

Seeding Considerations in Restoring Big Sagebrush Habitat

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Abstract—This paper describes methods of managing or seeding to restore big sagebrush communities for wildlife habitat. The focus is on three big sagebrush subspecies, Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*). Natural colonization of the native plant community may be the preferred management action on sites where native seed sources are available to successfully reestablish the desired wildlife habitat. On highly disturbed or otherwise damaged sites and where competition from weeds is excessive, seeding will be utilized to restore big sagebrush for wildlife habitat. Big sagebrush seed is never seeded alone in site rehabilitation and restoration projects. The best time to seed or interseed big sagebrush seed mixes, including grasses and forbs, is in late fall or early winter. The overall best method to reestablish big sagebrush is to use a range-land drill at a shallow setting following site preparation, including tillage and weed control. When big sagebrush is drill seeded with other seed types, it is recommended that it be seeded through a separate drill box to permit very shallow seeding and proper seed placement for plant establishment. Seedings of native plants, including big sagebrush, should be protected from grazing for at least 3 to 5 years to allow time for the shrubs and forbs to become established.

Introduction

Big sagebrush dominated plant communities occupy over 25 percent (67 million acres) of the landscape in the Great Basin region of Idaho, Utah, Nevada, Oregon, and California. A total of about 96 million acres in the Western States has historically been big sagebrush habitat (Blaisdell 1953). In some areas, over one-half of the big sagebrush areas have been severely disturbed, altered, or even removed by wildfire, grazing, prolonged drought, and other natural events or human activities. This paper will concentrate on seeding considerations for habitat restoration, including big sagebrush (*Artemisia tridentata*) subspecies Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*).

Beginning in the 1930s and 1940s, big sagebrush-dominated plant communities were reseeded to introduced forage grasses and forbs such as crested wheatgrass (*Agropyron cristatum*), Siberian wheatgrass (*Agropyron fragile* ssp. *sibericum*), alfalfa (*Medicago sativa*), and pubescent wheatgrass (*Elytrigia intermedia*). Intermediate wheatgrass (*Elytrigia intermedia*) was one of the preferred introduced species seeded on mountain big sagebrush sites, which usually have higher annual precipitation. These plant species were often used to improve forage production and reduce soil erosion after wildfires and other site disturbances.

Since the 1990s, the emphasis has been to restore wildlife habitat with a diversity of native plant species on public lands in the Western States. Seeds of many native and introduced species are commercially available, including certified cultivars and source-identified native germplasms.

Basin big sagebrush and Wyoming big sagebrush seeds are light brown to grayish brown or black and very similar in size and shape (Parkinson 2004). Mountain big sagebrush seeds are slightly larger and darker than basin big sagebrush or Wyoming big sagebrush seeds.

One proven method to obtain seed of the desired big sagebrush subspecies is to procure Certified Source Identified (SI) seed of the big sagebrush subspecies appropriate, or adapted, to the site. SI seed has been verified as to the subspecies. The SI seed is collected from mature plants growing on an identified natural site.

Identification of big sagebrush seed to subspecies may be difficult to determine just by looking at the seed. In the past, Bureau of Land Management and others that seeded big sagebrush seed were not always provided with seed of the subspecies that was specified in seeding contracts. Wyoming, basin, and mountain big sagebrush establish and thrive on sites with different environmental conditions. Using seed of the inappropriate subspecies of big sagebrush may be a reason for stand failure on some sites (Lysne and Pellant 2004).

The habitat management option of “do not seed” has been the action taken on about 50 percent of the potential rehabilitation or restoration sites on public land in the Great Basin States (Lambert and Hamby 2003). Natural colonization of native or introduced species is often allowed to occur on sites where the seeds of desired plants exist in the soil seed bank or on adjacent lands. Natural plant recovery will only be successful on those sites with adequate soil and moisture conditions and where competition from weeds is not a problem.

Some big sagebrush site restoration projects, especially those in Wyoming big sagebrush habitat, may initially require seeding for soil stabilization and weed control. These seedings may include adapted introduced plant species. At a later time, other desirable native plants can be seeded (or

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interseeded) to provide a greater diversity of native species for wildlife habitat.

