Plant Fact Sheet

CALIFORNIA BROME

Bromus carinatus Hook. & Arn.

plant symbol = BRCA5

Contributed by: USDA NRCS Plant Materials Center, Corvallis, Oregon

Dale Darris
USDA NRCS Corvallis PMC

Alternate names: Some taxonomic treatments include mountain brome (*Bromus marginatus*), (*Bromus carinatus* var. *marginatus*) and others. Consult the Flora of North America, Volume 24 (2007) and Intermountain Flora, Volume 6 (1977).

Uses: California brome is a medium-tall, competitive, native bunchgrass valued for its rapid and easy establishment in revegetation and erosion control. It is also widely used for rehabilitation after wildfires and mining, rangeland improvement, and restoration of upland plant communities. This species is considered to be a moderately to highly productive, nutritious, and palatable forage relished by all classes of livestock prior to maturity. In some ranges it is important summer forage for elk, but considered less palatable to deer. Bear, geese, and various rodents also consume the foliage. The deep fibrous root system makes the plant fairly resistant to grazing and drought. While a good range grass, used alone it may not be suitable for permanent pasture because of its short longevity. One of the better uses of California brome may be as a native competitor to aid in the reduction of exotic weeds a year or two in advance of planting other native grasses. California brome provides good cover for wildlife and the seed is consumed by small mammals and game birds. It is sometimes recommended as a cover crop for vineyards and orchards in California.

Description: California brome is a native, cool-season, annual, biennial, or short-lived perennial bunchgrass. It is a highly variable species. The base of this robust plant is very open with coarse, erect to spreading stems (culms) that grow 45-120 cm tall. Leaf blades are 1-12 mm wide, lax and spread out along stems. The inflorescence (seed head , panicle) is 10-30 cm long, large, open, and erect to somewhat drooping. The root system is deep and widespread.

Key to identification: California brome intergrades with mountain brome and some authors classify both as the same species. Other species are also very difficult to distinguish from California brome so a current taxonomic key should be consulted. Sitka brome (*Bromus sitchensis*) is a good example and their natural habitats overlap considerably. Both occur in full sun, but Sitka brome can also be found in somewhat shadier environments. According to some taxonomists, Sitka brome is taller with broader, more drooping panicles and spikelets (subunits of the seedhead) that occur more toward the tip of the branchlets compared to California brome. Pacific brome (*Bromus pacificus*) can also be confused with both bromes, but its leaves are soft hairy (on at least one side) and it has other distinguishing features. Pacific brome occurs mainly along the Pacific Coast in moist habitats but extends inland to the Puget trough of Washington at low elevations.

Adaptation: California brome is widely distributed in western North America from British Columbia and Alberta south to California and Mexico and eastward to Montana, Wyoming, Colorado, and New Mexico. It occurs in open areas including meadows, coastal prairies, montane slopes, and waste places as well as open woodlands, oak savanna, sagebrush, and chaparral from sea level to 11,000 ft in elevation. The species is adapted to moderately moist to dry soils with a pH of 5.5 to 8.0. While tolerant of somewhat poor drainage and fine textured clays, best growth is attained on medium-textured or loamy soils with good drainage. It is found in environments with

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Contributed by: USDA NRCS National Plant Data Center & California Plant Materials Center

F. Ballerini 2008

Alternate Names

Big brome, California brome grass, California Bromegrass, California brome.

Uses

Ethnobotanic: The seeds of California brome were feared by the Native Americans to be poisonous if swallowed. However, they were often dried and ground into flour to make bread and other foods.

Livestock: California brome is an important forage species for livestock throughout its growing season. It is sometimes planted as pasture grass.

Restoration: California brome is considered a pioneer species as well as a late seral species under open canopy/full sun situations. The grass is noted for its rapid establishment of deep roots and good soil stabilizing capabilities which make it valuable for revegetation and erosion control in disturbed areas such as rangeland sites, spent oil shale, coalmine spoils, heavy metal mine tailings, and roadsides. It is also well-suited for side-slopes and back-slopes because it can withstand periodic drought once established.

It is effective in improving water infiltration and has been used successfully on waterfront sites.

Wildlife: Elk, grizzly bear, geese, squirrels, pocket gophers, and other rodents consume California brome plants. Birds consume the seeds. California brome also provides good cover for small mammals, small non-game birds, and upland game birds.

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Weediness

The Western Society of Weed Science has listed California brome as having invasive characteristics. This plant may become weedy or invasive in some regions or habitats and may displace desirable vegetation if not properly managed. Please consult with your local NRCS Field Office, Cooperative Extension Service office, or state natural resource or agriculture department regarding its status and use. Weed information is also available from the PLANTS Web site at plants.usda.gov.

Description

General: Grass Family (Poaceae). California brome is a native, cool-season perennial bunchgrass that lives 3 to 5 years and grows to be 60 to 120 cm tall. The roots of California brome are fibrous, grow very quickly, and become deep and widespread. Young plants are erect, but older stems grow along the ground with only the apical tips remaining erect (decumbent). Stems are robust with hairy sheaths. Leaf blades are 0.5 to 1 cm wide and 15 to 30 cm long. They can be pubescent or glabrous. The inflorescence is a stiff, open panicle, 10 to 20 cm long and droops at maturity. The spikelets are 5 to 7 flowered, 2 to 4 cm long, 5 to 7 mm wide and flattened. Lemmas are 1 to 1.5 cm long, flattened, keeled and usually pubescent. The awns are 2 to 5 mm long. Seeds mature in May and June at low elevations and by late August at high elevations.

Distribution: California brome occurs from Alaska east to Ontario and south to Illinois, Texas, California, Baja California and northern Mexico. It is native from the Pacific Coast to the Rocky Mountains and is casually introduced in the Great Plains. For current distribution,

please consult the Plant Profile page for this species on the PLANTS Web site (http://plants.usda.gov).

Habitat: California brome grows in open woods and forests, shrublands, grasslands, meadows, and waste places. It is closely associated with pine dropseed, bracken fern, corn lily, dwarf purple monkey flower, mountain muhly, and Rocky Mountain iris and shares dominance in many plant communities such as coastal prairie, both montane and coastal Chapparal scrub, sagebrush steppes, aspen, oak woodland, and variously mixed conifer forests.

Adaptation
California brome grows well in a variety of soils including poorly drained types. It is most abundant in moderately moist, well-developed, deep, medium-textured soils. It tolerates soils in the pH range of 5.5 to 8.0. It occurs in bottomlands, mountain slopes, valleys, and ridge tops, up to elevations of 4,000 m. It requires nearly full to full sunlight.

Management
Several herbicides are labeled for control of perennial grasses. Effective control of California brome requires careful attention to growth stage of the plant, proper timing of applications, using labeled rates which will consistently achieve desired results and responsible rotation of methods and materials used to manage the undesirable plant. Herbicides differ considerably in their non-target vegetation impact, volatility and residual carryover. Always read the label before applying any herbicide.

It is reduced by heavy grazing and favored in moderate to light grazing. Sheep are more likely to kill plants by trampling them rather than overgrazing. Cattle are more likely to overgraze than trample the plants.

California brome is top-killed by fire, but appears to recover within a few years. It can sprout from surviving root crowns as early as the next growing season. Coverage of California brome is slightly reduced from pre-fire levels for several years after fire, then returns to pre-fire levels. It is sometimes seeded in after fire to help stabilize soil.

Pests and Potential Problems
California brome is sometimes prone to stem rust, head smut, leaf rust, and leaf spot.

Seeds and Plant Production
Seeds are collected between May and September depending on rate of maturation. Mature inflorescences turn from green-purple to brown and mature seeds are light brown-gray. Cleaning is not required for germination. Seeds should be stored in a dry, evenly temperate environment. Dry refrigeration is best for long term storage.

Under optimum conditions, *Bromus carinatus* germinates quickly from 0 to 1 ½ inches below the soil surface, with emergence generally occurring within 14-28 days. Some disagreement exists as to the optimum germination conditions; in general, the species responds to a dark period of 16-18 hours with corresponding temperatures between 59-68F and a light period of 6-8 hours with temperatures ranging between 68-86F. The species will vary somewhat based on local adaptation, but in general prefers available water of approximately 18 inches and little to no flooding or inundation. Available information suggests that *Bromus carinatus* does not persist in the soil seed bank, but readily germinates as conditions allow, exhausting reserves. Successful site establishment is most associated with a moderate level of site disturbance and substantial reduction in competition, especially for light, in addition to a favorable germination environment.

Cultivars, Improved, and Selected Materials (and area of origin)
California brome seed is readily available from commercial sources.

More information about USDA-NRCS plant releases may be found in the release notice available from your local NRCS office.

The following five germplasm releases were selected for phenotypic characteristics from an assembly of 28 accessions grown at three sites in California. Other locally-adapted germplasms may exist for your region; contact your local NRCS Field Office for details.

'Southern Cal 1000' Germplasm California brome (*Bromus carinatus*) was collected in 2006 in Orange County, California near Irvine Ranch at 1,000 feet elevation on silty clay soils in a purple needlegrass community. It is noted for its vigor, plant mass, and seed yield. It is recommended for use in southern California in MLRA 14d, 15d, 19 and 20.

'Central Coast 2600' Germplasm California brome (*Bromus carinatus*) was collected in 2006 in a location east of Los Olivos, California on Figueroa Mountain at 2,600 feet elevation on sandy clay soils in a blue oak grassland community. It is noted for its superior vigor, height, and seed yield. It is recommended for in California MLRAs 15d, 20, 22d, and 22e.

'Coastal 500' Germplasm California brome (*Bromus carinatus*) was collected in 2006 in San Luis Obispo County, California near Cal Poly Canyon at 500 feet elevation on sandy clay loam soils in a coast live oak grassland community. It is noted for its vigor, plant mass, and seed yield. It is recommended for use in California MLRAs 4c, 14c, 14d, 15c, and 15d.

'Northern Cal 40' Germplasm California brome (*Bromus carinatus*) was collected in 2006 near Point Pinole in Pinole, California at 40 feet elevation on silty clay loam soils within an annual grassland community. It is noted for its superior vigor, plant mass, early seed production, and seed yield amongst other coastal accessions. It is recommended for use in California MLRAs 14c, 14d, 15c, 15d, 15e, 16e, 17d, 17e, and 18d.

'Central Sierra 3200' Germplasm California brome (*Bromus carinatus*) was collected in 2006 in Yuba County, CA at Pike County Peak at 3,200 feet elevation on silty clay soils within a pine and fir community. It is noted for its superior vigor, plant mass, and seed yield amongst other higher elevation accessions within the trial. It is recommended for use in California MLRAs 18d, 22c, and 22d.

'Cucamonga' is recommended for erosion control and ground cover on droughty, low fertility grasslands. It can also be used for revegetation of disturbed areas, and wildfire land rehabilitation It is susceptible to head smut, which can be controlled with a mercuric fungicide. This cultivar was collected from a native stand near Cucamonga, California in 1939.

Control

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method.

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For more information about this and other plants, please contact your local NRCS field office or Conservation District at http://www.nrcs.usda.gov/ and visit the PLANTS Web site at http://plants.usda.gov/ or the Plant Materials Program Web site http://plant-materials.nrcs.usda.gov.

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USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Plant Fact Sheet

CALIFORNIA OATGRASS

Danthonia californica Bolander

Plant Symbol = DACA3

Contributed by: NRCS Plant Materials Center, Corvallis, Oregon

Alternate Names: Another common name is California danthonia. Synonyms include *Danthonia americana* and four botanical varieties: *americana*, *californica*, *palousensis*, and *piperi*.

Uses: California oatgrass is recommended for revegetation, wildlife plantings, and restoration of oak savannas, transitional wetlands, and upland prairies, especially in the Pacific Coast states. The species is valuable for enhancing biodiversity by exhibiting a spatial distribution compatible with forbs and improving habitat for feeding, nesting, and hiding by songbirds. It is a definitive component of certain prairies that form critical habitat for other endemic organisms including sensitive butterflies and beetles. The foliage is eaten by certain caterpillars and the grains are consumed by birds and mammals.

As a rangeland plant, California oatgrass is well utilized by livestock. Prior to maturity, it is rated as good to very good forage for cattle and horses in the Pacific Coast states, but less palatable for sheep and goats. Ratings are lower for eastern, drier portions of its natural range. Plants withstand heavy grazing but can be overgrazed leading to their depletion. Protein analysis is high and stands have formed that are dense enough for haying. Other potential uses include cover and erosion control in vineyards, young orchards, and parks, as well as along trails. As a candidate for native lawn, this species can be mowed to maintain a turf-like stand. It takes heavy foot traffic, trampling, and moderate summer moisture stress and can act as a stay-green firebreak.

Description: California oatgrass is a long lived perennial bunchgrass with stems (culms) that grow 30-100 cm tall and separate at the lower nodes (joints) upon maturity. The leaf sheaths are smooth to densely hairy. Leaves are both basal and attached to the stem. The upper blades are flat to in-rolled and spreading to abruptly bent with distinct spreading hairs where they meet the stem. The panicle (seed head) flowers between May and early July and is 3-8 cm long, loose, and open with 1-6 broadly spreading spikelets. Awns (linear appendages) on the seed are abruptly bent and 4-12 mm long. Seed is produced both in the terminal panicle and at the lower nodes enclosed (hidden) within the leaf sheaths of the stem. California oatgrass can be confused with timber oatgrass (*Danthonia intermedia*), poverty oatgrass (*D. spicata*), and one-spiked oatgrass (*D. unispicata*) but all three have more erect, compact panicles with the latter having a single spikelet in the seed head.

Adaptation: California oatgrass occurs naturally from British Columbia to southern California and eastward through the Rocky Mountain States and Provinces. Broadly adapted, it is a minor to dominant constituent of numerous woodland, shrubland, grassland, and transitional wetland habitats. The species is found on a wide array of soils types from excessively drained sandy loams to less permeable silts and clays and from relatively infertile sites to rich, moist bottomland. While it inhabits summer dry sites such as steep, sunny south and west slopes, shallow rocky outcrops, and serpentine soils (soils high in magnesium, iron, and

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certain heavy metals and deficient in other nutrients), as well as seasonally flooded wetlands, arid sites do not support it. The species occurs within the following ranges: elevation 0-7200 ft, annual precipitation 17 to 79 inches, and soil pH 5.5 to 8. Ratings are relatively low for fertility requirement, salinity tolerance, deer resistance, and shade tolerance, variable for drought resistance, and high for fire resistance and wildlife value. It has special adaptations for disturbance prone ecosystems.

Environmental concerns: California oatgrass is not considered to be weedy within its natural range. However, because of seed dormancy and latent seed in the soil, individuals may continue to sporadically emerge several years after stand removal. No toxic properties for domestic livestock, wildlife, or humans have been reported. The species has few significant pests but is one of many hosts for blind seed disease (*Gloeotinia temulenta*), a potentially serious pest in ryegrass (*Lolium* spp.) fields grown for seed.

Establishment: Growing California oatgrass from seed can be problematic as the result of delayed or sporadic germination and moderately slow seedling development combined with early competition from other species. The variable germination rates are the result of either a seed coat imposed dormancy, physiological (embryo) dormancy, no dormancy, or a combination of all three. To determine the amount of dormancy in a seed lot, both a TZ (tetrazolium) test for viability and germination test should be run. The difference between the two indicates the amount of dormancy. To overcome high dormancy, good germination will require fall sowing to cold moist stratify the seed outdoors over winter (alternatively, moist stratify in a cooler for 30-120 days at 1-4°F), scarification of the seed coat to weaken it, or both. Proven methods of scarification (sulfuric acid treatment, abrasion with sandpaper, use of a huller-scarifier or brush machine) each have their limitations. Hull removal (dehulling) and awn removal are coincidental to the process. Mechanical methods must be gentle enough to prevent damage to the seed embryo. An oat huller may be an option.

Keys to establishment for revegetation and other purposes are preplant weed control and proper seedbed preparation such as 1-3 years of fallow. Besides tillage and herbicides, site preparation methods and weed and stand management options include prescribed fire, grazing, mowing, or combinations thereof. The most successful stands are often achieved by sowing the seed alone rather than in a mix, succeeded by the use of a nonselective herbicide such as glyphosate to kill new weeds before the California oatgrass seedlings emerge following delayed germination. Very shallow soil coverage (1/4 inch or less) is critical because of the seed's light requirement. There are 90,000-165,000 seeds/lb depending on the degree of processing and natural variation. Each 1 lb of pure live seed (PLS) sown per acre results in 2-4 live seeds/ft^2. Sown alone, the suggested seeding rate for drilling is 9-15 PLS lbs/ac. The rate is doubled for broadcast seeding. A starter fertilizer is usually not recommended as it encourages excessive weed competition but a thin covering of mulch or jute netting is particularly useful on steeper banks. California oatgrass propagates readily by division. Plugs grown in standard potting media have worked better than direct seeding in many situations.

