as many hardwood species, in Northcentral and Northeastern States. Usually planted alone in small groups, colonies, or stands but can be used advantageously in rows, strips, or blocks with grasses, forbs, and shrubs.

#### PESTS AND DISEASES

Small and large mammals sometimes girdle or chew off seedlings or sprouts; elk bite the bark and rub their antlers, making an entrance for fungi. Cutworms, shoot dieback, and willow shoot sawfly attack suckers. Wood rotting fungi and cankers are pathogens of economic significance. The poplar borer and the forest tent caterpillar cause serious damage.

#### IMPROVED VARIETIES

Essentially none. Species is very polymorphic with distinct ecotypic, geographic race, and even clonal differences. Some hybrids are good seed producers, fast growing, and resistant to certain diseases; e.g., *P. tremuloides* x *P. tremula*.

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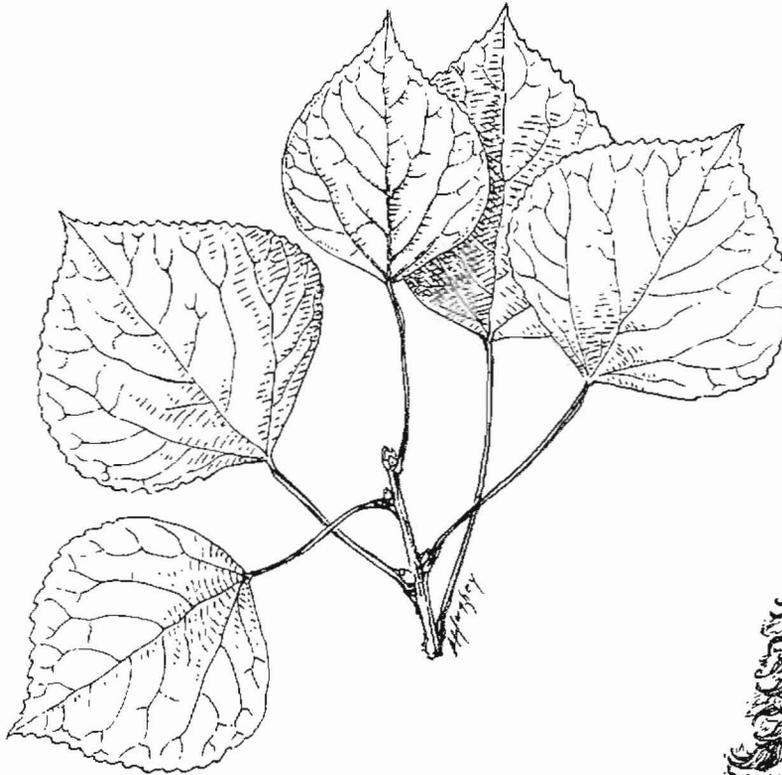


Figure 95. Quaking aspen (*Populus tremuloides*). Twig with leaves x 1; pistillate catkins with cottony fruit x 1.

## DOUGLAS-FIR

*Pseudotsuga menziesii* Franco

### ORIGIN

Native to 11 western conterminous States and Alaska. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Medium-sized, evergreen tree.

Var. *glauca*, Rocky Mountain form discussed here; up to about 130 feet tall and 3 feet diameter, with symmetrical conical crowns, variable branching from ascending to gracefully drooping, and thick gray-brown bark, developing blisters in youth and ridges separated by furrows in age. Leaves dark green to blue-green, single, needlelike, flattened, blunt-tipped, spirally arranged and with short petiole. Flowers monoecious; male orangish in diminutive stroboli; pistillate in green, streaked with red conelets, maturing into dark brown, pendent, ovoid cones 2 to 3 inches long, with distinctive three-forked bracts exerted beyond round-tipped scales, and producing winged nutlet seeds (1).

Plants with extensive lateral spreading root systems; windfirm if not overthinned. Flowers April to June and matures cones first season, late July to September. Palatability usually low to livestock with adequate herbage and other browse, but younger plants occasionally browsed, especially by sheep; also browsed by big game, much more in winter, and cambium sometimes stripped by bear; provides food and cover for wildlife, watershed cover, and valuable wood (2).