Descriptions of Big Sagebrush Subspecies

Basin Big Sagebrush (*Artemisia tridentata* ssp. *tridentata* Nutt.)

Basin big sagebrush is an evergreen shrub commonly 3 to 6 feet, but sometimes as much as 14 feet tall and 5 to 8 feet wide. It is erect, spreading, and heavily branched, with an uneven top. This subspecies of big sagebrush is native to the Interior Western United States, including the Great Basin. It is found on well-drained, moderately deep to deep loam or silt loam soils, and at elevations up to 9,500 feet. The moisture regime is semidry; 8 to 18 inches of mean annual precipitation is required. Basin big sagebrush is the most abundant shrub in the Western United States aridlands (Passey and others 1982). It is sometimes interspersed with Wyoming big sagebrush, and may also occur in riparian sites. It is generally fire intolerant.

Basin big sagebrush averages 2,500,000 cleaned seeds per pound (McArthur and others 1979); seed is harvested in the late fall. The drilled seeding rate is 0.1 to 0.2 lb pure live seed (PLS) per acre in a seed mixture. Big sagebrush seed is planted very shallow (approximately 1/16 inch deep). Caution: Basin big sagebrush seed is very short-lived and may be fragile when improperly handled. The seed must be kept in cold storage (<38 °F and <25 percent relative humidity [RH]). It is recommended the seed be used within 1 to 2 years of harvest.

Mountain Big Sagebrush (*Artemisia tridentata* ssp. *vaseyana* [Rydb.] Beetle)

Mountain big sagebrush is an evergreen shrub that is usually less than 3 feet tall with a spreading and even topped crown. It is native to the Interior Western United States, including the Great Basin region. It occurs on soils that are deep and well drained with pH usually about 7.0. It is naturally found in association with mountain shrub plant communities at moderate to high elevations, up to 10,000 feet. Its moisture regime is semidry; at least 13 inches of mean annual precipitation is required to maintain a population of this subspecies. After fire, mountain big sagebrush often recovers from seed remaining in the soil. On many restoration sites, mountain big sagebrush sites do not require reseeding unless there is an overwhelming population of weedy plants. In such situations, weed control would be required prior to seeding.

Mountain big sagebrush averages 2,250,000 cleaned seeds per pound (McArthur and others 1979); the seed is harvested earlier in the fall than the other two subspecies. The drilled seeding rate for mountain big sagebrush is 0.1 to 0.2 lb PLS per acre in a seed mixture. The seed should be planted about 1/16 inch deep in the soil (Jacobson and Welch 1987). 'Hobble Creek' is a native cultivar that originated in Wasatch County, Utah, and was released by the USDA Forest Service, Shrub Sciences Laboratory, Provo, Utah (Welch and others 1986).

Caution: mountain big sagebrush seed is very short-lived and may be fragile when improperly handled. The seed must be stored in cold storage (<38 °F) with humidity maintained at <25 percent R.H. It is recommended the seed be used within 1 to 2 years of harvest.

Wyoming Big Sagebrush (*Artemisia tridentata* ssp. *wyomingensis* Beetle & Young)

Wyoming big sagebrush is an evergreen shrub usually up to 3 feet tall and usually up to 3 feet wide at maturity. It is basally branched and rounded in form with an uneven top. It is native to the Interior Western United States, including the Great Basin region. This subspecies grows on shallow, gravelly, or sandy to silt clay loams at elevations from 2,000 to 7,000 feet. Its moisture regime is dry; 7 to 14 inches of mean annual precipitation is required for Wyoming big sagebrush. It is considered to be fire-intolerant and does not resprout after wildfire.

Wyoming big sagebrush averages 2,500,000 cleaned seeds per pound (McArthur and others 1979); the seed is harvested in late fall. The drilled seeding rate for Wyoming big sagebrush is 0.1 to 0.2 lb PLS per acre in a seed mixture. The seed is planted shallow in soil (1/16 inch in depth). Cultivar: 'Gordon Creek' Wyoming big sagebrush originated in Carbon County, Utah, and was released by the USDA Forest Service, Shrub Sciences Laboratory (Welch and others 1992). Currently there is no commercial seed production of Gordon Creek. Caution: Wyoming big sagebrush seed is very short-lived and may be fragile when improperly handled. The seed must be stored in cold storage (<38 °F) with humidity maintained at <25 percent RH. It is recommended the seed be used within 1 to 2 years of harvest.