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Plant Guide

CALIFORNIA OATGRASS

Danthonia californica

Bolander

Plant Symbol = DACA3

Contributed by: USDA NRCS Plant Materials Center, Corvallis, Oregon

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Alternate Names

Another common name is California danthonia. Synonyms include *Danthonia americana* and four botanical varieties of *Danthonia californica:* var. *americana*, var. *californica*, var. *palousensis*, and var. *piperi*.

Uses

Restoration and wildlife habitat: California oatgrass is an important native constituent of drier upland and moist lowland prairies as well as open woodlands. Therefore, it is commonly recommended for revegetation, wildlife plantings, and restoration of oak savannas, transitional wetlands, and grasslands, especially in the Pacific Coast states where it is most common.

Native bunchgrasses like California oatgrass are valuable for enhancing biodiversity. Healthy stands can reduce invasion by exotic species yet exhibit a spatial distribution compatible with forbs (Maslovat 2001). Combined with other native grasses and forbs, California oatgrass improves habitat diversity for feeding, nesting, and hiding by songbirds (Oregon Department of Fish and Wildlife 2000), as well as other animals. The grains are eaten by small birds and mammals (Mohlenbrock 1992). Prairies with California oatgrass as a definitive species are also unique refuges for other endemic organisms. For example, the Ohlone tiger beetle (*Cicindela ohlone*) is an endangered (federally listed) predatory insect known only to five remnant stands of California native grassland in Santa Cruz County (Santa Cruz Public Libraries 2003). These rare grasslands, including the coastal terrace prairies, remain biodiversity "hotspots" and are considered in need of protection (Stromberg et al. 2001).

Forage: As a rangeland plant, California oatgrass is well utilized by livestock and certain wildlife. Prior to maturity, the species is rated as good to very good forage for cattle and horses in the Pacific Coast states, but less palatable for sheep and goats. Ratings are lower for eastern, drier portions of its natural range (USDA Forest Service 1988). Others claim it is palatable to all classes of livestock and a mainstay grass for range grazing in places like Humboldt County, California (Cooper 1960). California oatgrass withstands heavy grazing (USDA Forest Service 1988, Cooper 1960). However, it is also reported that animals seek out and overgraze individual plants sometimes leading to rapid stand depletion (Crampton 1974). This species can provide green forage year round in some areas. Under moderate grazing it stools readily, forms a "sod" (ie. the bunches coalesce), and can produce a substantial volume of high quality forage. Less desirable species diminish as the sod forms. Higher nutritional content and grazing preference make California oatgrass desirable in a management system over soft chess (*Bromus mollis*) (Heady et al. 1963). Protein analysis is high at 8 to 26 percent; the low point coming in January after the herbage has been leached by precipitation (Cooper 1960). This species has formed

stands dense enough for haying in California (USDA Forest Service 1988).

Pollinators: California oatgrass is used as food by the caterpillar larva of certain butterflies including two skippers (*Hesperia lindseyi* and *Hesperia columbia)* (Robinson et al. 2007). It is an important component of native grasslands that form critical habitat for other butterflies including the vulnerable Vancouver ringlet (*Choenonymphya tullia insulana*), Taylor's checkerspot (*Euphydryas editha taylori*) (Chappell 2006), and the endangered Fender's blue butterfly (*Icaricia icarioides fenderi*) (Collins 2006).

Cover and turf: Other potential uses include cover and erosion control in vineyards, young orchards (Edminster 2003), grassy lanes, and parks, as well as along trails. As a candidate for native lawn, this species can be planted and mowed to maintain a turf-like stand in landscape settings or elsewhere (Wrysinski 2004, Daniels 2007, Amme 2003). California oatgrass persists along compacted hiking trails and takes heavy foot traffic, trampling, and moderate summer moisture stress. It also has potential as a stay-green firebreak (Edminster 2003, Fire Safe Council 2007).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Description

California oatgrass (family: Poaceae) is a slow establishing yet long lived, cool season (C_3) perennial bunchgrass of intermediate texture. Its stems (culms) grow 30-100 (10-130) cm tall and disarticulate (separate) at the lower nodes (joints). The leaf sheaths are smooth to densely hairy. Leaves are both basal and attached to the stem with the upper blades being 8-25 (10-30) cm long, flat to in-rolled, and spreading to abruptly bent. The ligule (at the throat of the leaf blade) is less than 1 mm and fringed with small straight hairs. Additionally, 1-3 mm long, soft spreading hairs appear at the leaf collar and throat (photo). Flowering occurs in May or June depending on location. The panicle (inflorescence) is 2-6 cm long, loose, and open with 1-5 (3-6) broadly spreading spikelets. Glumes are 14-18 mm long. There are 3-8 (5-10) florets (flowers) per spikelet (see photo). Lemmas are 5-10 (8-15) mm long, hairy along the margins with stiff awned teeth and an abruptly bent awn that is (4) 8-12 mm long (Darbyshire 2003, Hickman 1993, Hitchcock et al. 1969, Klinkenberg 2007).

California oatgrass
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Leaf blades often bend at a broad angle from the stem and hairs fringe or replace the ligule (var. *californica*). .Additional tufts of hairs appear at the leaf collar. Photo by Steve Matson used with permission.

Flowering and seed formation: California oatgrass produces seed from both open flowers that allow for cross-pollination and closed flowers that have obligate self-pollination. Its open pollinated flowers are referred to as chasmogamous and the seed they produce are chasmogenes (chasmogamic seed).

Closed pollinated flowers are cleistogamous and the seed they produce are cleistogenes (cleistogamic seed). The chasmogamous seed is produced in the exposed panicle and is sometimes referred to as terminal seed. In contrast, the cleistogamous seed is primarily found at the lower nodes of the flowering culm and typically remains enclosed in the leaf sheaths (Dobrenz and Beetle 1966, Campbell et al. 1983).

Spikelets are flattened with 5-10 flowers (florets) each. Photo by Steve Matson used with permission.

There are differences between chasmogamic and cleistogamic seed production. Sometimes referred to as hidden seed, cleistogenes are typically shorter or longer (narrower) and larger than seed from the inflorescence and some lack a developed lemma and palea (Dobrenz and Beetle1966). Most commonly, there are 3-4 spikelets per flowering culm and 5-6 florets per spikelet. However, a single lower node can bear 6-7 cleistogenes and there can be 5-6 such nodes per culm. Therefore, more hidden seed can be produced than terminal seed. Production of cleistogenes increases under grazing pressure (Dobrenz and Beetle 1966).

Seed coat characteristics may also differ between the two seed types as evidenced by contrasting germination responses to acid scarification reported by Laude (1949). Bruns (2005) found that seed set was lower in chasmogamous spikelets compared to cleistogamous spikelets and more maternal reproductive effort was put into cleistogamous seed production. However, chasmogamous seed had higher and quicker germination rates, as well as a higher rate of early seedling growth compared to cleistogamous progeny. In contrast, Weatherwax (1928) states there are no consistent differences in the two types of caryopses (naked seeds) and that both types germinate alike and seedling plants are alike in appearance and vigor through flowering.

By July or August after the panicle has matured and some of the terminal seed has shattered (fallen from the plant), the remaining culm will disarticulate (separate) at the basal node (Darris pers. obs.). Dispersal of remaining cleistogenes is probably aided by this process (Dobrenz and Beetle 1966). The dry stems with enclosed seed may wrap around the feet or limbs of passing animals (Darris pers. obs.).

Similar species: California oatgrass can be confused with timber oatgrass (*Danthonia intermedia*) which has a shorter stature, more erect, compact panicle branches, glumes that are longer than the flowers which are rarely visible, and hairless leaf sheaths. The panicles of poverty oatgrass (*Danthonia spicata*) and one-spike oatgrass (*Danthonia unispicata*) are also much narrower and therefore more spike-like, the latter having a single spikelet in the inflorescence (Stewart and Hebda 2000). The lemmas of California oatgrass are smooth along the back with hairs only at the margins while the lemmas of poverty oatgrass have hairs at both positions (Kozloff 2005).

Distribution: California oatgrass occurs naturally from British Columbia to southern California, east to Montana and Saskatchewan and south through the Rocky Mountains to New Mexico and Arizona. A form is also found in Chile (Hitchcock et al. 1969). For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Adaptation

General: California oatgrass has relatively broad adaptation and is considered a stress-tolerator. It occurs on a wide array of soil types from excessively drained sandy loams to less permeable silts and clays and from relatively infertile sites to rich bottomland. While the species occurs on more xeric sites such as sunny south and west slopes, adequate subsurface moisture or winter rains in milder climates are common themes. In California, arid sites do not support it; including the inner foothills of the Coast Range and Sierra Nevada foothills (Crampton 1974). Elevation range for the species is 0-2200 m (7200 ft) (Hickman 1993). Annual precipitation varies from 43 to 200 cm (17 to 79 in) in its natural range of habitats for the West Coast states.

California oatgrass is also found on serpentine soils of Oregon and California, suggesting that at least some populations or races are especially tolerant to drought, calcium and other key nutrient deficiencies, high magnesium, and high levels of certain heavy metals such as nickel. Serpentine soils are often shallow and rocky with low levels of silts and clays

(Brady et al. 2005). Based on soil types and site descriptions, California oatgrass appears to be adapted to moderately acid to alkaline soils (estimated pH 5.5-8).

Depending on region, the species is classified as a facultative upland, facultative, and facultative wetland plant. Fertility requirement is considered low as is salinity tolerance (USDA NRCS 2007). However, its common occurrence on coastal prairies and bluffs suggests some local resistance to salt spray. California oatgrass is rated low for drought resistance (8 on a scale of 1-10), relatively high for fire resistance (3), low for shade tolerance (8), high for wildlife value (2), and relatively low for deer resistance (7) (Fire Safe Council 2007). In contrast, others rate drought tolerance as medium or moderate (USDA NRCS 2007, Wrysinski 2004) and the species is known to inhabit sites that are very dry in summer. Klinkenberg (2007) reports a soil moisture regime of 2.1 [0=xeric, 4=mesic, 8=hydric]. Maslovat (2002) describes California oatgrass as having high tolerance to fire along with other characteristics making it a good candidate for disturbance prone ecosystems.

Habitat and plant communities: California oatgrass is a minor to dominant constituent of numerous woodland, shrubland, grassland, and transitional wetland habitats, particularly in the Pacific Coast States. Included among the woodland sites are several Garry oak (*Quercus garryana*) communities in California, Oregon, Washington, and southwestern British Columbia (Franklin and Dyrness 1973). This species is also an understory grass in certain lodgepole pine (*Pinus contorta*) communities in the interior Northwest as well as Jeffrey pine (*Pinus jeffreyi*) grass woodlands on serpentine soils of the Siskiyou Mountains region (Northwest Habitat Institute 2008, Franklin and Dyrness 1973).

California oatgrass is prominent within a number of primarily graminoid communities. Significant populations occur west of the Cascades in Oregon and Washington on prairie and oak savanna habitat. Most of the annual precipitation is from 43-140 cm (17-55 in) (Wildlife Habitat Institute 2008). In the eastern foothills of the Oregon Coast Range where winters are cool and relatively moist but summers hot and droughty, the *Danthonia californica* Valley association occupies xeric, rocky, south and west facing slopes. The species represents up to 70 percent of the cover on these sites (NatureServe 2008). California oatgrass is also a dominant, co-dominant, or frequent component in grassy bald associations such as *Danthonia californica-Eriophyllum lanatum* and *Festuca roemeri-Plectritis congesta*. One or both of these associations occur in patches from the Georgia Basin of Southwest British Columbia south through the San Juan Islands, Puget Sound, western Columbia Gorge, and the Willamette Valley of Oregon. These sites are seasonally moist to very dry with shallow soils, rock outcrops, and moderate to steep slopes with southern to western exposures and an annual precipitation range of 74 to 185 cm (29 to73 in). California oatgrass is part of the sole remaining native-dominated prairie community of the south Puget Sound: the *Festuca roemeri-Sericocarpus rigidus* association. The habitat is moderately dry with relatively rich, deep, excessively drained, gravelly sandy loam soils (Chappell 2006).

In maritime regions along the northern California Coast and into Oregon, winters are mild and wet and summers cool and dry. Here California oatgrass is a dominant, often signature plant of the coastal grasslands including three associations: *Danthonia californica-Festuca rubra*, *Danthonia californica-Aira caryophyllea*, and *Deschampsia caespitosa-Danthonia californica* (coastal). The extent of all these West Coast herbaceous communities was probably much greater prior to fire suppression, land use conversions, exotic weed invasion, and brush encroachment (NatureServe 2008). In this same area are California coastal scrub communities containing California oatgrass including the *Baccharis pilularis-Danthonia californica* association (NatureServe 2008). The species is also found in Ceonothus-Manzanita (*Arctostaphylos spp.)* shrublands or chaparral that extend from southwest Oregon throughout much of California. In this region the climate is typically very warm and relatively dry with about 43 to 76 cm (17 to 30 in) of annual precipitation. Soils are generally shallow over bedrock or are formed from coarse alluvial deposits and some are serpentine (Wildlife Habitat Institute 2008).

California oatgrass also occupies transitional wetlands in western Oregon and western Washington. The *Deschampsia caespitosa-Danthonia californica* association is found in nutrient rich wetlands and flat bottomlands that are temporarily to seasonally flooded. Dry, hot summers and mild, wet winters are the norm. This and similar communities were historically maintained by frequent burning. Soils are usually fine textured silts and clays, moderately permeable to impermeable, with a high winter and spring water table (NatureServe 2008). An example of this community is French Flat in Josephine County, Oregon, where tufted hairgrass (*Deschampsia caespitosa*) dominates the seasonally

hydric soils while California oatgrass dominates the mesic sites (Mousseaux 2004).

Establishment

Establishment of California oatgrass from seed can be problematic as the result of delayed germination and variable seed dormancy, as well as moderately slow seedling development combined with early competition from other species. Difficulties with reseeding *Danthonia* species were reported in the early to mid 1900's when interest grew in reintroducing native perennial grasses on depleted or weedy grazing lands in California (Laude 1949).

Seed dormancy and germination: Evidence suggests the variable seed dormancy in California oatgrass is the result of either single or double (combined) dormancy. The dormancy may be variants of seed coat imposed dormancy, physiological (embryo) or both. Moreover, the amount and possibly the type of dormancy can vary among populations of California oatgrass (Trask and Pyke 1998). It may also depend on crop year or seed lot (Laude 1949) within the same population because climatic conditions during seed development can influence the expression of seed dormancy. Furthermore, the length of time and conditions during storage may affect seed dormancy of grasses like California oatgrass by influencing after ripening (Simpson 1990). Amme (2008) reports that fresh seed or seed that is sown and watered immediately after collection can germinate readily at a high percentage. In contrast, germination is delayed after a period storage, suggesting that dormancy can deepen over time.

Field observations indicate dormancy will also vary among seeds within the same seed lot of California oatgrass. In some years at Corvallis, Oregon, both fall seeding of fields and fall sowing of containers resulted in a portion of seedlings emerging within three weeks, while additional seedlings emerged as early as March in each of the following two springs (Darris per. obs.). Others report more continuous but prolonged germination and emergence periods. Some variability in the dormancy and germination in mechanically harvested lots may be due in part to aggressive seed combining and conditioning/cleaning processes. In these instances some dehulling (ie. hulling or separating the caryopsis or kernel from the lemma and palea), may occur and the seed coat (pericarp) is inadvertently scarified or nicked on some seeds and not others.

Given the variable dormancy in California oatgrass seed, many methods have been used for improving germination with varying success. No treatment may be needed (Emery 1988, Dyer 2001) and direct sowing with untreated dry seed resulted in 60% germination in 21 days for Young (2001). Mechanical abrasion or "injury" with coarse sand paper or brush machines in the process of dehulling, acid scarification, or puncturing of the seed coat alone have improved germination by reducing seed coat imposed dormancy. However, mechanical scarification can be difficult to achieve without unwanted damage to the seed. In a study done by the Corvallis Plant Materials Center (PMC) (unpublished data) germination was greatly reduced by using a huller-scarifier (brush machine) to dehull and simultaneously scarify seed alone or in combination with prechilling (cold moist stratification) treatments. The mechanical procedure was far too aggressive and caused excessive damage to the seed and therefore significantly lower germination. This supports Laude (1949) who indicated mechanical scarification to weaken the seed coat did not appear feasible due to the protruding embryo being in an exposed position resulting in embryo injury.