### ECOLOGICAL RELATIONSHIPS

Adapted to moist, well-drained, shallow to deep soils, varying from coarse rocky, gravelly, and silty, to often medium-textured soils, moderately acid to neutral in reaction. Intolerant of soil salinity and much alkalinity. Taxon grows at elevations between 2,000 feet and 10,000 feet and progressively higher from north to south in the Rocky Mountains. Usually somewhat confined to north-facing or shaded exposures at lower and warmer elevations. Plants exhibit great variation in growth rate, form, foliage, and quality. Seed source or planting stock should be obtained locally or nearby from improved or tested provenance. Well adapted in the 16 to 25 inches MAP zones and moderately drought-tolerant beyond the seedling stage. Intermediate in shade tolerance and often occurs intermixed with aspen and conifers but also in pure stands. Not very fire-tolerant; older plants somewhat tolerant due to thick bark but greatly injured; saplings and poles are usually killed. Repeated browsing stunts and deforms reproduction and sometimes kills seedlings but light grazing benefits stands by reducing competition. Advanced reproduction fairly tolerant of shearing and shaping in Christmas tree plantations. Plants fairly competitive past the advanced reproduction stage, except to dense overstory species (2,3).

### CULTURE

#### Planting Depth, Rate, and Time

In nurseries, stratified seeds are drilled 1/8 to 3/4 inch deep in spring despite natural stratifying effect of fall sowing, due to hazards of frost heaval, winter kill of early germinates, rodent/bird losses, and logistic problems. Avoid exposing stratified seed to drying when handling in air and in dry nursery beds; exposure to 3 weeks of drying reverses stratification effects. Adjust seeding rate to obtain desired seedling density in nursery, often about 25 to 30 seedlings per square foot ideal but fewer desired when growing older stock (e.g., 2-0 or older). About 50 percent of viable seed develop seedlings in nurseries; hence, plant 50 to 60 PLS per square foot. Reforestation guides for the Southwest recommend rates of 1,700 to 4,800 good seed per acre for spot seeding; 10,000 to 12,000 for drill seeding; and 16,000 to 48,000 for broadcast seeding on moist, well prepared sites. Such direct seedings are made only with most favorable site conditions in Rocky Mountain-Intermountain areas. Seedlings are made just before the moistest growing season; during last half of June in the Southwest. Planting of nursery or containerized stock commonly done for windbreaks, landscaping, and reforestation (3,4).

## Seed Cleaning and Quality

Pick ripe cones when seed coats turn golden-brown and detach intact from their bract, from standing or felled trees, and from squirrel caches during good crop years. Store loosely bagged seeds in dry, well ventilated place only up to 3 or 4 months. Kiln dry cones at 90° to 110°F for 2 to 48 hours until cones open. Extract seeds from cones by tumbling dried cones; screen-separate seed from scales, dirt, and debris; dewing seed in a dewinger and fan or blow product. Avoid overprocessing in dewinger, particularly with much coarse material like cone scales. Seed quality recommended for commercial uses: 90 percent purity; 70 percent germination; 63 percent PLS; number of seeds per pound varies by sources: AZ, 32,000 per pound; CO, 39,000; and interior B.C., 44,000 (5).

## Germination and Seedling Characteristics

Nearly three-fourths of viable seed germinate in 9 to 12 days in lab testing; some seeds continue to germinate for 30 days. Prechilling is not prescribed by the International Seed Testing Association but often done routinely for var. *glauca*. Growth rate is rated moderately fast (5).

## MANAGEMENT

Rocky Mountain Douglas-fir used for mountain windbreaks, reforestation, Christmas tree plantations, and landscaping. Mostly seedling or container stock planted; less commonly some direct seeding employed on favorable sites. Site and/or spot microsite preparation, reduction of plant competition, exclusion of livestock, control of rodents and/or use of repellants, proper selection of planting/seeding stocks, proper care of stocks and planting/seeding practices or monitoring contract work, conservation land management/use practices designed for sustained yield, and total land use are important considerations (3,4).