Seeding Specifications

Seeding Dates for Big Sagebrush

Late fall is the overall best time to seed big sagebrush, and rangeland drill seeding is the recommended method. Early winter is the preferred time for aerial seeding. Whichever seeding method is used, it is best to seed prior to any significant snowfall.

Seeding Requirements

A firm, packed, weed-free seedbed should be prepared on restoration sites. The best soils for establishing big sagebrush from seed are silt loam to sandy loams, deep to shallow and well drained. One of the best methods for successful establishment of big sagebrush by seed is to broadcast the seed on the soil surface and then lightly rake or harrow to barely cover the small seed. Another method of big sagebrush establishment that has been successfully used is to apply the seed with a rangeland seed drill (Truax, Tye, and so forth). The seed drill is set to place the seed very shallow, about 1/16 inch deep. The packer wheels of the seed drill should lightly cover the seed with soil. The best chance for a successful seeding is if the seed drill has a separate seed box for the big sagebrush seed.

Aerial or broadcast seeding has been successful on some sites in late fall or just prior to snowfall in early winter. Aerial seeding may not be as good a seeding method as a properly installed drilled seeding or broadcasting seeding followed by harrowing to lightly cover seed with soil (Lysne and Pellant 2004).

Seeding Rate for Big Sagebrush Subspecies

The typical drill seed rate, pure live seed (PLS), for all three big sagebrush subspecies is $\frac{1}{10}$ lb per acre in a seed mix. Basin big sagebrush has, on average, 2,500,000 cleaned seeds per pound ($\frac{1}{10}$ lb = 57 seeds per square foot). Mountain big sagebrush has 2,250,000 cleaned seeds per pound ($\frac{1}{10}$ lb = 51 seeds per square foot). Wyoming big sagebrush has 2,500,000 cleaned seeds per pound, according to McArthur (1979) ($\frac{1}{10}$ lb = 57 seed per square foot).

Seed Mixes

Challenges to Seeding Small Seeds—Big sagebrush seed is much smaller than most other species that are typically drill seeded. Big sagebrush seedlings are slow growing and often less competitive than most other species that occur in the same habitat. The best options to establish big sagebrush are to use a rangeland drill with a separate seed box for big sagebrush or broadcast seed and very lightly cover with soil. An additional option is to grow the seed in a greenhouse to produce container seedlings and then transplant to the field location, or grow the seed in a field to produce bare-root stock and transplant to the desired site.

Establishing Big Sagebrush With Understory Species—Big sagebrush subspecies are not seeded alone. Sagebrush seed is included in seed mixtures with other species, usually grasses and forbs. If big sagebrush is drill seeded, it is recommended that it be seeded through a separate drill box to permit very shallow seeding. The drilled seed mix should be installed at the PLS rate of 60 to 80 seeds per square foot. To determine a seed mix for your specific ecological situation, utilize information available through the PLANTS database (<http://plants.usda.gov/>). The PLANTS Web site includes links to *VegSpec*, a database to help with seeding prescriptions, and the Ecological Site Information System (ESIS).

The following seed mixes are examples for each of the three big sagebrush subspecies and include understory grasses and native forbs for habitat restoration projects (tables 1, 2, and 3). Examples of two seed mixes for soil stabilization and erosion control are also provided (table 4).

Checklist of Potential Causes for Seeding Problems or Failure

The seed doesn't grow when initially planted.

1. The seed selected was not appropriate for the given environment. This problem may be due to inaccurate seeding specifications or inadequate seed availability. For many native species, a local seed source may be preferable to those sources that originate further away from the seeding

Table 1—Example of generic basin big sagebrush steppe seed mix, drilled rate (PLS).

Native species	Pounds per acre
Basin big sagebrush	0.1
Rubber rabbitbrush	0.1
Bluebunch wheatgrass	2.0
Indian ricegrass, on sandy soil	2.0
Thurber's needlegrass	1.0
Sandberg's bluegrass	1.0
Bottlebrush squirreltail	2.0
Six-weeks fescue	1.0
Pale agoseris	0.2
Threadstalk milkvetch	0.2
Western yarrow	0.1
Arrowleaf balsamroot	0.2
Tapertip hawksbeard	0.2
Nineleaf biscuitroot	0.2
Fleabane spp.	0.1
Total	8.4

Table 2—Example of generic mountain big sagebrush community seed mix, drilled rate (PLS).