An alternative physical means of scarification may be the use of an oat huller to condition the seed. It appears to dehull more gently and reduce breakage to the ends of the seed compared to a huller-scarifier (Darris pers. obs.). Further testing is needed to confirm if this machine can simultaneously dehull and effectively scarify the seed coat to get good germination without resorting to acid treatment.

In one greenhouse study, inflorescence (terminal) seed treated for 15 minutes with concentrated sulfuric acid (sp. gr. 1.84) as a means of scarification resulted in faster and higher seedling emergence for all 16 populations after 4 weeks, and for all but 4 populations after 16 weeks (Laude 1949). The acid both dehulled the seed and etched the seed coat. However, 15 minutes seemed too severe for cleistogenes. For terminal seed, 15 minutes of acid treatment gave the best results in the field (8-20% seedling emergence), 30 to 45 minutes gave the best results in a germinator (81% germination), and 20 minutes resulted in the highest emergence (19-27%) in a greenhouse. In contrast, 5 to 10 minutes gave the best results for cleistogenes in the field (4% emergence) and greenhouse (10% emergence), while 10 to 15 minute treatments were best in the germinator (71-81% germination). In all cases, performance declined for acid treatments beyond these time frames. This work underscores the fact that different results can occur between controlled environments and field conditions and between the two seed types of California oatgrass. It also demonstrates the importance of recommending the

best treatments found in field tests for field use (Laude 1949).

It would appear dormancy reduction in these trials was primarily the result of injury to or weakening of the seed coat and not dehulling (Laude 1949). Glumes or the seed covering formed by lemma and palea (the seed "hull") can create seed dormancy in grasses (Simpson 1990) apart from the coat itself. However, whether in a germinator, greenhouse, or field and regardless of seed type, both untreated seed with lemma and palea intact and dehulled seed barely germinated while dehulled seed nicked with a scalpel showed a substantial improvement in percent germination and emergence. The author considers nicking the seed and acid treatment to be akin for the necessary purpose of weakening the seed coat.

The seed coat imposed dormancy in California oatgrass may or may not be a form of physical dormancy (seed coat constraint on moisture imbibition). Laude (1949) found that dehulled but unscarified seed and acid scarified seed both adsorbed moisture similarly. As a result, the author suggests the dormancy is caused by restricted gas exchange or mechanical constraints and not the prevention of moisture uptake. However, based on structural characteristics of grass seed coats, Simpson (1990) argues that rate or specific location of moisture uptake by the seed rather than gas exchange can be explanations. This suggests the possibility of California oatgrass seed possessing a variant of "physical" dormancy but further investigation is needed.

For reducing physiological dormancy, a solution of potassium nitrate (KNO_3) or moist prechilling (cold moist stratification) alone have improved germination, as has giberellic acid (GA_3) in combination with seed scarification, KNO_3 plus scarification, or prechilling. Improvement with a combination of chemical and physical treatments supports the notion that California oatgrass can have complex or combined dormancy. Dobrenz and Beetle (1966) found that for both chasmogamic and cleistogamic seed, germination was similar and did not occur without blotters being soaked with KNO_3. Results were 0% germination for controls and 10% germination using a solution of 0.2 % KNO_3. In a study with four populations having 0 to 91% initial dormancy, a combination of seed scarification (by dehulling and rubbing seeds/caryopses between course sandpaper) and GA_3 (300 ppm or 0.03%) improved cumulative germination to over 80% in all but one seed lot, while breaking over 90% of the dormancy. KNO_3 only enhanced germination in combination with scarification and GA_3 (Task and Pyke 1998). In a pilot study to enhance germination Trask (1996) found GA_3 (400 ppm) alone to be the most successful treatment regardless of whether the seed was scarified or not. A combination of light, a 20/25°C (68/77°F) night/day temperature regime, and seven week prechill is suggested by Chirco and Turner (1986-2007). Unpublished work by the Corvallis PMC on two populations of California oatgrass demonstrated that moist prechilling of both inflorescence seed and cleistogenes at 5°C (39°F) for 45 to 90 days was effective in significantly improving germination as recorded for the first 28 days in a germinator.

Other practitioners indicate improved germination with 30 days of moist prechilling at 3-4°C (37-39°F) in combination with manual removal of the hull (Keeley 2000), 12 to 13 weeks of cold moist stratification alone, or simple fall sowing (Boyer 2007a). From personal communication with Jebb (1995), Rose et al. (1998) report California oatgrass does better with a one to three day soak in running water followed by three months of cold moist stratification at 1-5°C (34-41°F). Guerrant and Raven (1995) achieved good germination with cold stratification at 5°C (41°F) for six weeks followed by warm stratification for six weeks using 16 hour days at 20°C (68°F) and 8 hour nights at 10°C (50°F). Knapp and Rice (1994) found seed viability and germination varied among populations. They had "high" germination rates by squeezing the caryopsis out from the glumes and lemmas, pre-treating with 400 ppm GA_3, and cold moist stratifying for 2-3 weeks at 4°C (39°F). In successful field applications using fall sown seed, it may not be clear whether germination was enhanced by cold moist stratification over winter, or weakening of the seed coat by soil influences, or both.

Finally, Maslovat (2001) reported that California oatgrass required light to germinate and associates this trait with natural regeneration after disturbance. However, for the Corvallis PMC some seed germinated in the dark, suggesting light may not always be necessary.

Summary: California oatgrass seed can be nondormant, for example when "fresh", or commonly possess one or more types of dormancy that need to be overcome for germination to occur. The kind or amount of treatment(s) required, if any, may be specific to population, crop year, seed lot, seed type, storage conditions, or age of seed. The Association of Official Seed Analysts (AOSA) has not set official rules for testing the germination of California

oatgrass. Nevertheless, for many seed lots the most practical method to improve germination without resorting to chemical enhancements is cold moist stratification. This can be done by fall seeding or moist prechilling in a controlled environment for 21-120 days. For other seed lots, dehulling/scarification of the seed will greatly improve germination if the seed coat can be scratched, nicked, or eroded without undue injury to the embryo. Manual methods to remove the caryopsis from the hull (squeezing out the caryopsis, rolling seed between rubber mats) along with the use of sandpaper or scalpels to weaken the surface are not practical on a large scale. A mechanical means is needed for large seed lots but a brush machine appears to be too aggressive. Gentler mechanical means of dehulling and scarifying, such as the use of an oat huller, needs further evaluation. Acid scarification requires special safety precautions but merits consideration. Finally, in some cases a combination of both stratification and scarification may prove to be the most effective way of reducing dormancy.

Natural establishment: Maslovat (2001) examined and described factors influencing natural and assisted establishment of California oatgrass in Garry oak ecosystems of Southwest British Columbia. Characteristics of this grass suggest it is an important colonizer following disturbances such as fire. While a modest seed producer, its seed dormancy and need for light to germinate help create a persistent seed bank (Maslovat 2001). The seed often remains viable in the ground for years. Stands can be resurrected from this latent seed by mowing or other disturbances (Amme 2003).

Seedling recruitment appears aided by retention of shallow litter or moss and variable microtopography, especially minor depressions and grooves that favor higher moisture storage. Deeper litter, often exacerbated by long term fire suppression, may act as an impediment to root penetration and seedling emergence. However, raking of the soil to completely remove litter and clippings can reduce seed germination and establishment on some sites (Maslovat 2001).

The awns found on unprocessed seeds of California oatgrass presumably improve dispersal by attaching to passing animals. In addition, the same awns are hygroscopic (bend and straighten with wetting and drying), a trait implicated in natural seed burial. They may also assist in seed migration and selection of more favorable microsites (Maslovat 2001).

Site preparation: Keys to establishing California oatgrass for revegetation and other goals are preplant weed control and proper seedbed preparation. Starting situations can vary greatly, calling for site specific strategies. Among the most difficult cases are abandoned fields and other areas dominated by exotic weeds that have an extensive weed seed bank built up in the soil. One option for site preparation is to fallow the area for one to three years with repeated tillage operations following each flush of new weeds in order to reduce the weed seed bank prior to sowing. A nonselective herbicide (usually glyphosate) can be used in combination with the tillage (Darris 2003, Campbell 2004, Stromberg et al. 2002, Stromberg and Kephart 2003). Others suggest the weed seeds are usually too numerous and better addressed with minimal soil disturbance and two years of herbicide application followed by planting with a no-till drill (Boyer 2007b).

In restoring oak savanna or other grassland habitats, plowing or other major tillage operations are not recommended next to existing desirable native trees and shrubs, on sites that already have some native plant diversity or rare plants, or before ground nesting birds have completed their nesting cycle (Campbell 2004). In order to preserve native perennial grasses already on site, herbicides are a poor choice where weedy annual grasses are a problem because (except for fine fescues) the chemicals used to control one group also control the other (McClaran 1981). Such sites or inclusions are better candidates for interseeding, no-till drilling, or transplanting.

Besides tillage and herbicides, other site preparation methods include burning, grazing, mowing, soil solarization or combinations thereof (Campbell 2004, Rodgers 1981, Kephart and Amme 1992). Where permitted, burning can be a good choice for site preparation depending on existing conditions (Campbell 2004, Rogers 1981).

Seed testing: Given the potential for highly variable seed dormancy, it is strongly recommended that all seed lots of California oatgrass be given a TZ (tetrazolium chloride) test to determine total viability along with a germination test before purchasing and planting. The difference between the two tests will give an estimate of the percent dormant seed. If dormancy is low, special stratification or scarification treatments are unnecessary. If dormancy is high, pure live seeding rate calculations need to be based on total seed viability and not percent germination.

Direct seeding: Direct sowing of California oatgrass in the Pacific Northwest USA is usually best in late summer or fall (August-October) to naturally stratify the seed over winter (Maslovat 2001), assuming high dormancy in the seed lot. However, seeding date may be extended into the early winter (November) if site conditions have low risk of disturbance after seeding and the time outdoors remains long enough for natural stratification to occur (cool moist conditions may be required for up to 4 months). Emergence in milder winter growing climes typically occurs in late February and March (Boyer 2007b). Late winter or spring sowing with dormant seed can also result in germination the following March (Maslovat 2001), but seed losses from predation, erosion, weed competition, natural mortality, or other factors are potentially greater due to the lengthier period of inactivity. Spring planting may work equally well in some regions if seed is primarily nondormant or cold moist stratified or scarified in advance.

On occasion, de-awing of California oatgrass seed may be needed to facilitate movement through certain seeding machinery. However, Maslovat (2001) describes the ecological importance of the awn and states "restoration of this species will only be successful if the disaspores [seeds] remain awned". Despite this pronouncement, germination of some seed lots benefit from dehulling/scarifying and substantial awn removal cannot be prevented during mechanical or acid conditioning.

The most successful stands of California oatgrass are usually achieved by drilling, no-till drilling, or broadcasting the seed alone rather than in a mix. As with natural establishment, very shallow soil coverage (0.6 cm or 0.25 in or less) is critical because of the light requirement. Broadcast seeding may additionally benefit from irregular surfaces. Mixing the species with nondormant seed of fast establishing grasses or forbs, native or otherwise, can lead to poor establishment because quicker germinating species will occupy the space first. To achieve a more natural appearance in prairie restoration, California oatgrass can be sown alone in irregular patches within more favorable soil inclusions then surrounded by a variety of higher diversity plantings. This is similar to the mosaic seeding approach described by Campbell (2004). Plant diversity can also be achieved afterwards by over seeding new stands the following spring or fall with forbs and/or other native grasses that have nondormant seed. Some restoration practitioners suggest seeding forbs a year before the grasses for improved species richness, as native forbs are more able to establish without grass competition (Clark and Wilson 2005). However, California oatgrass may be an exception and could be sown with forbs because of its seed dormancy.

For California oatgrass to be sown in a mixture, the most viable options may be (1) combining it with species that have similar seed dormancy, (2) using it with low rates of a less competitive, more diminutive species or short-lived plants useful for winter cover, or (3) both. Species for the first option could include Columbia needlegrass (*Achnatherum nelsonii*) or Lemmon's needlegrass (*Achnatherum lemmonii*). Choices for the second option include slender hairgrass (*Deschampsia elongata*) (Boyer 2007b, Darris 2003) which only lives 1 to 3 years, or better yet, annual hairgrass *(Deschampsia danthonioides*). However, both native hairgrasses establish readily when fall sown and should be limited to 0.5 kg/ha (~1/2 lb/ac) in a mix with California oatgrass. They are also prolific re-seeders.

It is reported that California oatgrass has anywhere from 198,000 to 363,000 seeds/kg (90,000-165,000 seeds/lb) (Wrysinski 2004, Heritage Seedlings 2007, Darris and Lambert 2000, Guerrant and Raven 1995). The number probably depends on the degree of physical seed conditioning, genetics, and growing conditions at the time of seed formation. Dehulled and de-awned seed lots will be in the high end of the range. Each 1 kg of pure live seed (PLS) sown per ha will result in 20-37 live seeds/m2 (1 lb PLS/ac results in about 2-4 live seeds/ft^2). Sown alone, suggested seeding rates for drilling are 10-16 PLS kg/ha (9-15 PLS lbs/ac), depending on goals and site conditions. Rates are high because of unpredictability and should be doubled for broadcast seeding.

Amendments: A starter fertilizer is usually not recommended for slow establishing native grasses like California oatgrass as it encourages excessive weed competition. A covering of mulch such as a thin layer of native straw, hydromulch, or erosion blanket is particularly useful on steeper banks. For improved stability, the straw can be crimped into the soil or covered with a netting (Kephart and Amme 1992) such as jute.

Weed control: Guidelines for the use of a number of herbicides for controlling weeds in native grass plantings in California are outlined by Drewitz and Anderson (2003). Pesticide labels vary by state and change over time, so the most current, local information must be reviewed and followed. Seed dormancy in California oatgrass can be put to good use. Sowing monotypic stands allows for fall and

early winter germinating weeds to be controlled with glyphosate or other nonselective herbicide before the oatgrass seedlings emerge (Boyer 2007b, Darris 2003). After emergence and early growth of the California oatgrass, broadleaf weeds can further be controlled with a selective broadleaf herbicide applied at the right stage (Peachy et al. 2007). Mowing over the top of the oatgrass seedlings is a good alternative to control taller weeds, as is wicking with an herbicide, especially before the weeds go to seed. Timely, controlled grazing may also be beneficial for weed control in newer stands.

Transplanting: Some practitioners have had more establishment success using transplanted seedlings instead of seed (Suttle and Thornsen 2007, Buisson et al. 2004, Angelo 2005, McClaran 1981). Reasons can include low germination rates and slow seedling and plant development the first year limiting the species ability to compete with weeds and other plants. Container grown seedlings are well suited to smaller projects. Initial costs are higher per acre, but site preparation requirements can be less and establishment risks lower compared to direct seeding. If a "sod" appearance is desired, a grid spacing of 12-15 cm (5-6 in) may be needed. Amme (2003) suggests a good "turf" of California oatgrass can be established with a spacing of 20-25 cm (8-10 in).

Management

As with all species, best management practices for California oatgrass can vary widely depending on the purpose of the planting or field (erosion control, turf, range, wildlife, or habitat restoration), available resources, site conditions, climate, stand composition, and other factors. Swards of native perennial grasses or grass-forb meadows containing California oatgrass can be improved and maintained with properly timed mowing, grazing, burning, herbicide applications, or combinations thereof. In California, the Pacific Northwest, and possibly other regions, doing nothing is often not an option in the long run because of ongoing and sometimes increasing competition from weedy annuals or invasive perennials, and the spread of shrubs or trees previously controlled or excluded by fire (Stromberg and Kephart 2003)

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Mowing: Mowing is a viable option for controlling certain annual and perennial weeds as well as undesirable woody plants. For example, invasive perennial grasses such as tall oatgrass (*Arrhenatherum elatius*) are replacing native species on grasslands targeted for habitat conservation. From experimental work in western Oregon, Wilson and Clark (2001) report that after several years of late spring mowing at a 15 cm (6 in) height, both flowering and abundance of California oatgrass increased as a result of release from suppression by tall oatgrass. The annual mowing was timed to the flowering of tall oatgrass and its maximum above ground allocation.