## ASSOCIATED SPECIES

Taxon occurs in pure stands and in mixtures with ponderosa pine (*Pinus ponderosa*), Western larch (*Larix occidentalis*), grand fir (*Abies grandis*), white fir (*A. concolor*), western white pine (*P. monticola*), lodgepole pine (*P. contorta*), Engelmann spruce (*Picea engelmannii*), quaking aspen (*Populus tremuloides*), and subalpine fir (*A. lasiocarpa*). Can be planted alone or in mixtures with other adapted conifers and hardwoods, the species varying in region, elevation, and site.

## PESTS AND DISEASES

Rodents and browsing animals threaten planted seed and plants. Spruce budworm and Douglas fir beetle are important enemies. Douglas fir dwarf mistletoe and a needlecast are damaging diseases.

## IMPROVED VARIETIES

None. Great range in branching, growth rate, foliage, and color should permit improvement by selection and breeding.

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Figure 96. Douglas-fir (*Pseudotsuga menziesii*). Twig with needles and cone of var. 'menziesii' x 1 (x 1/2 for cone of var. 'glauca').

## BUR OAK

*Quercus macrocarpa* Michx.

### ORIGIN

Native to Northcentral United States and Eastern Great Plains south to Texas. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Spreading, medium-sized, deciduous tree.

Massive bole, often 3 to 4 feet or larger diameter; low, stout branches up to 100 feet tall, often less; broad, round, open crown, corky twigs, and thick, ridge and furrowed, graybrown bark. Leaves with five to nine-rounded lobes, deeply incised in the middle, almost in two; obovate oblong and brighter green above. Staminate flowers small, in clustered, pendent catkins; pistillate solitary to few in leaf axils. Fruit an acorn up to 2 inches long, 1/2 to entirely enclosed in a distinctive fringed ("mossy") cup (1).

Trees often stump sprouting; roots deep and extensive; those of seedling with a deep tap root. Plants flower April to June from south to north, shortly after leaves appear; acorns ripen August to November. Provides valuable food and cover for wildlife and watershed protection, as well as valued wood and landscape aesthetics (1,2).

### ECOLOGICAL RELATIONSHIPS

Species tolerant of broad spectrum of soil physical and chemical properties: thrives on moist flats and hummocky first and second bottoms along the Ohio River; occurs on shallow uplands in coarse soils derived from limestone and other sedimentaries; often on bluffs and at edge of dry prairies in northern and western edges of its range. Common on medium to somewhat coarse-textured soils, but occasionally on clays. Adapted to acid (lower pH limit is 4.0) to moderately basic and mostly nonsaline soils. Grows in the over 15 inches to 40 inches MAP zones and thrives in the 30 to 40 inches zones. Height and volume related to both MAP and site, as well as genotype. Rather drought-tolerant, particularly northwestern strains and seedlings. Intolerant of permanent flooding; seedlings often killed by growing season floods. Local plant/seed sources generally cold-hardy but sometimes frosted by out-of-season late freezes. Seek sources within 100 miles of planting site and as similar in site characteristics as possible. Bur oak very tolerant of city smoke, more so than most tree species. Large trees are relatively fire-resistant and the species also is relatively insect and disease-resistant. Intense livestock grazing that compacts soils rarely interacts with drought, causing some mortality. Moderately intolerant of shade and often succeeded by tolerant hardwoods. Vigorous root development of seedlings makes it competitive with prairie grasses, accounting for its often behaving as a pioneer in prairie margins (1,2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

Plant acorns 1/2 to 1 inch deep. Spot seed, using 2 to 3 acorns per spot and as many spots as the desired tree density: e.g., 900 to 1,000 per acre (6 foot by 6 foot by 7 foot spacing) is recommended. Acorns are planted in the fall in the Western Interior Coal Province. Nursery grown 1-0 and 2-0 stock is planted in the northern and drier sections or on difficult sites to revegetate. Nursery stock is grown by drilling or broadcasting and covering acorns 1/4 to 1 inch deep at a rate sufficient to produce 10 to 35 seedlings per square foot. Fall sown beds are mulched until spring germination starts. Nursery stock is set out in late winter or early spring, terminating by April 15 in southern and central regions and by May 15 in northern regions (3,5).