Native species	Pounds per acre
Mountain big sagebrush	0.1
Woods rose/mountain snowberry	0.5
Sulfur-flowered buckwheat	0.2
Idaho fescue	2.0
Bluebunch wheatgrass	2.0
Bottlebrush squirreltail	1.0
Slender wheatgrass	1.0
Pale agoseris	0.2
Woollypod milkvetch	0.2
Arrowleaf balsamroot	0.2
Tapertip hawksbeard	0.2
Sagebrush mariposa-lily	0.2
Total	7.8

Table 3—Example of generic Wyoming big sagebrush steppe seed mix, drilled rate (PLS).

Native species	Pounds per acre
Wyoming big sagebrush	0.1
Rubber rabbitbrush	0.1
Indian ricegrass (on sandy site)	2.0
Thurber's needlegrass	1.0
Sandberg's bluegrass	1.0
Bottlebrush squirreltail	2.0
Six-weeks fescue	1.0
Pale agoseris	0.2
Threadstalk milkvetch	0.2
Western yarrow	0.1
Tapertip hawksbeard	0.2
Nineleaf biscuitroot	0.2
Fleabane spp.	0.1
Total	8.25

Table 4—Samples of soil stabilization seed mixes for sites with less than 12 inches mean annual precipitation.

Species and variety	Pounds per acre
	<i>PLS, drilled rate</i>
A. Species for a sandy soil site	
Siberian wheatgrass, 'Vavilov' or 'P27'	2
Indian ricegrass, 'Nezpar'	1
Thickspike wheatgrass, 'Critana', 'Bannock', or 'Schwendimar'	1
Sand dropseed	1
Alfalfa, 'Ladak'	2
Total	7
B. Species for a silt-clay loam soil site	
Crested wheatgrass, 'Nordan' or 'Hycrest'	2
Western wheatgrass, 'Arriba'	1
Snake River wheatgrass, 'Secar'	2
Pubescent wheatgrass, 'Luna'	1
Sainfoin, 'Eski'	1
Total	7

location in terms of distance, elevation, or other site factors. The seed from nonlocal collections or seed production fields may be less well adapted to the restoration site. Seed not adapted to the site may have no or a low percentage of seeds that germinate, establish successfully, and persist over time.

2. The seed may remain dormant in the soil for varying periods of time. Most seed planted in late fall or early winter will germinate the following spring. Some seed, such as the hard-coated seeds of Indian ricegrass, may take several years under normal conditions before initiation of germination.

3. There may have been poor seed storage conditions prior to seeding. In general, seed stored for more than 2 weeks must be held in a climate-controlled warehouse with temperatures not to exceed 80 °F and 30 percent RH.

4. The seed delivered was not viable. This results when viability has declined following testing or when seed is damaged during transport or handling. To overcome this potential problem, arrange for a certified seed sampler to confirm or deny the original seed tag information by taking seed samples of the seed lots prior to mixing. Then have the seed samples sent to a certified seed lab for purity and germination or TZ tests and noxious weed seed analysis. Do not accept seed lots with low germination rates or unacceptable PLS. Acceptable germination rates or PLS percent should be determined by the agency or by the Seed Certification standards for the seed type or species. An example of the Certified seed standard minimums set for bluebunch wheatgrass are 85 percent pure seed, 80 percent germination, and 68 percent PLS (AOSCA 2001).

5. The seed was planted at too great a depth. Be sure that all seed drills and other equipment are set to install the seed in the soil correctly before you start the seeding operation.

6. The seed was damaged during application. Some damage to seed may occur with rough handling, transportation of seed to the field site, or during hydroseeding applications.

7. If seed is applied in mulch, the medium may not be capable of sustaining seed germination on dry sites. Some

temporary mulches, especially those made of recycled newsprint, can contain inks and metals that are toxic to the newly germinated seedlings.