For annual weed control, mowing two to three times, especially the first year after establishment can be beneficial and may be required. In California, close mowing in the early spring (March) generally favors perennial grass establishment and enhances vigor. At the same time it reduces direct competition from weedy annuals and the production of annual grass seed along with their buildup in the soil bank (Kephart and Amme 1992). Annuals should be mowed to about 10 cm (4 in) in height after food reserves have been moved into their seedheads but before the large seeds are viable (Stromberg and Kephart 2003). A fall mowing also improves perennial grass growth while providing space and light for new seedlings (Kephart and Amme 1992)

When used in a home garden, grass alley, trail side, or turf setting, California oatgrass can be mowed as low as 6-8 cm (2.5-3 in) in height (Darris pers. obs.). Daniels (2007) suggests mowing only once a year in early spring. The species will maintain itself as a tough, persistent "sod" of intermediate texture if plants are spaced tightly enough (Darris pers. obs.). It can be kept green year round if occasionally irrigated and cut back (Amme 2003).

Grazing: Adaptive and flexible grazing techniques are an option for improving abundance of native grasses like California oatgrass and other desirable herbaceous plants in grassland communities (Stromberg and Kephart 2003, Menke 1992, Bartolome et al. 2004). However, universal prescriptions cannot be made due to variable site, timing, climatic, stand composition, and other factors. The amount of cover for this species can increase, decrease or remain unchanged under grazing.

In California's Coast Range grasslands, Bartolome and others (2004) report that California oatgrass had little response over time to seasonal grazing but increased when grazing was removed. In contrast, its foliar cover increased under continuous grazing and decreased when grazing ceased on California coastal grassland (Hatch et. al. 1999). Similarly, others observed higher cover (Hayes and Holl 2003) and increased vegetative growth and fewer competing annuals under moderate or even heavy grazing (Heady et. al 1963). California oatgrass and other native perennial grasses increased, range condition

and health of the herd improved, and annuals decreased when heavy grazing was replaced by moderate stocking rates and deferred-rotation grazing (Cooper 1960). The species will develop a shorter more spreading form in response to clipping that can make it less noticeable to grazers (Edwards 1992). However, grazing (and burning) practices favorable to one native grass species may damage others (Hatch et. al. 1999).

According to Menke (1992), grazing can be the primary step in a perennial native grass restoration project as well as ongoing maintenance. For restoring California native grasslands, he prescribes several days of high intensity, short-duration sheep or cattle grazing in order to remove the inflorescences of alien annual grasses before they set seed. The grazing event must be planned so that it still allows enough time for native perennial grasses (like California oatgrass) to flower and produce seed before spring soil moisture is exhausted. This action promotes increased vigor and crown cover of the natives. Secondarily, an intense period of heavy livestock grazing during midsummer dormancy of the perennial bunchgrasses reduces dead stems, litter buildup, and self-shading while hoof action enhances nutrient cycling by putting dead material in contact with the soil.

Prescribed fire: Controlled burning is widely recognized as an important tool to control invasion of native and exotic woody plants in order to maintain prairies, ranges or other natural systems containing California oatgrass. As a species which evolved in western prairie ecosystems where fire is a natural process, it is generally tolerant to late summer burning. In a study by Hatch and others (1999) the species was unaffected by fire. However, it is less tolerant to fire than *Nassella pulchra* in California grasslands (Bainbridge and D'Antonio 2003). In these areas, fire is used to decrease the abundance of non-native species and increase or restore native vegetation but results are inconsistent (Bainbridge and D'Antonio 2003). Menke (1992) considers late spring-early summer burning to reduce alien weed seed production a viable enhancement tool for California grasslands with significant native bunchgrass populations. Burning is timed to the period when most weed seeds are still within the flower heads (panicles) so they can be destroyed. If litter levels are excessive, high mortality may result unless this fuel load is reduced in advance by mowing or grazing. Once stands are improved, burning is recommended only once every three to four years. Three years is about the time for alien annuals to recover to pre-fire levels (Menke 1992).

Herbicides: Certain invasive non-native species that pose a continuing threat to native plant communities and other systems with California oatgrass can be effectively managed with herbicides. Whenever possible, they should be integrated with other management measures. Weed control for natural areas is described in depth by Tu and others (2001). References such as the Pacific Northwest Weed Management Handbook (Peachy et al. 2007) cover herbicide recommendations for cropping systems, non-crop areas, and other situations that can apply to California oatgrass.

Pests and Potential Problems

Few pest problems for California oatgrass have been recorded. However, it is one of many native grass hosts for the fungus (*Gloeotinia temulenta*) which causes blind seed disease, a potentially serious pest in ryegrass (*Lolium* spp.) seed production fields (Fischer 1944, Alderman 2001). Field burning is among several effective controls. The species can be infected by a nematode (*Cynipanguina danthoniae*) that causes leaf galls (Maggenti et al. 1974).

Amme (1986) indicated that California oatgrass, along with other native grasses tested, appeared disease resistant during germination, transplanting, and growth in liners. No losses were attributed to damping-off. Rust (*Puccinia* sp.) and other stem or leaf diseases have not been regularly observed or have been of little consequence for seed producers (Kanegy 2007) and the Plant Materials Center, Corvallis, Oregon (Darris pers. obs.).

Environmental Concerns

California oatgrass is not considered to be weedy within its natural range and is easy to control by mechanical or chemical means. However, because of seed dormancy, a resilient seed coat, and latent seed in the soil, individuals may continue to sporadically emerge several years after a stand is removed. The species is not reported to have toxic properties for domestic livestock, wildlife, or humans.

Seed and Plant Production

As with sowing California oatgrass for revegetation and other uses, planting new fields for agronomic seed increase and producing container nursery stock from seed may be confounded by poor or delayed germination due to seed dormancy. If dormancy is known or suspected, seed should have a TZ test to determine viability and then fall (Sept-Oct) sown or cold, moist stratified for 30-120 days. Dehulling or scarification may also be needed as described earlier.

Seed production: Suggested seeding rates are high (11-20 PLS kg/ha or 10-18 PLS lbs/ac) to insure adequate stands since not all seed dormancy may be overcome. Clean, firm, weed free seedbeds and a seeding depth of 0.3 to 0.6 cm (0.13 to 0.25 in) are ideal. The suggested row spacing is 30-45 cm (12-18 in) but wider rows may be needed for cultivators or shielded row sprayers used for applying herbicides. To fit their irrigation systems and equipment, some growers produce the seed in nursery beds usually comprised of four narrow rows with wider (91-107 cm or 36-42 in) rows between the beds (Anderson 2008). Given issues of seed dormancy and slow establishment, a more reliable alternative is to start fields in the fall or spring from greenhouse grown plugs set 15-25 cm (6-10 in) apart within row.

Fertilization and irrigation: Typically, no fertilizer is applied until May after new fall plantings when 27-44 kg of nitrogen/ha (25-40 lbs N/ac) is used. For established seed fields of California oatgrass in western Oregon, annual applications of nitrogen are made in late February or March at rates of 55-110 kg N/ha (50-100 lbs N/ac). Suggested rates may change as more information is learned. Other fertilizers containing potassium, phosphorus, sulfur, or micronutrients may be needed according to soil tests.

In western Oregon, no irrigation is required for new stands as long as the planting of seedlings or seeding is done in fall as recommended. Spring plantings will require irrigation the first year only. However, on droughty soils or in the Central Valley of California and other summer dry, low precipitation areas, summer irrigation may be needed every year.

Weed and pest control: Weeds are controlled in new and existing stands by tillage, mowing, hand hoeing, spot or shielded spray treatments between rows with glyphosate herbicide, and applications of broadleaf herbicides with general labels for grass seed production (Peachy et al. 2007). Mowing off taller weeds and their flower heads that overtop the California oatgrass the first year provides some control. A better option is to use a flail forage harvester that both mows off and removes weed seed stalks, including annual bluegrass (*Poa annua*). While a number of herbicides are labeled for control of this and other annual weedy grasses in established fields of perennial grasses grown for seed, only one of these products (dimethenamid-P) can be legally applied to native California oatgrass in Oregon (BASF Corporation 2007). Supplemental labeling expires December 31, 2009 unless renewed. Significant disease pests such as rust (*Puccinia* spp.), ergot (*Claviceps purpurea*), or smut (*Ustilago* spp.) and insect problems have not been reported. Always read and follow label directions completely when applying any herbicide or other pesticide.

Harvesting: Harvesting California oatgrass is usually done by swathing (windrowing) followed by combining a week or two later after the seed and stalks have adequately dried. It is important to harvest the hidden seed (cleistogenes) in the stems since their numbers are often greater than the amount of seed produced in the exposed inflorescence. To extract both types of seed in a single operation, some growers (Kenagy 2007, Anderson 2008) use a combine equipped with an aggressive four row, spike toothed cylinder and concave set at narrow clearance. Other options include double harvesting using a combine with a rasp cylinder or stripping and vacuuming the seed with a flail-vac seed stripper. The stripper, mounted like a front end loader on a tractor, has a fast spinning brush which rips, pulls, or vacuums the seed from the seed heads and throws it into a hopper. Newer forms of seed strippers may work as well. However, stripping wastes hidden seed unless stems are harvested separately. This can be done later in summer when they readily break off near the base of the plant. The additional seed is then extracted with an aggressive stationary seed thresher or hammer mill that breaks apart the stems.

Flowering and seed formation is commonly absent or meager the first year. This may be due to the plant's slow development, vernalization requirement, or both. Yields increase in subsequent years and often will not peak until the third growing season. They can average 110-330 kg/ha (100-300 lbs/ac). Properly managed, fields can remain productive for a decade or more.

Crop residues: Post harvest residue management usually involves simple mowing to remove decadent foliage and improve exposure of grass crowns and growing points to light and cool temperatures, or flail chopping to break up the stems and leaf matter into finer material. Excessive plant litter left on the soil surface can reduce the effectiveness of certain herbicides in grass seed production, so baling heavier residues, if present, may also be a good option. A flail forage harvester will both cut and remove the crop aftermath in one operation. Given the general tolerance of California oatgrass to fire, summer burning during plant dormancy may be an alternative but no information on its application or benefit for seed production of this species has been reported.

Seed cleaning and conditioning: Threshed seed is usually first run through a scalping machine or screen

to remove stems and other course materials. As described earlier, dehulling/scarification of some seed lots can improve germination if excessive seed damage can be avoided in the process. Options include using a huller/scarifier (brush machine) equipped with gentler brushes or run at slower speeds, or possibly an oat dehuller. Seed is often de-awned in the same process which may be a goal in itself to improve flow through certain seeding equipment and reduce storage volume. Final cleaning is done with an air-screen machine but care is needed to prevent the wasteful disposal of longer cleistogenes or smaller dehulled seed (groats or kernals). In Oregon, seed certification standards for California oatgrass require a minimum purity of 90% and allow a maximum of 0.15% other crops, 10% inert matter, 0.15% common weed seeds, and four restricted weed seeds/lb (Oregon Seed Certification Service 2008).

Plant production: Containers or flats of California oatgrass can be sown in winter or early spring with untreated, dry seed presumably low in dormancy (Young 2001, Dyer 2001) or fresh seed sown immediately after harvest before dormancy develops (Amme 2008). Standard, well drained potting media amended with micronutrients and optional starter or slow release fertilizers works well. Others suggest a medium of 1:1 peat and vermiculite and a light application of nitrogen fertilizer weekly (Rose et al. 1998) or every six weeks with 10-10-5 NPK soluble fertilizer (Amme 1986). Sometimes the seed is dehulled/scarified then sown in plastic flats lined with newspaper and kept at temperatures from 15-25°C (59-75°F) (Keeley 2000). Several shapes and sizes of plug type containers are used for production of seedling transplants.

The seed should be covered with 0.6 cm (0.25 in) or less of potting media or vermiculite and kept moist. Germination and sprouting commences in 10-21 days, but can continue for months (Amme 1986). Plants are maintained with irrigation under controlled greenhouse conditions at 18-25°C (65-75°F). Fertilization is typically discontinued during the summer months. Compared to fall and winter sown and potted seedlings (liners), those similarly handled in late spring and early summer had few or no flowering culms by fall (Amme 1986). Cutting the plants back once or twice helps prevent containers from drying out and encourages new growth of culms. If held over, a single clipping maintained good vigor for California oatgrass through the second year (Amme 1986).

For seed lots where physiological dormancy is initially high, flats or containers are fall sown at the Corvallis PMC with untreated or partially dehulled seed and left outdoors over winter to naturally stratify. Alternatively, flats or trays of plugs are sown, well watered, placed in plastic bags, and moved into a walk-in cooler for cold moist stratification at 1-4°C (34-40°F) for 90-120 days. If the principal dormancy is seed-coat imposed, it is suggested that seed be carefully acid scarified or dehulled in advance and then sown soon after at any time of the year. Once in the warm greenhouse and seedlings emerge, it can take 9-12 weeks for plants to become well established in 7-10 cubic inch, cone shaped containers. Plants should be acclimated for several weeks or more in a lath house or shadehouse prior to spring outplanting or maintained there until fall. For seed with physiological dormancy, remaining "empty" containers may be held over until next spring as they often contain viable seed that will germinate after a second winter period.

California oatgrass propagates readily by division. One method is to collect plants during the dormant season or maintain them in a lath house until dormant. Bring the clumps into a greenhouse in January, and divide them up into segments with a single root. Plantlets are then potted in plug or cone shaped containers, kept moist in the greenhouse at 18-21°C (65-70°F), and later moved back to a lath house (Dyer 2001, Rose et al. 1998). One gallon pots can be split into 3-5 plugs (Las Pilitas Nursery 2007).

Cultivars, Improved, and Selected Materials (and area of origin)

In 2000, the NRCS Plant Materials Center at Corvallis, Oregon, the US Fish and Wildlife Service, and the Oregon Agricultural Experiment Station released Baskett Slough Germplasm California oatgrass, a selected class pre-variety (Darris and Lambert, 2000). The origin of this "natural" germplasm is the Baskett Slough National Wildlife Refuge in Polk County, Oregon. It was not bred or hybridized and particular attention was given to include genetic diversity indicative of the population. Primarily for restoration and erosion control, its intended area of use is US EPA Level III Ecoregion 3 or the southern portion of USDA Major Land Resource Area (MLRA) 2 which includes the Willamette Valley of Oregon and a part of southwest Washington below 1500 ft. elevation. Seed is commercially available. Several other source identified populations of California oatgrass are periodically grown and sold as seed in Oregon and California. Native plant nurseries regularly produce plants of known origin in plugs and pots.

Population genetics and seed transfer:
Understanding patterns of genetic variation in California oatgrass across the landscape provides insight into adaptation and can help guide seed movement of populations within and among regions. In an analysis of data from a common garden study containing 66 populations (accessions) primarily from western Oregon and southwest Washington, plant vigor and seed abundance significantly correlated with winter precipitation, winter minimum temperature, and summer maximum temperature. However, for the subset of 33 Willamette Valley accessions, there were no significant correlations suggesting this region could be treated as a single seed zone for the species (Johnson undated).

In an evaluation of isozyme (protein enzyme) systems in 22 populations of California oatgrass from Oregon and California, Knapp and Rice (1994) found higher levels of among-population variation than within. Such a pattern is more typical of self-pollinating species unlike open–pollinated conifers which tend to exhibit the opposite. This makes it more likely for California oatgrass to have genetically distinct populations resulting in the need for smaller seed transfer zones compared to tree species. In addition, variety c*alifornica* and variety *americana* were found to have distinct genetic compositions. As a result, for purposes of restoration, they advise against mixing the two varieties and are in favor of matching each variety to the variety growing in the vicinity. However, most taxonomic authorities do not recognize the two varieties as separate entities. Knapp and Rice also noted seedlings from one population with narrower leaves came from a unique vernal pool location suggesting that restorationists should consider localized selection pressures when considering seed sources for a planting.

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For more information about this and other plants, please contact your local NRCS field office or Conservation District, and visit the PLANTS Web site<http://plants.usda.gov> or the Plant Materials Program Web site <http://Plant-Materials.nrcs.usda.gov>

Plant Guide

BOTTLEBRUSH SQUIRRELTAIL & BIG SQUIRRELTAIL

Elymus elymoides (Raf.) Swezey & *Elymus multisetus* M.E. Jones

Plant Symbol = ELEL5 & ELMU3

Contributed by: USDA NRCS Idaho State Office

Image courtesy of Mike Haddock
Kansas State University
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Alternate Names

For *E. histrix*: *Elymus elymoides* (Raf.) Swezey var. *brevifolius* (J.G. Sm.) Barkworth; *Elymus elymoides* (Raf.) Swezey ssp. *californicus* (J.G. Sm.) Barkworth; *Elymus elymoides* (Raf.) Swezey ssp. *elymoides*; *Elymus elymoides* (Raf.) Swezey ssp. *hordeoides* (Suksdorf) Barkworth; *Sitanion hystrix* (Nutt.) J.G. Smith; *Elymus hystrix* L. var. *bigeloviana* (Fern.) Bowden and *Elymus hystri*x L. var. *histrix*
For *E. multisetus*: *Sitanion jubatum* J.G. Sm.