#### Seed Cleaning and Quality

Collect ripe acorns from ground before they start germinating or shake them from branches onto canvas or plastic sheets. Separate sound acorns from cups and debris by hand or floatation. Seed quality not standardized: purity dependent on cleaning effectiveness, up to 100 percent but often less; average germination 45 percent; and seeds average 75 per pound (5).

### Germination and Seedling Characteristics

About half of the viable seed germinate in 28 days in the lab and remainder by 40 or 45 days. Germination in hypogeal and the cotyledons remain in the seedbed. Although not dormant, acorns are pretreated by cold-moist stratification for 1 to 2 months prior to use and germination tests are run with acorns in sand at alternating 68°/86°F temperatures (5).

### MANAGEMENT

Species seeded and also planted in the Western Interior Coal Province (Missouri, Kansas, Oklahoma); one data set shows 24 percent survival and 28 foot height at 30 years from direct seeding vs. 39 percent survival and 29 foot height from planting. Also used elsewhere in the coal regions, particularly in the Northcentral and Northern Great Plains regions, as well as in the Western Interior Coal Province, for minesoil or mine spoil reclamation, wildlife food, forest products and landscaping, sometimes including city street plantings (e.g., in Minneapolis). Plan and prepare planting/seeding sites carefully, including restoring topsoil and grading. Applying necessary fertilizers and soil amendments; removing plant competition; excluding livestock; controlling small mammals (rodents/rabbits/etc.); carefully selecting and handling planting and seeding stock, seeding and planting operations or monitoring contracts, including planting patterns and methods; and recruitment and thinning to optimize survival, site stability, production, and products and benefits are essential considerations (4).

### ASSOCIATED SPECIES

Bur oak grows in mixtures with quaking aspen (*Populus tremuloides*); black ash (*Fraxinus nigra*); red maple (*Acer rubrum*); shellbark and bitternut hickories (*Carya laciniata* and *C. cordiformis*); American elm (*Ulmus americana*); white ash (*Fraxinus americana*); hackberries (*Celtis* spp.); lindens (*Tilia* spp.); eastern cottonwood (*Populus deltoides*); and northern red, northern pin, white, and swamp white oaks (*Quercus borealis*, *Q. ellipsoidalis*, *Q. alba*, and *Q. bicolor*); and a great variety of undercover shrub and herb species. Reportedly grows well in mixtures with black locust (*Robinia pseudoacacia*) and many other species (2).

### PESTS AND DISEASES

Relatively resistant to insects and diseases. June beetles, variable oak leaf caterpillar, and bur oak kermes attack foliage and twigs. Cotton root rot, canker, dieback, and Armillaria root rots occasionally debilitating diseases. Acorns consumed by squirrels, deer, wood duck, and rodents (2).

### IMPROVED VARIETIES

None. Look for superior stock. Botanical var. *olivaeformis*, a northern form with acorns about half the size of the species', often germinates in spring in contrast to usual fall germination of prevailing nondormant southern sources. Leaves also are smaller and less deeply lobed. Occurs on drier sites. It has been suggested that this northwestern form has resulted from past hybridization with *Q. gambelii* and should be a new taxon, *Q. mandanensis*.