8. The time of seeding was past the normal germination season for that species or population. This problem can vary among species. Some species will actually germinate under snow cover during the winter, while others will break seed dormancy and germinate in the following spring or summer.

The seed has germinated and later dies off.

1. Soil nutrients and moisture content are insufficient to sustain seedling growth.

2. The soil type, such as silt loam, clay loam, or sandy loam, is not capable of sustaining seed germination and seedling development of plants that were seeded.

3. Diseases, such as damping off (a fungal disease), may kill seedlings soon after germination.

Environmental conditions may cause additional stress and prevent seedling establishment.

1. Conditions that may increase seedling mortality include drought, excessive heat or cold spells, wind, flood, early frost, or late frost.

2. Competing vegetation, especially weeds such as cheatgrass (*Bromus tectorum*), will cause seedling mortality in less competitive plant species (West and Hassan 1985). Control of weeds may be essential to seedling establishment.

3. After seeding it was found that the seeding mix contained some weed seeds that germinated and took over the site. To overcome this problem, arrange for all seed lots to be tested by a certified seed lab for noxious and other weed seeds prior to mixing. Do not accept seed lots with unacceptable weed seeds on the seed lab analysis.

4. Animals and insects may have eaten the seed/seedlings. You may need to provide some manner of protection to emerging seedlings. Seedlings of native plants, including big sagebrush, should be protected from grazing for at least 3 to 5 years to allow time for the shrubs and forbs to become established.

5. The soil may lack the microorganisms and fungal mycorrhizae necessary for seedling establishment. Inoculation of seed or soil with microorganisms may be necessary for plant health.

Monitoring Seedlings

Use monitoring protocols from the BLM/NRCS Monitoring Handbook (Elzinga and others 1998) or other monitoring protocols as *determined* by the administering agency to evaluate the success of seedings. On arid sites, a seeding is often considered to be successful if at least 0.5 plants per square foot are established.

Planting Big Sagebrush Using Seedlings

On some sites in the Western United States, good establishment of big sagebrush has resulted when seedlings are planted in early spring on locations with the "best" soils and aspect (Everett 1980). Arrangements should be made with a nursery or grower to purchase or produce big sagebrush

seedlings when restoration plantings are the preferred plant establishment option. Field-grown bare-root stock or greenhouse-grown containerized plants may be used. The time of sowing seed in a production field to lifting of conservation grade bare-root stock ready for planting could be as much as 2 years. Greenhouse grown seedlings may be ready to plant within a 6 to 8 month time period.

To establish the big sagebrush seedlings it is recommended that they be randomly placed in clumps or blocks on the best sites for restoring big sagebrush. Seedlings planted in natural blocks or clumps become fertile islands of big sagebrush as they mature. These may establish additional plants throughout the adjacent areas.

Sources for Big Sagebrush Seed

Wildland Collected Seed (Source-Identified)—Big sagebrush seed is collected from natural big sagebrush stands. Most seeds of big sagebrush subspecies are sold as Source-Identified seed from wildland collection sites. Certified Source Identified seed of native plants is recommended for all rehabilitation and restoration seedings. The Source Identified Certification tag, usually yellow, verifies the species, County, State, elevation, seed lot number, and sometimes other geographic location information for the collected seed.

Commercial Seed Field Production—Certified seed, cultivars or source-identified, of native or introduced plants is recommended for all rehabilitation and restoration seedings. The Certified tag on a seed bag (blue tag) verifies the cultivar, species, location where the seed was grown, no noxious weed seed for the States specified, and the minimum percent pure seed and percent germination.

Hobble Creek is the only big sagebrush cultivar currently available in limited quantities from seed vendors. Native and introduced cultivars of other plant species are available in limited to good quantities from seed vendors (table 5).

Summary

Natural colonization of the native plant community may be the preferred management action on sites where native seed sources are available to successfully reestablish the desired wildlife habitat. On highly disturbed or otherwise damaged sites or where excessive competition of weeds occurs, seeding will be used to restore the big sagebrush for wildlife habitat.