Uses

Reclamation/re-vegetation: Squirreltail displays many qualities which make it a good choice for what has been described as "assisted succession." It is a short-lived perennial grass which can act as an early-seral species by competing with and replacing annual weedy species following fire. It is thought that after squirreltail establishes, annual weedy species should decrease in frequency and longer-lived, native perennials may be more successfully reseeded and established.

Its ability to germinate in the late fall and very early spring at a wide range of temperatures add to its capability to compete with cheatgrass (*Bromus tectorum* L.). Studies also indicate that squirreltail is capable of establishing in medusahead wildrye (*Taeniatherum caput-medusae* (L.) Nevski) infested sites. This makes squirreltail one of the more competitive native grasses available for reseeding disturbed rangelands. It is also a self-fertilizing species which allows it to produce seed despite sparse stands following seeding.

Squirreltail is considered to be one of the most fire resistant native bunchgrasses. Older plants contain relatively low amounts of dead material when compared with other native bunchgrasses. This allows for hot, but quick burns which do not penetrate and damage the crown. However, during dry years plants can be damaged by severe burns. As an early-seral species, new plants often increase for two to three years following burns.

Erosion control: When in large, dense stands, squirreltail is very effective at controlling wind and water erosion, due to its persistent ground cover.

Forage/wildlife: Squirreltail is considered to be fair to desirable forage for cattle, horses and sheep in spring before seed head development and late summer to fall after seed shatter. The long, sharp awns of the florets and glumes can be injurious to grazing animals during mid to late spring into summer. Leaves green up in very early spring and are palatable through the fall, especially following rain. The tendency for some leaves to remain green through the winter makes squirreltail an important, though not especially nutritious, winter forage species. Table 1 shows crude protein levels for the spring, summer and winter.

United States Department of Agriculture-Natural Resources Conservation Service
Plant Materials <http://plant-materials.nrcs.usda.gov/>
Plant Fact Sheet/Guide Coordination Page <http://plant-materials.nrcs.usda.gov/intranet/pfs.html>
National Plant Data Center <http://npdc.usda.gov>

Table 1. Crude protein levels by season

	% Crude protein
Spring	18.5
Summer	8.0
Winter	4.3

(*Adapted from Monsen et al, 2004*)

Legal Status
Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Taxonomy
Though bottlebrush and big squirreltail are commonly referred to as *Sitanion hystrix* (Nutt.) J.G. Smith and *Sitanion jubatum* J.G. Smith, respectively, squirreltail is becoming more widely accepted through cytological and molecular evidence as belonging to the genus *Elymus*.

The squirreltail complex, *Elymus* section *Sitanion*, is composed of two species, *E. multisetus* (J.G. Sm.) M.E. Jones (big squirreltail) and *E. elymoides* (Raf.) Swezey (bottlebrush squirreltail), with *E. elymoides* being further divided into four subspecies: *elymoides*, *brevifolius* (J.G. Sm.) Barkworth, *californicus* (J.G. Sm.) Barkworth, and *hordeoides* (Suksd.) Barkworth. The following key will be useful in separating the various members of section *Sitanion* including subspecies.

1. glumes 3- to many-cleft; auricles mostly apparent, circa 1mm in length *E. multisetus*
1. glumes entire or 2-cleft; auricles mostly < 1mm *E. elymoides*
    2. spikelets usually 2 per node
        3. lowermost floret of one or both spikelets at each node sterile and reduced to a glume-like structure
            4. glumes 2-cleft; awns of glumes longer than those of the lemmas ssp. *elymoides*
            4. glumes entire; awns of lemma longer than those of the glumes ssp. *californicus*
        3. lowermost floret fertile and not reduced ssp. *brevifolius*
    2. spikelets 3 per node, the floret of the central spikelet fertile, those of the lateral spikelets sterile and rudimentary ssp. *hordeoides*

Description
General: Squirreltail is a cool-season C-3 bunchgrass native to the western United States. Foliage can be glabrous but is more often white hairy throughout. Plants are short, 10 to 45 cm (4 to 25 inches) tall, with culms erect to spreading. Leaf blades are flat to involute, 1 to 6 mm (0.04 to 0.24 inches) wide. The inflorescence is a spike from 2 to 17 cm (0.8 to 6.7 inches) long, not counting the awns. Internodes of the inflorescence are from 2 to 10 mm (0.08 to 0.40 inches) long with the rachis disarticulating regularly. At maturity the spike can be over 12 cm (4.7 inches) wide due to the widely spreading awns. Awns are scabrous and may grow from 2 to as much as 10 cm (0.8 to 3.9 inches) long, these often becoming purple with maturity.

Squirreltail is a self-pollinating allotetraploid and is known to hybridize with other species of *Elymus* as well as with members of *Hordeum* (barley) and *Pseudoroegneria* (bluebunch wheatgrass). Plants flower from late May to August.

Distribution: Squirreltail (in the broad sense) can be found throughout western North America from Canada to Mexico. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Bottlebrush and big squirreltail grow in a wide range of habitats, from shadscale communities to alpine tundra. *Elymus elymoides* ssp. *elymoides* is common at low to middle elevations in the western states. Subspecies *californicus* is native to mid-elevations up to alpine areas of Canada, California, Nevada and Utah. Subspecies *brevifolius* is found in a wide variety of habitats including desert and mountain plant communities, while subspecies *hordeoides* is restricted to the low lands of the Great Basin. *Elymus multisetus* occupies a similar range to ssp. *elymoides*, but is typically found in somewhat wetter, more mesic sites often in and near mountain foothills.

Adaptation
In general, squirreltail is adapted to a wide range of ecological and topographical conditions. Plants can be found from 600 to 3,500 meters (2,000 to 11,500 feet) elevation in desert shrub to alpine plant communities. The different species-subspecies are adapted to sites receiving as little as 8 inches mean annual precipitation on upland sites or 5 to 9 inches in low lying areas that receive additional moisture. Big squirreltail is normally found in sites with 10 inches or more mean annual precipitation. Squirreltail grows well in medium to fine-textured soils, but also commonly occupies coarse-textured to gravelly soils. It tolerates low to moderately saline to alkaline run-in

or overflow sites with electrical conductivity (EC) generally less than 10.

Establishment
For best results, seed should be planted to a depth of ¼ to ½ inches into a firm weed-free seedbed. For pure stands the recommended drill seeding rate is 7 lb pure live seed (PLS) per acre. Seed can be planted in early spring, but late dormant fall seeding is recommended for best annual weed suppression.

Squirreltail does not establish well into existing perennial shrub communities without mechanical treatment to reduce shrub density. Studies show four times the establishment success rate of squirreltail when planted after thinning big sagebrush (*Artemisia tridentata* Nuttall) as opposed to an untreated site. Similarly, it has been difficult to establish squirreltail in stands of crested wheatgrass (*Agropyron cristatum* [L.] Gaertner). It is recommended that crested wheatgrass and other perennial species competition be eliminated or severely reduced prior to seeding native seed mixtures that include squirreltail.

Management
Seeds germinate in the fall or spring. Plants green up early and remain green through the fall and into winter. Stands should be protected from heavy grazing, especially during flowering to ensure sufficient seed production to maintain the stand. New plantings should also be protected from grazing for at least two growing seasons. A direct seeded squirreltail stand in a big sagebrush/bluebunch wheatgrass community in south-central Idaho has survived for 30 years with recruitment from natural reseeding.

Wildland seed collection occurs from July to September before disarticulation of the spike. Best germination rates come from seed collected in stands with fifty percent of the seed heads having divergent awns and the other half having straight awns of a reddish color. This occurs approximately one week prior to disarticulation. One hour collecting for a single person averages a yield of about 1.6 oz of clean seed. Seed yields can vary widely depending on stand density and age.

Pests and Potential Problems
Plants are known to be susceptible to rust.

Seed Production
Plant seed in a 36-inch between-row spacing at a rate of 2.4 lbs PLS/acre for 30 PLS per foot of row. Fields should be weed free and have good field moisture to a depth of at least four inches. Soil should be kept moist throughout the germination phase (about 14-28 days). Fifty percent of germination should occur within 15 to 30 days after planting. Broadleaf weeds can be controlled with low rates of bromoxynil at the three to five leaf stage. Always apply herbicides according to label directions. No fertilizer should be applied during the first year to discourage annual weed competition.

Soil moisture should be carefully maintained during early green-up, boot stage, milk stage of seed development and after harvest. No irrigation should be applied during flowering to encourage seed set. Fertilize established fields at 100 lb nitrogen and 40 lb phosphorus per acre in mid-September. Soil testing is recommended to ensure proper rates of fertilization.

Photo courtesy of L&H Seed Company
Production field of Fish Creek Germplasm
(*Elymus elymoides* ssp. *elymoides)*

Broadleaf weeds can be controlled with herbicides. Application should occur prior to boot stage. Between-row cultivation can be used to control other weeds for the life of the stand.

Seed is ready to harvest in about mid-July of the second growing season (see "management" section for timing). Harvest by windrowing followed by combining. Some report difficulty with mechanical harvesting due to the ready disarticulation of the rachis of mature seed heads. Swathing prior to maturity and curing in windrows will help reduce this problem. Flail-vac and seed stripping harvesting equipment have also been used with varying degrees of success.

Because of the large amount of inert material produced from awns and glumes, this is a very time-consuming species to clean. Thresh seed through a hammer mill to remove awns. Follow with a clipper or other separator. Purity should exceed 90% with greater than 85% viability. Big squirreltail, in

particular, has proven difficult to debeard without seed damage. Some seed companies have modified equipment that has resulted in improved seed viability.

Seed yields under irrigated conditions average approximately 200 lb/acre with 190,000 seeds/lb. Harvested seed should be dried to 12% or less moisture before storing. Storing seed in a cool dry environment will retain viability for several years.

Cultivars, Improved, and Selected Materials (and area of origin)

Because of the broad array of subspecies of squirreltail and the genetic variation between species and subspecies, careful identification of the species and subspecies native to the planting site is recommended. Care should be taken to match the appropriate phenotype and genotype of the plant materials with those of the local plant communities to improve the chance of stand success and to prevent genetic contamination of existing populations.

Fish Creek Germplasm, 2003 (*E. elymoides* ssp. *elymoides*): This natural track, selected class germplasm was released by the USDA-ARS Forage and Range Research Laboratory in Logan, UT in cooperation with BLM, Utah Agricultural Experiment Station and USDA-NRCS. It was originally collected by T.A. Jones as accession T-1223 in Blaine County, Idaho in August 1995. The native site was described as a big sagebrush and Sandberg bluegrass (*Poa secunda* Presl.) community at approximately 1450 meters (4,760 feet) elevation. Estimated annual precipitation at the site is 35-38 cm (14-15 in). Fish Creek shows a 33% lighter awn mass as compared to Sand Hollow. The spike also disarticulates in a determinate fashion at the base of the spike, two traits which make Fish Creek easier to harvest and to clean than other releases. Fish Creek is adapted to and intended for use in the Snake River Plain. Second generation seed is maintained by the USDA-ARS Forage and Range Research Laboratory, Logan UT. G3 to G5 seed is available through the Utah Crop Improvement Association.

Toe Jam Creek Germplasm, 2003 (*E. elymoides* ssp. *californicus*): This natural track, selected class germplasm was released by the USDA-ARS Forage and Range Research Laboratory in Logan, UT in cooperation with BLM, Utah Agricultural Experiment Station and USDA-NRCS. The original collection for Toe Jam Creek was made in Elko County, Nevada west of Tuscarora by J. Garrison of NRCS. Elevation at the site is 1829 meters (6,000 feet), and average precipitation is estimated at 31cm (12 in.). Toe Jam Creek is intended for use in the lower Snake River Plain and the northern Great Basin. Similar to Fish Creek, Toe Jam Creek exhibits a lower awn mass than Sand Hollow making them presumably easier to remove without damaging the caryopsis. G3 seed is maintained by the USDA-ARS Forage and Range Research Laboratory, Logan UT. Seed through G6 is available through the Utah Crop Improvement Association.

Sand Hollow Germplasm, 1996 (*E. multisetus*): The Sand Hollow collection site is considerably drier than those typical for big squirreltail. It was originally collected in 1984 in Gem County, Idaho by Greg Painter of NRCS in a bluebunch wheatgrass, Sandberg bluegrass and tapertip hawksbeard (*Crepis acuminata* Nutt.) community. The collection site is at 830 meters (2,720 feet) elevation and receives an average of 28 centimeters (11.0 inches) annual precipitation. Sand Hollow is considered to be adapted to the mountain foothills of the Snake River Plain region of Idaho and in adjacent regions of Oregon, Nevada and Utah. It was released as a selected class germplasm for high seed production, higher-than-average seed weight and late heading date. G2 seed is maintained by the USDA-ARS Forage and Range Research Laboratory, Logan UT. Seed from G3 and G4 generations are available for seed certification through the Utah Crop Improvement Association.

Tusas Germplasm, 2001 (*Elymus elymoides* ssp. *brevifolius*): Tusas Germplasm bottlebrush squirreltail was released by the NRCS and New Mexico State University Agricultural Science Center at Los Lunas, New Mexico. This natural track, selected class release is a composite of eight accessions from throughout New Mexico. Collection site elevations ranged from 1,460 meters (4,800 feet) to 2,800 meters (9,200 feet). From the initial 131 collections, eight were selected for vigor, late flowering and higher seed yield. An equal number of seedlings from each accession were taken to form the composite, Tusas. It is intended for use in the southwestern United States for erosion control, wildlife food and cover, revegetation of disturbed sites and restoration of weed infested rangelands. Breeder and G2 seed are maintained by the NRCS NM Plant Materials Center. Seed is available through the New Mexico Crop Improvement Association.

Pueblo Germplasm and Wapiti Germplasm, 2005 (*Elymus elymoides* ssp. *brevifolius*): Pueblo and Wapiti Germplasm are natural track, selected class releases, each originating from a single source. Pueblo was originally collected in 1976 southwest of

Pueblo, Colorado in Pueblo County at an elevation of 7,200 feet in shallow, gravelly soils. The original collection of Wapiti was made in 1981 along the Gooseberry Creek drainage in Rio Blanco County, Colorado. The original collection site was in a stony loam soil at 7,800 feet elevation. Eight bottlebrush squirreltail accessions were evaluated by the Upper Colorado Environmental Plant Center (UCEPC) from 1983 to 1987 and compared for forage production, seed production percent stand, leaf height, vigor, leaf abundance and stem height. Of these, two accessions were chosen for further development, Pueblo and Wapiti. Both are intended for use in erosion control and forage production for livestock and wildlife as well as a variety of conservation applications. These releases should be considered as potentially adapted within the natural range of the species. The UCEPC will maintain G1 and G2 seed. G2 seed will be available to growers. Growers may produce one generation (G3) beyond G2 for Pueblo and Wapiti Germplasm seed. Seed used for certified seed production must be obtained from UCEPC.

Contact your local Natural Resources Conservation Service (formerly Soil Conservation Service) office for more information. Look in the phone book under "United States Government". The Natural Resources Conservation Service will be listed under the subheading "Department of Agriculture."

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For more information about this and other plants, please contact your local NRCS field office or Conservation District, and visit the PLANTS Web site<http://plants.usda.gov> or the Plant Materials Program Web site <http://Plant-Materials.nrcs.usda.gov>

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Plant Guide

BEARDLESS WILDRYE

Leymus triticoides (Buckl.) Pilger

Plant Symbol = LETR5

Contributed by: USDA NRCS Lockeford Plant Materials Center, California & Bridger Plant Materials Center, Montana

Photo by Anna Young-Mathews, Lockeford PMC

Alternate Names

Creeping wildrye, alkali ryegrass, valley wild rye, *Elymus triticoides*

Uses

Beardless wildrye is primarily used for soil stabilization, especially along channel or river banks, and for wildlife habitat in wetland and riparian plantings. It is also recommended for use as forage and for reclamation of saline-affected, irrigated cropland and pastureland.

Soil stabilization: This grass is tolerant to periods of prolonged inundation, and lays flat during high water flow periods, thus allowing full water flow while still protecting the stream, river or canal bank. It can tolerate up to 12 inches (30 cm) of sediment deposition (USDA-NRCS, 1991).

Forage: Beardless wildrye is moderately palatable to all livestock, especially in the early spring before it becomes coarse. It tolerates trampling and recovers well following grazing (Bishop, 1996).