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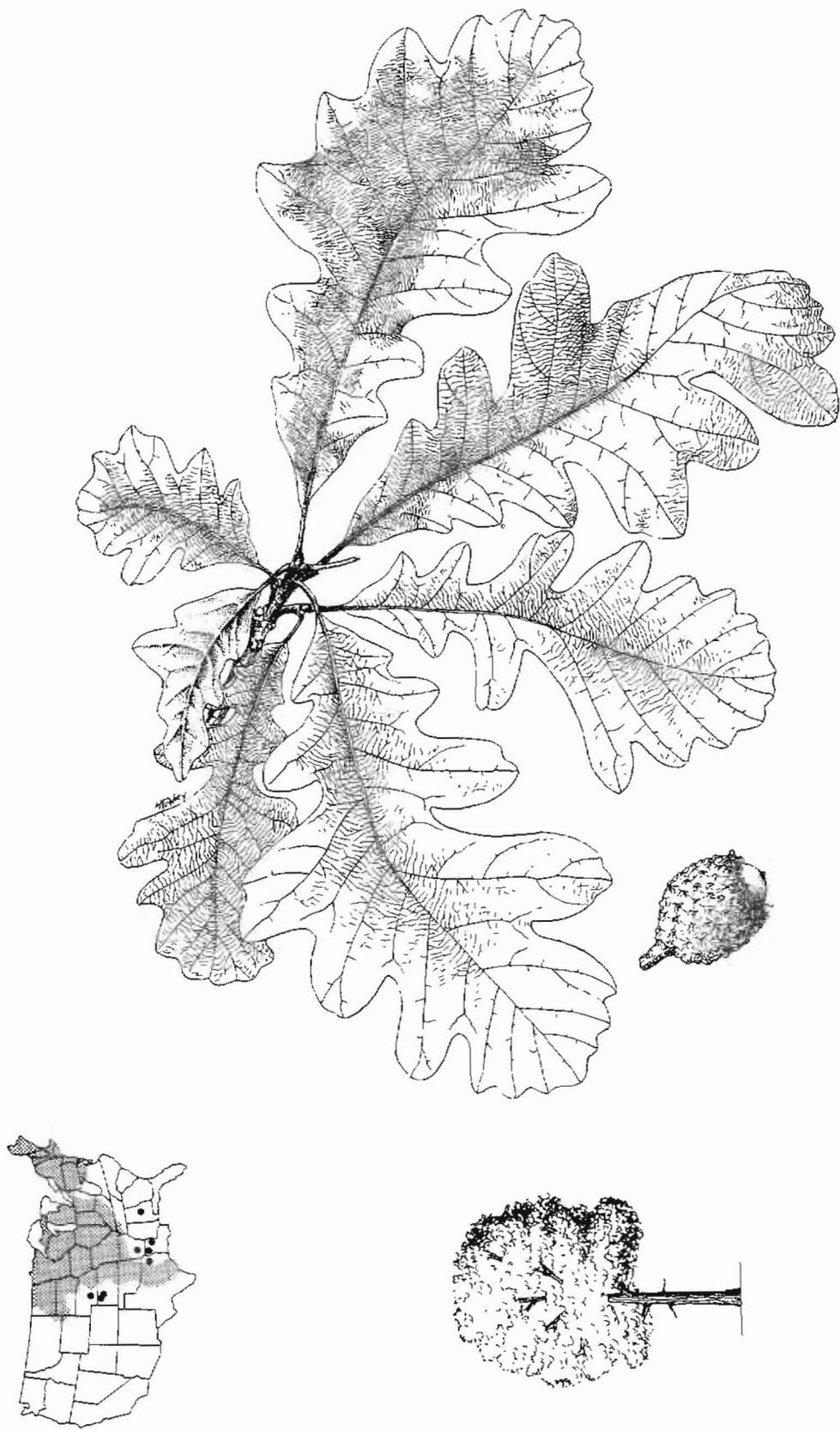


Figure 97. Bur oak (*Quercus macrocarpa*). Twig with leaves x 1/2; acorn x 1.

## BLACK WILLOW

*Salix nigra* Marsh

### ORIGIN

Native of the Eastern United States. See map for distribution in the U.S.

### SPECIES CHARACTERISTICS

Small to large, short-lived, deciduous tree.

Willow as tall as 100 feet, with 3 foot trunks, often divided, broad open crowns, stout branches, and gray-black deeply furrowed and thickly-ridged bark. Leave simple, lanceolate, 3 to 6 inches long, finely serrate with lustrous upper and paler lower surfaces. Flowers inconspicuous in aments, the staminate somewhat leafy, and pistillate bearing hairy-tufted, minute seed (1).

Roots shallow and extensive. Young plants readily sprout and easily propagated by stem cuttings. Plants flower February to April in South and as late as May to June in northern areas; flowers appear before the leaves. Seeds ripen and fall April to July. Palatability fair for livestock and deer when foliage within reach, particularly in heavily stock woodlots. Plants provide wildlife and watershed cover, aesthetic screening, and wood products on better wetland sites (1,2).