Big sagebrush seed is never seeded alone in site rehabilitation and restoration projects. The best time to seed or interseed big sagebrush seed mixes, including grasses and forbs, is in late fall or early winter. The best method to seed big sagebrush is by using a rangeland seed drill. The seed is drilled shallowly with the seed drill set for the appropriate planting depth and PLS seeding rate. Wyoming big sagebrush sites are usually the most arid and shallowest soil sites where big sagebrush naturally occurs. Mountain big sagebrush sites are those sagebrush sites, in general, with the coolest average temperature and annual rainfall greater than 12 inches. Basin big sagebrush sites are often transitional between the foothills and mountains where the

Table 5—Partial list of commercial big sagebrush seed vendors (these seed vendors may have seed of other species also).

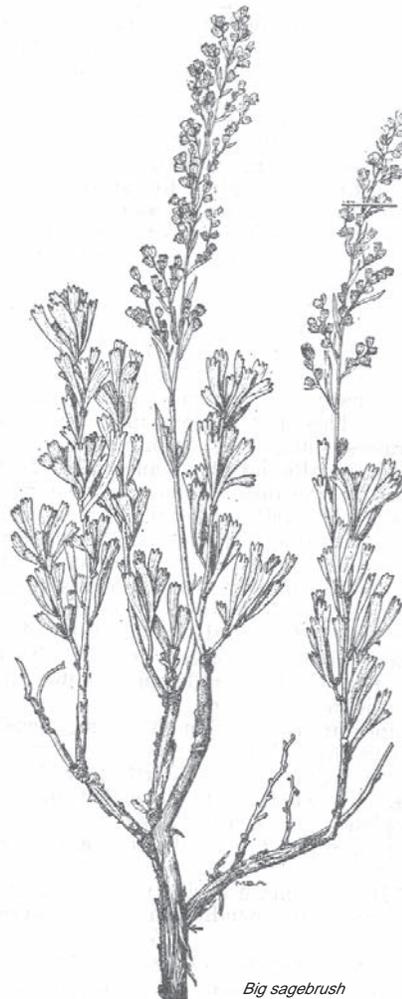
Vendor	Vendor
Barton Seed Co. 222 E. Union Street Manti, UT 84642 Phone: (435) 835-9200	Maughan Seed Co. PO Box 72 700 W. 2100 S. Manti, UT 84642 Phone: (435) 835-0401
Comstock Seed Co. 917 Hwy 88 Gardnerville, NV 89410 Phone: (775) 746-3681	NP Seed Co. 206 E. 300 S. Manti, UT 84642 Phone: (435) 835-8301
Fremont Trading Co. 450 S. 50 E. Ephraim, UT 84627 Phone: (435) 283-4701	Rainier Seed Co. PO Box 70 Port Orchard, WA 98367 Phone: (800) 828-8873
Geertson Seed Farms 1665 Burroughs Road Adrian, OR 97901 Phone: (541) 339-3768	Native-Seed Co. 7361 Pineridge Drive Park City, UT 84098 Phone: (435) 640-0557
Granite Seed Co. 1697 W. 2100 N. Lehi, UT 84043 Phone: (801) 768-4422	Plummer Seed Co. PO Box 70 Ephraim, UT 84627 Phone: (435) 283-4844
Harvest Moon Seed Co. PO Box 532 Richfield, UT 84701 Phone: (435) 979-8549	Stevenson Intermountain Seed Co. PO Box 2 Ephraim, UT 84627 Phone: (435) 283-6639
Intermountain Seed Co. Box 62 370 W. 300 N. Ephraim, UT 84627 Phone: (435) 283-4703	Southern Utah Seed Co. PO Box 124 192 W. 100 S. Junction, UT 84740 Phone: (435) 577-2142
Landmark Seed Co. N. 120 Wall St., Suite 400 Spokane, WA 99201 Phone: (509) 835-4967	Wagstaff Seed 1900 E. Oakhill Lane Wallsburg, UT 84082 Phone: (435) 654-3439

mountain big sagebrush community is found and the arid lowlands are dominated by the Wyoming big sagebrush community. Basin big sagebrush often naturally occurs on microsites with deeper soils in Wyoming big sagebrush habitat and may be found along Interior Western riparian zones. After seeding, the restored sites should be rested, or protected, from grazing for at least 3 to 5 years to allow time for the shrubs, forbs, and grasses to become fully established for wildlife habitat.

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Big sagebrush