Wildlife: Wet meadows dominated by beardless wildrye provide high quality nesting habitat for waterfowl, shorebirds, and wetland-obligate passarines, as well as foraging areas for Canada geese and Sandhill cranes (Kilbride et al., 1997). Seasonal wetlands and dry meadows of beardless wildrye also provide habitat for reptiles, rodents and other small mammals (McAdoo et al., 2006; Olson, 2001).

Ethnobotanical: Beardless wildrye seed was used historically by Native Americans as meal, or pinole (Chesnut, 1902).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Description

General: Grass Family (Poaceae). Beardless wildrye is a cool-season, perennial, sod-forming native grass. It grows 18 to 51 inches tall (45-130 cm) and is strongly rhizomatous (Hickman, 1993). Stems are usually smooth, but are occasionally hairy. Leaf blades are green to blue-green, stiff and flat early in the growth season, becoming rolled later in the year, and are 0.1 to 0.2 inch wide (2.5-4 mm). The spike is narrow and 2 to 7.9 inches long (5-20 cm), with typically two or more spikelets occurring per node, except for occasional single spikelets near the top. Glumes and lemmas are sharp pointed, and lemmas are generally tipped with an approximately 0.1 inch (3 mm) awn.

Identification: Beardless wildrye hybridizes with *Leymus condensatus*, *L. mollis* and *L. cinereus*. It may be confused with western wheatgrass (*Pascopyrum smithii*) due to their similar habitat and growth habit (OSU Extension Service, 1979). It can be distinguished from western wheatgrass by the double spikelets at each node (*P. smithii* usually has only one spikelet per node). Beardless wildrye also lacks the minute saw-toothed edge found on the leaves of western wheatgrass, and it is generally taller than western wheatgrass. The glumes of beardless wildrye are narrow, short and acute, with only a single vein, while those of western wheatgrass are lanceolate, long-tapering, and have several veins (Barkworth and Atkins, 1984)

Distribution: Beardless wildrye is found throughout the western United States at elevations below 9,000 ft (2,740 m), ranging from Washington to Montana and south to California and western Texas (CHC, 2010; Hickman, 1993). For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Adaptation

Beardless wildrye grows in dry to moist, often saline meadows (Barkworth, 2009). It does well on sandy loams to poorly-drained soils where adequate soil moisture is

present throughout the growing season, and is found in valleys, foothills, mountain flats and meadows (USDA-SCS, 1988). It is thought that beardless wildrye was one of the dominant species in the prairies and lowland oak woodlands of the Central Valley of California prior to European settlement and conversion to agriculture (Holstein, 2001).

This species tolerates neutral to strongly alkaline soils (pH 6.0 to 9.0), moderate shading, 7 to 60 inches (17-150 cm) of precipitation, and soils classified as strongly saline (greater than 15 dS/m) (PLANTS database, 2010). Winter hardiness and frost tolerance are good, though variable among seed lots.

Establishment

Vegetative planting of rhizomes ('sprigging') or plugs in mid-September to November is recommended to establish beardless wildrye on sites typically saturated or inundated in the spring or early summer, or where rapid cover is needed. Stand establishment from sprigs is slow during the first year, but once established rhizomes spread rapidly to produce better coverage and more forage than stands originating from seed. In California, plugs are often planted on 1-ft (30-cm) centers if rapid cover and erosion control is needed, or on 2 to 3-ft (60 to 90-cm) centers for large projects without erosion control problems (J. Anderson, Hedgerow Farms, personal communication, 2009).

High levels of seed dormancy due to an impermeable seed coat make stand establishment difficult (Knapp and Wiesner, 1978). Fall, dormant plantings are recommended for northern regions in order to break seed dormancy by overwintering in the soil. Seedlings have poor vigor, develop slowly, and compete poorly with weeds and other forage grasses in the first year of establishment. It is very important to minimize weed competition with properly prepared seedbeds and appropriate weed management in the year prior to seeding.

For range and pasture seedings, seeds should be drilled into a well-disked seedbed in late fall at a depth of 0 to ¼ inch (6 mm) and a rate of 7 to 10 lbs pure live seed (PLS) per acre (8-11 kg/ha) for full-rate, monotypic seedings (Bridger MTPMC, unpublished report, 1980). For restoration plantings where drilling is not possible, seeds can be broadcast at a rate of 15 PLS lbs/acre (17 kg/ha) (USDA-SCS, 1988). For areas with high erosion potential, beardless wildrye (or other) straw can be blown on the site and crimped in to keep seeds moist and in place during germination.

Because seeds can take 3 to 4 weeks to germinate, weeds should be controlled before seedlings appear. Beardless wildrye is tolerant to most standard, broad-leaf herbicides, except for Telar® (active ingredient: chlorsulfuron), which can impact seedlings if application rates are too high. Seedlings are generally more tolerant to all standard, broad-leaf herbicides once they have reached the 3- to 4-leaf stage. For seed production, Milestone® (active ingredient: aminopyralid) has been observed to decrease seed production, although plant growth was unaffected (J. Anderson, Hedgerow Farms, personal communication, 2009).

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

Management

Once established, stands of beardless wildrye survive for many years. Beardless wildrye is highly productive for hay production when planted at a rate of 7 PLS lbs/acre (8 kg/ha) on irrigated or sub-irrigated sites. Best yields are attained on fields with adequate levels of fertility, especially available nitrogen. High concentrations of salts and/or low levels of moisture result in poorer stand establishment, lower forage yields, and slower growth rates.

Pests and Potential Problems

Beardless wildrye is susceptible to a soil-borne pathogen, "take-all" disease, caused by the root-inhabiting fungus *Ophiobolus graminis* (Stroh, 1968). A temporary solution to arrest the disease may be achieved with an application of P_2O_5 at a rate of 100 lbs/acre (112 kg/ha). More drastic follow-up measures to renovate the site include plowing to a 6-inch (15-cm) depth, harrowing, and irrigating to promote rhizome emergence.

Beardless wildrye varies in resistance to leaf rust, stripe rust, and ergot. 'Rio' was found to have the lowest levels of rust infestation in trials of 12 California beardless wildrye accessions. In some years, infection of ergot is high, resulting in limited use of the name 'honey grass' (USDA, 1949). No ill effects are known from livestock consumption of the infected material.

Environmental Concerns

There are no known environmental concerns associated with beardless wildrye.

Seeds and Plant Production

There are approximately 172,000 seeds per pound (379,000 seeds/kg) (Bridger MTPMC, unpublished report, 1988; USDA-NRCS, 1991). The recommended seeding rate for seed production under irrigation is 3.5 PLS lbs/acre (3.9 kg/ha) at 24-inch (60 cm) row spacing (Bridger MTPMC, unpublished report, 1988). Seed generally matures in June – July, with little preharvest seed shatter. Seed yields are maximized by use of a flail-

vac harvester (USDA-SCS, 1988). No special problems are presented in cleaning the seed.

Seed production in California from cultivated stands has generally been poor, possibly due to natural hybridization with other *Leymus* species, such as giant wildrye (*L. condensatus*), and resulting sterility (Holstein, 2001). Rio was selected for superior seed set, with production averaging 300 lbs/acre (336 kg/ha) (USDA-NRCS, 1991).

Cultivars, Improved, and Selected Materials (and area of origin)

'Rio' was released in 1991 by the Lockeford Plant Materials Center, CA in cooperation with the California Agricultural Experiment Station, UC Davis. It was collected in 1973 from a native stand in Stratford, Kings County, CA. The collection site is at an elevation of 230 ft (70 m) in climate zone 8 in the San Joaquin Valley, where average annual precipitation ranges from 5 to 7 inches (13-18 cm). Seed and rhizomes were harvested from test plots at the Lockeford PMC and used for testing throughout the Mediterranean climate in California, in Major Land Resource Areas (MLRAs) 4, 14, 15, 17, 18, 19 and 20. Rio demonstrated superior seed viability and initial sod establishment in comparison with 12 other California native collections (USDA-NRCS, 1991).

Rio in grassed waterway planting at CAPMC, 2010.

'Shoshone' beardless wildrye was released in 1980 through a cooperative agreement among the Bridger, MT PMC and the agricultural experiment stations of Montana and Wyoming. After its release, however, Shoshone was determined to be the Eurasian species *Leymus multicaulis*, manystem wildrye (Asay and Jensen, 1996). Please see the Manystem Wildrye Plant Guide for more information on Shoshone. Several source identified germplasms of beardless wildrye are commercially available.

Contact your local Natural Resources Conservation Service (formerly Soil Conservation Service) office for more information. Look in the phone book under United States Government. The Natural Resources Conservation Service will be listed under the subheading "Department of Agriculture."

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PURPLE NEEDLEGRASS

Nassella pulchra (Hitchc.) Barkworth

Plant Symbol = NAPU4

Contributed by: USDA NRCS California State Office and Lockeford Plant Materials Center, California

Purple needlegrass. Photo by Lynn Watson.

Alternate Names

Purple stipa, purple tussockgrass

Uses

Restoration

Purple needlegrass, the state grass of California, is appropriate for restoration and range improvement throughout much of California's Central Valley and foothills. The species is highly valued as an erosion control grass due to its longevity, tolerance to poor soil conditions and its ability to establish a coarse root system on disturbed sites with low soil fertility. The species is known for establishing easily on disturbed soils, roadsides and gopher mounds. It has been successfully used in re-establishing native perennial grasses following weed control on sites previously occupied by introduced annual species.

Wildlife/livestock

Purple needlegrass is a valuable forage species which provides food for deer, elk and other wildlife. It can be an important source of food for livestock, having moderate protein values and high palatability (USDA 2009). The leaves green up early in the season and provide good quality early forage for grazing animals. Unfortunately, but the sharp-tipped seeds and awns can become injurious as they dry later in the season. However, shatter is complete within a month of maturity and difficulties can be avoided through pasture management. This species is generally not that important as a livestock forage as it fails to make up a significant portion of the forage base over most of its range, and because under rangeland conditions livestock tend to avoid it later in the season. The fact that livestock do not prefer the species over others is part of reason why it persists in such abundance when compared to other natives of greater palatability for livestock.

Low water use lawn and landscaping

Purple needlegrass is an excellent native grass for use in low water landscaping. The species has also been used in native grass lawns, but its bunching habit prevents it from forming a uniform sod. Animals such as dogs have been known to get the seed lodged in their fur. The awns then break off leaving the small, sharp seed which can burrow under the skin. These problems can be avoided by mowing the seed prior to maturity. Lawns should be mowed to no lower than 4 inches (10 cm).

Status

Consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Description

General: Grass Family (*Poaceae*). Purple needlegrass is a densely tufted, long-lived, upright perennial bunchgrass with conspicuously long awns. It has numerous basal leaves and a distinct nodding habit at anthesis. Plants are generally 2 to 3 feet tall (0.6 to 0.9 m) producing an open, nodding panicle of 4 to 8 inches (10 to 20 cm). The leaf blades are smooth to finely hairy. Basal blades are long, flat and 0.03 to 0.2 inches (0.8 to 3.5 mm) wide. The seeds (florets) range from 0.3 to 0.4 inches (7.5 to 11.5 mm) long with a hairy lemma and a twice-bent awn reaching 1.5 to 4 inches (38 to 100 mm) in length (Hickman 1993). There are typically between 115,000 and 150,000 seeds/lb in a well processed seed lot. Unprocessed seed with the awns still attached can have as few as 50,000 seeds/lb.

Purple needlegrass has been reported to root as deep as 16 feet (4.8 m) in deep soils (Netstate 2009), but the roots more typically range from 2 to 6 feet deep (pers. obs.). Plants become dormant after seed production, but begin growth again with fall rain. Plants will also regreen after summer dormancy even without the presence of precipitation. This is believed to be in response to shortening day lengths.

Purple needlegrass is wind pollinated. Plants can regenerate either asexually by tillering and bunch fragmentation, or via seed dispersal. Seed burial is facilitated by the sharp pointed seed and long awns which twist as they dry, driving the seed into the soil.

Purple needlegrass has been shown to have very high self pollinating rates (Larsen et al. 2001). Results indicate that inbreeding and/or selection have contributed to the significant differentiation of needlegrass populations.

There are two native and one introduced *Nassella* species which are commonly mistaken for purple needlegrass in California. The native needlegrasses, nodding needlegrass (*N. cernua*) and foothill needlegrass (*N. lepida*), have a wavy distal awn segment which differs from the straight distal awn segment found on purple needlegrass (Hickman 1993). Additionally, nodding needlegrass typically has a longer awn and thinner seed than purple needlegrass, while foothill needlegrass has much smaller seed and shorter awns than purple needlegrass.

Nassella manicata is native to South America and has been detected in California in the San Francisco Bay area and near Folsom, California (Amme 2003). It was previously misidentified as *N. formaricum* in The Jepson Manual (Barkworth 2007). The Flora of North America separates the two species with *N. manicata* having florets 6-8 mm long with lemmas glabrous between the veins at maturity, and *N. pulchra* having florets 7.5 –11.5 mm long with lemmas evenly pubescent at maturity (Barkworth 2007).

Seed of *Nassella manicata* (left) and *N. pulchra* (right). Photo by James Effenberger, California Department of Food and Agriculture, 2009.

Distribution

County level distribution map of purple needlegrass. Image from PLANTS database (2009).

The distribution of purple needlegrass prior to European settlement is undetermined. It was previously widely believed that purple needlegrass was a climax species in California, occupying much of the valley and coastal grasslands. New studies suggest, however, that beardless wildrye may have been more dominant on heavier clays, while purple needlegrass was the dominant grass in more sandy areas (Holstein 2001). Purple needlegrass currently occurs on the west side of the Coast Range from northern Baja California north to southern Oregon, the Central Valley and foothills of the Cascade Range and Sierra

Nevada as well as the Channel Islands. For current distribution consult the Plant Profile page for this species on the PLANTS Web site.

Habitat
Prior to European settlement, purple needlegrass was one of the dominant grass species of California's valley grasslands and foothills. The species now occurs in grasslands, oak and pine woodlands, mixed evergreen forests, chaparral, and coastal scrub, but has been replaced in many instances by introduced annual grasses such as annual rye (*Lolium perenne* ssp. m*ultiflorum*), wild oat (*Avena fatua*), slender oat (*A. barbata*), ripgut brome (*Bromus diandrus*), soft chess (*B. hordeaceus*), mouse barley (*Hordeum murinum*), and rattail fescue (*Vulpia myuros*).

In natural plant communities it is frequently associated with Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria macrantha*), Sandberg bluegrass (*Poa secunda*) and bottlebrush squirreltail (*Elymus elymoides*) (Heady 1977). It can also be found with California oatgrass (*Danthonia californica*), California fescue (*Festuca californica*), tussockgrass (*Nassella lepida*), beardless wildrye (*Leymus triticoides*), and melic grass (*Melica* spp.). In coastal areas purple needlegrass is found in association with red fescue (*Festuca rubra*) and California brome (*Bromus carinatus*).

Adaptation
Purple needlegrass grows in oak woodland, chaparral and grasslands in areas receiving between 8 and 40 inches (20 to 100 cm) of annual precipitation. Its elevational range extends from sea level to 4,300 feet (1300 m). It is well adapted to droughty soils, clays and serpentine soils. The species grows well in full sun as well as partial shade and is tolerant of extreme summer heat and drought. Purple needlegrass does not tolerate being overshaded by non-native annuals. Some ecotypes of the species have partial flood tolerance.

Establishment
For best results, seed should be planted to a depth of ¼ to ½ inch into a firm weed-free seedbed. The pure stand recommended drill seeding rate is 9.5 lb pure live seed (PLS) per acre for approximately 25 seeds/ft². This is based on 115,000 PLS/lb. For broadcast applications the pure seed rate is 15 lbs/ac. Planting 1 lb/acre yields approximately 3 seeds/ft². Seed can be planted in early spring, but late dormant fall seeding is recommended for best emergence and competition against annual weeds. For seed mixtures, using rice hulls or another dilutent is recommended to prevent the settling of smaller seed in the mixture. Like other native perennial grasses, this platn should generally not be seeded in mixes including annual grasses which reduce the likelihood of establishment.

During establishment, disturbance should be minimized. Purple needlegrass does not compete well with annual grass or broadleaf weeds during the establishment period because of slow establishment during the first year. It requires bare ground to re-seed, but volunteers readily into openings and increases once it is established. Stands are usually maintained by abundant seed production in non-grazed or properly grazed areas. The species can also expand vegetatively when tussocks are fragmented.