### ECOLOGICAL RELATIONSHIPS

Species tolerant of any soil texture if constantly provided with enough moisture, typically that found in wetlands. Tolerant of flooding and high water tables. Thrives in over 50 inches MAP zones or where the equivalent found along stream and lake edges in the over 30 inches MAP zones. Not drought-tolerant and whole stands die out when water tables lower and habitats dry up. Commonly found in moderately acidic (lower pH limit is 4.5) to near-neutral soils/sediments. Weak wood structure and roots shallow, resulting in much breakage and windthrow on looser and wetter sites with age. Seed crops sometimes nil after late spring frosts, suggesting likelihood of poorer adaptation by importing stock beyond its natural range. Shade-intolerant when mixed with tolerant hardwoods. Pure stands often stagnate unless thinned periodically. Trees somewhat tolerant of grazing and browsing but reproduction and young plants killed or malformed. Some fire tolerance due to sprouting habit but fires injure and make wood subject to fungal decay (1,2,3,4).

### CULTURE

#### Planting Depth, Rate, and Time

In nurseries, seed are broadcasted on well prepared beds and lightly packed with a roller. Rate is adjusted for seed quality to give the desired seedling density. Seed must be planted immediately after collection due to lack of dormancy and very rapid loss of viability in storage. Reclamation projects now use some nursery grown planting stock for drier and leveler sites with trafficability for equipment. Until recently, and even now, much land is planted by using stem cuttings or rootstocks from young established plants, usually 1 to 3-years old (5).

#### Seed Cleaning and Quality

Collect willow seed by picking capsules from trees as quickly as they ripen — when capsule color turns yellowish. Some seed can be collected along banks of streams. Normally seed need not be separated from opened capsules. Seed lose viability rapidly, usually after 10 days at room temperature; only refrigerated storage of moistened seed is advisable for as long as 1 month. Commercial seed is not usually available. No seed quality data are on record (5).

#### Germination and Seedling Characteristics

International Seed Testing Association prescribes alternating 68°/86°F temperatures for germination testing: 7 days for germinative energy and 14 days for germinative activity. Germination is epigeal.

Germination and growth are rapid and seedlings 4 feet tall at the end of first year growth and 50 feet at end of 10 years occur in favorable sites, particularly along the lower stretches of the Missouri River (5).

## MANAGEMENT

Species meets need for material to use in very unique but potentially erosive habitats of stream and lake edges and periodically flooded lands. Considerable ingenuity required to apply principles of good artificial planting and mangement: total land use planning; site preparation; grading and topsoil replacement; applying necessary fertilizers and soil amendmets; removal and control of plant competition; selection and procurement of adapted planting/seeded stocks; care and timing in seeding/planting, including monitoring contracts; obtaining plant recruitments and early thinning; and adoption of conservative management and utilization practices (3,4).

## ASSOCIATED SPECIES

Associates of black willow include eastern cottonwood (*Populus deltoides deltoides*), black spruce (*Picea mariana*), river birch (*Betula nigra*), American sycamore (*Platanus occidentalis*), pond baldcypress (*Taxodium ascendens*), common baldcypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), red maple (*Acer rubrum*), red mulberry (*Morus rubra*), boxelder maple (*Acer negundo*), and other lesser vegetal species. Black willow is usually planted alone; in variable site situations, it may be planted with some of the above species in a pattern that harmoniously fits site adaptations with use objectives (2).

## PESTS AND DISEASES

Sapsuckers degrade lumber by feeding on inner bark. Cottonwood leaf beetle and willow sawfly defoliate. Top and branch rots result in cull wood. Leaf rust, fungus scab, and black canker affect seedings and cause leaf and shoot destruction (2).

## IMPROVED VARIETIES

None. A hybrid of *S. nigra* x *S. amygdaloides* is recognized.

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Figure 98. Black willow (*Salix nigra*). Branch x 1/2; pistillate catkin x 1 2/3; capsule fruit x 13.

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