Management
The most important management issue for purple needlegrass seedings is preventing overwhelming weed competition, especially from exotic grasses but also aggressive broadleaf weeds. Studies have shown the presence of annual exotic grasses can reduce the growth and seed production of purple needlegrass at all developmental stages (Hamilton et al. 1999). Young needlegrass seedlings grow at a much slower rate than most weeds. The weeds easily overshade and outcompete new seedlings for sunlight and can dramatically impact establishment. Where possible, control competing vegetation. Some options for competition control include mowing, herbicide applications and closely controlled and timed grazing. It is a good idea to control weeds prior to needlegrass emergence if possible. Other options include mowing, herbicide wicking and limited grazing.

New seedings should not be grazed for two to three years following planting to ensure full establishment. However, under heavy competition by weeds, limited grazing can open the plant canopy and allow sunlight for new seedlings. Purple needlegrass should not be grazed during flowering to ensure formation of the seed and to allow food storage in the crown. The plants have a good tolerance for mowing, especially after seed maturity, but can be mowed earlier.

Purple needlegrass is fire tolerant and may benefit from prescribed burning. It commonly produces a more abundant seed crop the year after a fire. The season during which the fire occurs may determine the effects on the grass. It typically will re-sprout after spring or fall burns, but does not recover as well after a summer burn due to typically higher fire temperatures at the soil surface. Larger plants often do not recover due to higher crown temperatures especially when excessive thatch has been allowed to build up, increasing fire temperatures.

Pests and Potential Problems
Seedlings are susceptible to damping off in cold wet weather, especially in December and January. Pre-treating seed with a fungicide has been used to effectively reduce fungal problems. Smut has been detected in purple needlegrass plantings, but is not typically a problem. Seed can be affected by smut but this has not been very prevalent. Rust can also be a problem in green house seedling transplants but has not been a problem in field plantings.

Seed and Plant Production
Seed production fields can be planted at a rate of 4.4 lbs PLS/ac using 20 or 30 inch row spacing. Some growers have also planted purple needlegrass on 5 foot beds with 4 rows per bed at 8 inch spacing. Seed matures in mid- to late spring and can be collected for two to four weeks but shatters very quickly during hot, dry weather.

Fields can be harvested several times as seed matures using a seed stripper. Stripped seed should be dried prior to processing. During drying and curing the awns curl up on each other and the product becomes a connected mat of seed and awns. This can be run through a stationary combine to separate the awns from the seed, but some seed is broken during this process. Heavy fields can be swathed into windrows and combined once the seed and straw have cured.


First year purple needlegrass seed production field at the NRCS Plant Materials Center in Lockeford, CA.. Photo by Derek Tilley.

It is important to accurately determine when the field is mature enough to swath. It is also very important to form the windrows so that the seed is incorporated into or on top of the straw. The seed in the panicles that hang over the side of the windrow will shatter on to the ground during curing, but this is minimal. If windrows are rained on or are cut with high moisture levels, black mold can infect the material and the seed which can adversely affect viability.
Seed yields vary considerably ranging between 75 to 600 pounds/acre depending on the year, wind, rains, and age of the stand. If desired, straw can be baled directly after swathing for seed bales. Bales made after combining and windrowing also contain small amounts of seed.

Cultivars, Improved, and Selected Materials (and area of origin)
There are numerous germplasms of purple needlegrass available from the commercial seed industry.

The NRCS Lockeford Plant Materials Center has released three purple needlegrass accessions in 1997 following a common garden study evaluating 32 accessions. They were chosen for natural-track, selected class release based on their early flowering, superior vigor, height and plant establishment density compared to other accessions. The assigned names were designations of release origin (LK=Lockeford), sequential number release (1 through 3) and recommended area of use by Major Land Resource Area (MLRA) and 4Eta zone (b through h) as used by Arkley and Ulrich (1962). The selected natural germplasm releases have been found to be genetically well defined and most similar to natural seed collected near the corresponding source populations (Larsen et al., 2001). Thus, these commercial germplasm sources should be useful for conservation plantings within the intended areas of utilization. Breeder and Foundation seed of these releases is maintained at the NRCS Lockeford Plant Materials Center.
LK 115d Selected Germplasm: This collection was made in Tehama County, California along Highway at approximately 2,300 feet (700 m) in elevation. Mean annual precipitation at the site is 25 inches (0.6 m). LK 115d was released primarily for use in northern portions of California's Central Valley and southern foothills of the Cascade Range.

LK 215e Selected Germplasm was collected in Colusa County, California at the Walnut Valley Ranch near Lodoga, California. Elevation at the site was approximately 1,280 feet (390 m) with annual precipitation ranging from 9 to 40 inches (0.2 to 1.0 m). Potential area of adaptation includes the Central Valley and inner coastal foothills.

LK 315d Selected Germplasm was collected in Alameda County, California at Rancho Los Mochos Boy Scout Camp. The elevation of the original collection was approximately 2,056 feet (627 m). Mean annual precipitation at the collection site is 14 to 35 inches (0.3 to 0.9 m). LK 315d was released primarily for use in the Bay area and outer coastal foothills.

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USDA NRCS
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Plant Fact Sheet

SANDBERG BLUEGRASS

Poa secunda J. Presl

Plant Symbol = POSE

Contributed by: USDA NRCS Plant Materials Program

Robert H. Mohlenbrock
USDA NRCS 1992
Western Wetland Flora
@USDA NRCS PLANTS

Alternate Names

big bluegrass; *Poa ampla*, *Poa canbyi*, *Poa confuse*, *Poa gracillima*, *Poa sandbergii*, *Poa scabrella*, *Poa nevadensis*, *Poa laevigata*, *Poa juncifolia*, *Poa incurve*; some of these synonyms, such as *Poa nevadensis* are sometimes recognized at the species level in some states.

Uses

Livestock: Early spring grazing by cattle or sheep is one of the primary uses of Sandberg bluegrass seedings. In adapted areas, there is no other grass that provides an equal volume of early spring forage. It makes good spring calving or lambing pasture.

Wildlife: Upland game birds, especially pheasants, choose fields of Sandberg bluegrass for nesting sites because Sandberg bluegrass has more early spring growth than other dryland grasses and the basal leaves provide good shade.

Woodland: Sandberg bluegrass has been successfully used for reseeding burned-over forest lands in pine forests of the West. It has a remarkable ability to produce roots which effectively suppress weed growth.

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Description

Sandberg bluegrass is one of the native bluegrasses and is an important component of the sagebrush grassland vegetation in the western United States. It is a medium-sized cool season bunchgrass with numerous fine basal leaves 8 to 16 inches long. These leaves are a smooth, deep blue green and are folded with keel-shaped tips typical of bluegrasses. This long-lived perennial reaches 2 to 4 feet in height. Its inflorescence is a narrow panicle up to 8 inches long. It has a strong fibrous root system but will occasionally develop short rhizomes. The flower spikelets do not have a web of hairs at the base, unlike Kentucky bluegrass, which does.

Sandberg bluegrass begins growth early in spring, before crested wheatgrass, and matures in early summer unless moisture is sufficient to keep it green all summer. In this respect it is the most persistent of all the cool season grasses.

Adaptation and Distribution

This native bluegrass thrives on a variety of soils from moderately coarse sands to fine clays. It will tolerate coarse sands and dense clays, but will not grow under saline conditions and can tolerate weakly acid or alkaline soils. Well-drained mountain loams are a good place to look for Sandberg bluegrass stands.

Although it grows in moist conditions (15 to 20 inch precipitation zone) it will not tolerate early spring flooding, high water tables, or poor drainage. It does

best with cool winter moisture above 7,000 feet. It has excellent cold tolerance but does not do as well as other cool season grasses during drought. Its tolerance to shade and grazing is moderate but its ability to withstand burning is very low except when dormant.

Sandberg bluegrass is distributed throughout the West. For a current distribution map, please consult the Plant Profile page for this species on the PLANTS Web site.

Establishment
Seed of Sandberg bluegrass should be drilled at 1/4 to 3/4 inches deep depending upon soil type: 1/4 inch for fine, moist soils, 1/2 inch for medium textures, and 3/4 inch for coarse or dry soils. On semiarid lands, 3 pounds pure live seed (PLS) per acre is adequate. Harsh or erosive sites require doubling of the seeding rate as does broadcast seeding.

The seed should be planted 2 months prior to the most reliable precipitation: usually early spring, late summer or late fall depending upon the area. When seeding in spring it is advisable to plant as soon as possible since high soil temperatures will put the seedlings into dormancy. Prechilling will improve germination of the seed. Seedling vigor is moderate to good for a bluegrass. It does not respond significantly to irrigation and gives only moderate response to nitrogen applications. It is weakly compatible to seeding with other cool season species. It can be seeded with other grasses, forbs, legumes, or shrubs. Weed control may be needed.

Management
Sandberg bluegrass has good palatability to livestock in spring and fall and to deer in the spring. It has excellent palatability to elk all year. Cattle prefer Sandberg bluegrass in the spring and it should be grazed when it reaches eight inches in height. Livestock graze Sandberg bluegrass in the vegetative

stage, but avoid it when headed. Livestock should be removed while there is still enough moisture in the ground to allow regrowth before plants go dormant. Regrowth can be grazed after the plants turn green in the fall, but a 6-inch stubble should be left.

Overgrazing and severe trampling are injurious to native stands of this grass and without proper protective grazing, a range will deteriorate rapidly. New seedlings are easily pulled up by grazing animals and, therefore, should not be grazed until the stands are more than 2 years old and are sufficiently well-rooted to withstand grazing. Spring and fall grazing are recommended. When properly managed, Sandberg bluegrass will compete with cheatgrass.

Pests and Potential Problems
The primary pests of Sandberg bluegrass are grasshoppers, jackrabbits, and rodents. Diseases include leaf and stem rusts and stem maggots.

Cultivars, Improved, and Selected Materials (and area of origin)
'Sherman' (OR). Seed can be obtained from most commercial seed stores.

Prepared By & Species Coordinator:
USDA NRCS Plant Materials Program

Edited: 05Feb2002 JLK; 060809 jsp

For more information about this and other plants, please contact your local NRCS field office or Conservation District, and visit the PLANTS Web site<http://plants.usda.gov> or the Plant Materials Program Web site <http://Plant-Materials.nrcs.usda.gov>

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Plant Guide

SANDBERG BLUEGRASS

Poa secunda J. Presl

including:

***P. ampla* Merr. (POAM)**
***P. canbyi* (Scribn.) Howell (POCA)**
***P. gracillima* Vasey (POGR)**
***P. juncifolia* Scribn. (POJU)**
***P. nevadensis* Vasey (PONE3)**
***P. sandbergii* Vasey (POSA12)**
***P. scabrella* (Thurb.) Benth (POSC)**
Plant Symbol = POSE

Contributed by: USDA – NRCS, Boise, Idaho

Photo by Mark Majerus. Bridger, MT Plant Materials Center

Alternate Names
P. ampla = Big bluegrass
P. canbyi = Canby's bluegrass
P. gracillima = Pacific or Slender bluegrass
P. juncifolia = Alkali bluegrass
P. nevadensis = Nevada bluegrass
P. sandbergii = Sandberg bluegrass
P. scabrella = Pine bluegrass

Description
General: The Sandberg bluegrass complex is composed of cool-season (with some summer active ecotypes) perennial bunchgrasses that mature early in the growing season. This grass is one of the first to green up in the spring, but is cured and dormant by early summer. The plant usually occurs as small tufts, with soft basal leaves and few to many flowering stalks that are naked except for one or two small leaves. The leaves have the typical bluegrass characteristics of prow-shaped tip and double groove down the center of the leaf surface. Sandberg bluegrass has a prominent membranaceous, acute ligule. The seeds are glabrous except for short crisp hairs on the lower portion of the lemmas. The flowers are in narrow panicles that are somewhat spreading during anthesis. Plants seldom exceed 60 cm (24 in) in height. Plants of the Sandberg bluegrass complex have extensive, deep penetrating, coarse, fibrous roots that make them quite drought tolerant and resistant to grazing and trampling. Species within the complex have approximately 2,000,000 seeds per kilogram (925,000 seeds per pound).

Distribution: Plants occur throughout Western North America with disjunct populations in Quebec and Chile. For current distribution, consult the Plant Profile page for this species on the PLANTS Web site.

Taxonomy
The type specimen for *Poa secunda* was collected between 1790 and 1794 in "cordilleras Chilensibus" by Thaddeus Haenke and was described by Presl in 1830. In 1892, Sandberg collected a plant near Lewiston, Idaho which was described the following year by Vasey as *Poa sandbergii*. Presl's work is recognized as having taxonomic priority due to its earlier date (Arnow 1981).

The Sandberg bluegrass complex has included up to 45 named species including eight species recognized by Hitchcock (1935): Canby's bluegrass (*P. canbyi)*, big bluegrass (*P. ampla*), little mountain bluegrass (*P. curtifolia*), Pacific bluegrass (*P. gracillima*), alkali bluegrass (*P. juncifolia*), Nevada bluegrass (*P. nevadensis*), Pine bluegrass (*P. scabrella)* and the traditional Sandberg bluegrass (*P. sandbergii*) (Arnow 1981). Kellogg (1985a, 1985b) however, demonstrated that for all species except *P. curtifolia*, the characters used to separate the species were unreliable. Many were often environmentally determined, for example plants turning red when dry, leaf rolling and leaf glaucusness. Research has shown that under garden and greenhouse conditions these characters don't exhibit themselves as in field conditions (Kellogg 1985b). Other characters vary so widely within a population that they are also unusable to delineate groups within the complex.

Based on these findings, Kellogg (1985a) synonomized the entire complex with the exception of *P. curtifolia*, a well-defined species endemic to serpentine outcrops in the Wenatchee Mountains in Kittitas and Chelan Counties, Washington (Hitchcock and others 1971).

Variation in Sandberg bluegrass releases; left to right: Sherman big bluegrass, High Plains and Mountain Home Sandberg bluegrass. Photo by Derek J. Tilley, Aberdeen, ID Plant Materials Center.

Although evidence currently points to a large, highly variable suite of forms making up the Sandberg bluegrass complex, the authors of this paper believe that unique phenotypes exist and the separation of these forms is still useful in describing ecological sites, predicting revegetation performance and in making land management decisions. In this light, the authors have decided to provide descriptions here of the seven separate forms of Sandberg bluegrass recognized by Hitchcock (1935), minus *P. curtifolia*, as an aid to land managers.

The following taxonomic key taken from Cronquist and others (1977) should be useful in separating the seven species of the Sandberg bluegrass complex.

1. Lemmas crisp puberulent to nearly glabrous, the pubescence sometimes confined to the very base.
   2. Panicles open, the lower branches nearly at right angles to the axis; culms often decumbent at the base; plants summer flowering ……*P. gracillima*
   2. Panicles contracted or somewhat open; culms usually erect.
      3. Plants relatively small, culms mostly less than 30 cm tall; basal leaves forming a short dense tuft, 3-10 cm high; panicles 2-7 cm long; mostly spring flowering...*P. sandbergii*
      3. Plants larger, mostly more than 30 cm tall; basal leaves looser, the tuft 5-30 cm high; panicles 6-16 cm long; mostly summer flowering
         4. Basal tuft of leaves 3-15 cm high; panicles 4-12 cm long….....*P. scabrella*
         4. Basal tuft of leaves 15-30 cm high; panicles 9-16 cm long……....*P. canbyi*
1. Lemmas usually glabrous, sometimes minutely scaberulous
   5. Ligules decurrent, long, 1.5-6.5 mm long, acuminate or sharply acute…….*P. nevadensis*
   5. Ligules not obviously decurrent, short, 1-2 mm long, rounded or obtuse to truncate.
      6. Blades involute, mostly less than 1.5 mm broad, greenish; plants 20-70 cm tall; usually growing in alkaline soils .....*P. juncifolia*
      6. Blades mostly flat, 1.5-3.5 mm broad, often glaucous; plants robust, 60-180 cm tall; growing in non-alkaline soils……...*P. ampla*

'Sherman' big bluegrass. Photo from USDA-NRCS.

Big bluegrass (*Poa ampla*)
This is the most robust species within the Sandberg bluegrass complex. Culms reach 60 to 130 cm (24 to 48 in) tall, with basal leaves growing to 40 cm (16 in) long and 1.5 to 3.5 mm (1/16 to 1/8 in) wide. The leaves are typically bluish-green and somewhat glaucus. Panicles range from 10 to 18 cm (4 to 7 in) long and are narrow with densely arranged spikelets. This species occupies sagebrush slopes, mid-elevation meadows and openings in aspen stands. Big bluegrass is notable for early green-up, greater forage production and its importance to range management.

Canby's bluegrass (*Poa canbyi*)
Canby's bluegrass bears green to glaucus leaves with culms to 80 cm (31 in) tall. The basal leaves are typically 15 to 30 cm (6 to 12 in) long and 1 to 3 mm (1/16 to 3/32 in) wide. The panicles are loose to compact with erect branches growing to a length of 16 cm (6 ¼ in). Plants of Canby's bluegrass grow on open grassy or sagebrush slopes at middle elevations. In its native habitat this species actively grows during the late spring and matures by early July as opposed to *P. sandbergii* (Cronquist and others 1977).

Pacific or Slender bluegrass (*Poa gracillima*)
This is another summer active species. Culms range from 20 to 50 cm (8 to 20 in) tall. Leaf blades are flat and lax from 5 to 15 cm (2 to 5 in) long and 0.7 to 2 mm (1/32 to 1/16 in) wide. The panicles are open and pyramidal. Lemmas of Pacific bluegrass have longer hairs on the keel than *P. sandbergii*. This species can be found in meadows, stream banks and rocky slopes from British Columbia to the California Sierras, with populations also in northern Nevada, northern Utah and Colorado.

Nevada bluegrass (*Poa nevadensis*)
This species is a perennial bunchgrass with culms as much as 100 cm (39 in) tall. Basal leaves typically reach a length of 25 cm (10 in) with a width of 1 to 3 mm (1/16 to 3/32 in). Nevada bluegrass has distinctive long acuminate ligules from 1.5 to as much as 6 mm (1/16 to ¼ in) long. The narrow panicles are 10 to 18 cm (4 to 7 in) long with yellowish-green to purplish-tinged spikelets. Nevada bluegrass can be found in relatively moist areas in sagebrush communities including mountain foothills and meadows from Alaska to southern California, through Nevada to Arizona and Colorado.

Alkali bluegrass (*Poa juncifolia*)
This species is regarded as being closely related to *P. ampla* (Cronquist and others 1977) and it has been shown that when grown under garden conditions the differences between the two species are lost (Hitchcock and others 1969). Typically the plants are smaller with culms growing 30 to 70 cm (12 to 26 in) tall. Leaf blades are tightly rolled and less than 2 mm (1/16 in) wide. Panicles are narrow, 7 to 15 cm (2 ¾ to 6 in) long with short, ascending branches. This species prefers moist or dry alkaline meadows from the sagebrush zone to mountain communities from British Columbia to South Dakota and south to Nevada, Utah and New Mexico.

Sandberg bluegrass (*Poa sandbergii*)
This is probably the most common bluegrass species in the Intermountain West, at least in the drier portions of the region, and is an important forage species for small animals in spring and fall (Cronquist and others 1977). Plants are relatively small with culms reaching 20 to 35 cm (8 to 14 in) tall and basal leaves 3 to 5 cm (1 to 2 in) long. Plants occur in dry areas in sagebrush and mountain shrub communities, and occasionally in alpine sites.

Pine bluegrass (*Poa scabrella*)
This species can be tentatively separated from Canby's bluegrass by its being a spring flowering species as opposed to summer, and from Sandberg bluegrass by its smaller size. However; it is admittedly very closely related to both and extremely difficult to separate when the species are found in close proximity to one another. Typically this species is found on relatively dry sites on sagebrush hills and woodlands at low to mid-elevations from British Columbia to Baja California, Nevada Utah and Colorado, and east to Minnesota.


Pine bluegrass. http://www.tarleton.edu/~range/Home/home.htm

Uses
Sandberg bluegrass and the other spring ecotypes are palatable to livestock early in the growing season, becoming less preferred during the summer when cured. Summer growing ecotypes are palatable longer into the season. By autumn Sandberg bluegrass is frequently selected again as available alternatives diminish. Deer, pronghorn antelope, and bighorn sheep utilize Sandberg bluegrass forage and birds and small mammals utilize the seed (Johnson and Larson 1999).

Because of the small stature and early maturity, most of the species of Sandberg bluegrass do not provide much usable forage; however, big bluegrass and Nevada bluegrass can be important forage producers for larger animals. Sandberg bluegrass is usually a minor component of many grassland communities, but is still considered one of the six most important rangeland grasses of the Intermountain and Pacific Northwest regions (USDA Forest Service 1937).

The anticipated use of commercially available Sandberg bluegrass seed is for inclusion in native mixtures for wildlife habitat, reclamation of disturbed sites, restoration of native rangeland, and conservation plantings.

Status
Consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Adaptation
Sandberg bluegrass is considered an increaser in mid and short-grass prairies, mountain meadows, and foothills of south-central Canada and western United States (Dakotas

west to Washington), south to Mexico (Hitchcock 1935) (Hitchcock & Cronquist 1976). It is found at elevations ranging from 100 to 3,650 meters (300 to 12,000 ft). It grows well on medium texture soils but is also common on badlands, ridge tops, and dry, stony, or sandy soils. It is a pioneer species, one of the first grasses to colonize on disturbed sites. Plants of the Sandberg bluegrass complex occupy a niche in bunchgrass plant communities. The primary area of use would include the northern Great Plains (Montana, Wyoming, North Dakota, South Dakota, Colorado), the Intermountain West including the Great Basin (Idaho, Nevada, Oregon, Washington, Utah), and the Palouse country (Idaho, Oregon, Washington).

Sandberg bluegrass is considered to be a facultative apomyct, reproducing primarily (but not limited to) agamospermy, or asexual seed production (Kellogg 1987). Larson and others (2001) showed that genetic diversity within natural populations of Sandberg bluegrass was much greater than that in the releases Sherman or Canbar. Accordingly, releases, such as Reliable Sandberg bluegrass germplasm, have been developed from multiple plant populations to ensure higher amounts of genetic diversity and greater adaptation (Waldron and others 2006).

Establishment

For best results, seed should be planted into a firm, weed-free seedbed, preferably with a drill that will ensure a uniform seed placement of about 6 mm (1/8 to 1/4 inch). The small seed can be broadcast seeded, harrowed, and packed for good seed-soil contact; however, in dryland situations good precipitation at the time of germination is critical for emergence and survival. The full seeding rate is 1.7 kg/ha PLS (2.0 lb/ac PLS), but this species would seldom be seeded in a pure stand. This species would normally be included in native seed mixtures at a rate of 0.3 to 0.6 kg/ha PLS (1/4 to 1/2 lb/ac PLS). Seeding in early spring is favored in areas that have summer moisture patterns such as the Northern Great Plains, while fall dormant seedings are preferred in winter rainfall areas such as the Columbia Basin and most of the Intermountain West. Sandberg bluegrass is considered a pioneer species and is often one of the first grasses to respond to surface manipulation of deteriorated rangeland. Sandberg bluegrass is a relatively short-lived grass, but often perpetuates itself through prolific seed set and shatter**.**

Management

Sandberg bluegrass will withstand heavy grazing and trampling, in part, because of its early maturity and apparent dormancy during the summer and fall grazing period. When planted in a native reclamation mix, it will be a minor component of the establishing plant community; therefore management should be based on other key species in the mixture. Any new planting should be deferred from livestock grazing until it is well established which may require 1 to 3 years (Schwendiman 1971).

Pests and Potential Problems

Sandberg bluegrass is susceptible to stem and leaf rusts which can significantly decrease seed production (Mosman 2005). Rust outbreaks can be prevented and controlled by applying a 14 oz rate of systemic fungicides such as Propiconazole and Azoxystrobin ('Quilt' [tm]). Always follow the label in any pesticide application.

Environmental Concerns

Sandberg bluegrass is a native perennial grass that is considered an increaser under heavy grazing conditions and is a pioneer (early colonizing species) on rangeland disturbances or surface manipulated sites. This species is a bunchgrass and seed shatter does not travel far from the parent plant. It occupies space in bunchgrass plant communities and assists with deterring invasive species encroachment due to its extensive root system.

It is recommended in mixtures on sites needing an early spring perennial grass to compete against annual weeds. Sandberg bluegrass is known to fill in interspaces between larger bunchgrasses and effectively impedes the spreading of cheatgrass (Monsen and others 2004). Seed may be consumed by songbirds, upland game birds, and small mammals and spread through feces. Sandberg bluegrass is not aggressive, and therefore is not considered to be invasive.

Seed Production

Seed should be planted in rows using a drill that will ensure a uniform 6 mm (1/4 inch) planting depth. Seeding is best in early spring (April 1 to May 15). Seed in rows with at least 45-60 cm (18-24 in) spacing on irrigated sites and 75-90 cm (30-36 in) on dryland sites.

Seed production should not be attempted on dryland sites receiving less than 380 mm (15 inches) of annual precipitation. Seed of this species matures early, so a long growing season is not necessary. However, seed production should not be attempted in areas that have a high probability of a killing frost past May 15[th]. Commercial seed production fields of Sandberg bluegrass will not produce seed the first (establishment) year. Seed production fields should be established using a rate of 150 to 250 seeds per linear meter of row (50-80 PLS/ linear foot). This will equate to 0.6 to 1.2 kg/ha (0.5 to 1 lb/ac) of pure live seed. Because of the extremely small seed size, seeding rates are often in the neighborhood of 2.2 kg/ha (2 lb/ac) because of the difficulty in metering such a small volume of seed through a drill.

Seeding in wide-spaced rows facilitates weed control and allows for more robust plant development resulting in optimum seed production. Close cultivation should occur only during the establishment year. As the stand matures, cultivation should be further away from the row, allowing

tillering from the edges and preventing damage to surface roots. There are several broadleaf herbicides that are registered for use in grass seed production fields, however, options are limited for chemical control of annual grassy weeds.

The average harvest date in south-central Montana ranges from June 24 to August 19; the harvest date varying with spring and early summer climatic conditions. Good seed production can be expected during the second and third year of production with seed production dropping off drastically the fourth year. Expected seed production is 85-175 kg/ha (75-150 lbs/ac) on dryland and 110-445 kg/ha (100-400 lbs/ac) on irrigated sites. Seed ripening is uniform enough that seed can be direct combined, but swathing and combining from a cured windrow is the preferred method of harvest.

Cultivars, Improved, and Selected Materials (and area of origin)

Various "ecotypes" should be utilized within a reasonable geographic range from the original source, since available releases are primarily source identified or selected germplasm releases and have not been progeny tested to determine their range of adaptation and performance.

Seed production field of High Plains Sandberg bluegrass at the Bridger, MT PMC. Photo by Susan Winslow.

High Plains Selected Class Germplasm of Sandberg bluegrass *(Poa sandbergii)* was released in 2000 from the Bridger Plant Materials Center. This is the first release of the *Poa sandbergii* type to the commercial seed industry. This release is a composite of three accessions originating from the high plains of Wyoming; one each from Natrona (300-350 mm precip., elev. 1,590 m), Campbell (250-300 mm precip., elev. 1,430 m), and Uinta (175-225 mm precip., elev. 1,920 m) counties. G_1 (equivalent to Foundation) seed is available to commercial growers through the Foundation Seed Program at Montana State University and the University of Wyoming. The Montana and Wyoming Seed Certification Programs will recognize G_2 (equivalent to Registered) and G_3 (equivalent to Certified) classes of germplasm.

Mountain Home Germplasm (*Poa sandbergii)* is test material from the USDA Forest Service Rocky Mountain Research Station in Boise, ID. Mountain Home Germplasm is not a release at this point, but is under commercial production and being utilized in seed mixes in the Intermountain West.

Hanford Source Sandberg bluegrass (*Poa sandbergii*) is a source identified release from L&H Seeds in Connell, Washington. The original material was collected from Hanford, Washington from an area receiving an average 6 inches of annual precipitation. It is adapted to droughty regions in the west and/or locations with well drained sandy soils.

Duffy Creek and Wallowa (*Poa sandbergii)* are source identified releases from Benson Farms Inc. Both are intended for use in arid sites throughout the western states.

Reliable Sandberg bluegrass (*Poa sandbergii)* was released by the USDA-ARS and the Utah Agricultural Experiment Station in 2004 as a Selected Class germplasm. This is a multi-origin germplasm stemming from 28 collections representing seven USDA-NRCS ecological sites. Reliable was developed for its high genetic diversity and to provide adaptation over a broad ecological range (Waldron and others 2006). G_1 and G_2 seed is maintained by the USDA-ARS Forage and Range Research Laboratory, Logan, UT. G_3 seed is available through the Utah Crop Improvement Association. Seed through the G_5 generation will be eligible for certification as Selected Class germplasm.

Canbar canby's bluegrass (*Poa canbyi)* is a cultivar release and was selected from a single collection made in the Blue Mountains, Columbia County, Washington. It is adapted to sites receiving 8 to 24 inches annual precipitation and is intended for use in basin, Wyoming and mountain big sagebrush plant communities in western states. Canbar should be used in a mixture on sites needing an early spring perennial grass to compete against annual weeds. Canbar is known to fill in interspaces between larger bunchgrasses and effectively impedes the spreading of cheatgrass (Monsen and others 2004). Foundation seed is available through the Washington State Crop Improvement Association. Breeder seed is maintained by the Pullman, Washington Plant Materials Center.

Service Sandberg bluegrass (*Poa ampla)* comes from a collection made east of Whitehorse, Yukon Territory, Canada. It is intended for use in reclamation, native habitat restoration and erosion control throughout most of Alaska (Alderson and Sharp 1994). Breeder seed is available through the Alaska Plant Materials Center, Palmer, Alaska.

Sherman big bluegrass was collected from a native population near Moro, Sherman County, Oregon in 1932

and this cultivar was released in 1945 by the Washington, Idaho and Oregon Agricultural Experiment Stations and the Pullman Washington Plant Materials Center. This is a large stature bunchgrass growing to nearly 1 meter tall (Alderson and Sharp 1994). It is intended for use in range reseeding, cropland retirement plantings, and revegetation of disturbed lands in mountain brush communities and openings in aspen and conifer forests. It is best adapted to areas that receive 10-24 inches of annual precipitation. Plants of Sherman are readily eaten by livestock and large game. Foundation seed is available through Washington State Crop Improvement Association, and breeder seed is maintained by the Pullman, Washington Plant Materials Center.

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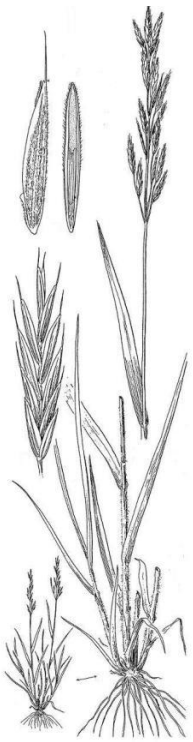
full sun to slight shade. The species withstands fall fires and controlled burns and will sprout from surviving crowns. In other cases, stands may top kill but full stand recovery occurs after a few years.

Commercial availability: Seed is readily found on the market. Sources derived from local, natural origins should be favored. Cultivated varieties are also available for use in certain regions of the West.



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Relative abundance in the wild: The species is very common in open areas, meadows, and waste places. Seed is easy to collect.

Limitations or environmental concerns: California brome spreads easily by seed and can quickly become a moderate to serious weed pest in certain agricultural crops. Its use should generally be avoided in certain areas of intensive agriculture such as fields of introduced grasses grown for seed. Seed may remain viable in the soil for several years. High seeding rates in mixes with other less competitive native grasses should be avoided. California brome is susceptible to a disease called head smut. Wild stands or fields to be harvested for seed should be inspected carefully for the disease and infected plants avoided or removed. Smut can be controlled by treating the seed with an approved fungicide prior to sowing. Leaf and stem rusts are other potential pests.

Establishment: Seed dormancy is usually absent in natural populations from low elevation so California brome can be fall or spring sown. Germination occurs in 10-14 days and seedling growth and plant development are rapid. However, seed obtained from higher elevation populations may have dormancy requiring 30-90 days of cold moist stratification (moist pre-chilling) or fall sowing for best germination. Physical conditioning of the seed to remove the awns (narrow appendage at the tip of the seed) is an option to improve flow through seeding equipment. There are 60, 000-82,000 seeds/lb with the upper range associated with de-awned seed. Therefore, each pound of seed planted per acre will result in about 1.5-2.0 seeds/sq. ft. When sown alone, the suggested rate is 8-10 lbs of pure live seed (PLS) per acre. Lower rates (1-3 lbs/ac) should be used in seed mixes with less competitive grasses.

Stand management depends on your project objectives (prairie restoration, cover crop, rotational livestock grazing, etc.). As a cover crop, the species has intermediate tolerance to mowing. Fire is an effective tool for post harvest residue management in seed production. The species decreases under heavy grazing but increases with light to moderate use.

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