

Information and tools to conserve and restore Great Basin ecosystems

Seeding Big Sagebrush Successfully on Intermountain Rangelands

Purpose: To provide land managers with state-of-the-art information on the establishment of big sagebrush through direct seeding.

Introduction

Big sagebrush (*Artemisia tridentata*) is the dominant shrub species on over 60 million acres of Intermountain rangeland. For much of the first half of the 20th century, big sagebrush tended to increase in cover on rangelands where understory grasses were depleted by overgrazing, prompting efforts to reduce or even eradicate this species as part of efforts to increase forage production. Its value for wildlife was eventually recognized, however, and efforts to direct-seed it as part of seed mixes for winter game range rehabilitation date from the 1960s.

More recently, devastating large-scale fires, in part a consequence of annual grass invasion, have impacted a sizeable portion of the sagebrush steppe ecosystem, especially in the Great Basin. Post-wildfire seeding of big sagebrush has been undertaken as part of reseeding efforts on large acreages. Sagebrush does not need to recruit from seed every year in order to persist on a site, so it is not too surprising that some years are not suitable for establishment from seed even on favorable sites. Poor weather for establishment can render even the most artful seeding effort ineffective. Here we discuss some of the many factors that can increase the likelihood of successful sagebrush establishment from direct seeding. By following the guidelines below, we have found that big sagebrush can be established successfully from seeding in many years, even on Wyoming big sagebrush sites, as long as they are in climatically suitable areas.

The effects of rapid climate change add a new and challenging dimension to the problem of sagebrush restoration. Bioclimate envelope modeling predicts that many drier, lower-elevation areas historically occupied by Wyoming big sagebrush will probably become climatically unsuitable for sagebrush within fifty years (Still and Richardson 2015). It is likely that we are already seeing the effects of climate change on sagebrush seedling establishment in these areas, as years with weather suitable for successful establishment occur

In Brief:

- Big sagebrush can be seeded successfully on climatically suitable sites in the Great Basin using the proper seeding guidelines.
- These guidelines include using sufficient quantities of high-quality seed of the correct subspecies and ecotype, seeding in late fall to mid-winter, making sure that the seed is not planted too deeply, and seeding into an environment with reduced competition.
- Reducing the seeding rates of highly competitive grasses will increase the chances of sagebrush establishment.
- Aerial seeding the first winter after a burn following drilling of larger-seeded species at reasonable rates is one approach for large scale-post-fire restoration projects that has been successful.



2005 Esmeralda Fire, Emergency Stabilization and Rehabilitation (ESR) sagebrush and yarrow seeding on Willow Creek Ridge, 14 miles east of Midas, Nevada. Photo taken October, 2014.

increasingly less often. Adult stands may be able to persist in areas where seeding establishment has become unlikely. This means that traditional sagebrush seeding prescriptions that worked well in most years even in marginal areas in the past now have a much reduced probability of success in these areas. After such stands are lost to wildfire, it becomes very difficult or impossible to reestablish sagebrush from seed, or even to ensure long-term persistence using transplant stock on a local scale. Seeding decisions in the face of issues associated with climate change should be based on the best science available, with close coordination between scientists and managers on the ground.

The Right Seed Lot

Big sagebrush is a complex species with a very wide ecological range, so it is not surprising that not all sagebrush seed lots are 'created equal'. The three principal subspecies occupy different habitats, with mountain big sagebrush (ssp. *vaseyana*) on higher elevation sites, basin big sagebrush (ssp. *tridentata*) on deep soils in the valleys, and Wyoming big sagebrush (ssp. *wyomingensis*) on drier upland sites at low elevation. It is important to know which subspecies is appropriate for the site to be seeded, and to make sure that purchased seed belongs to the correct subspecies. Even seeding the right subspecies does not necessarily guarantee a good fit ecologically, as each subspecies contains numerous ecotypes whose establishment and growth characteristics are fine-tuned to specific environments. Guidelines based on provisional seed zones are a good place to start (Bower et al. 2014), and purchase of certified seed collected from sites verified by inspection (www.utahcrop.org/certified-wildland) is another step closer.

A recent study examining big sagebrush seed size differences suggests that even the above precautions may not be enough to ensure that seed collections labeled Wyoming big sagebrush (larger seeds) are true to subspecies rather than mixtures that also include basin big sagebrush (smaller seeds; Richardson et al. 2015). Many sagebrush seeding failures are undoubtedly due to the planting of poorly adapted seed lots. There may soon be seed size criteria employed as part of the seed testing and certification procedure, which will increase the chances of obtaining site-adapted seed lots. Mountain big sagebrush seed is intermediate in size, but the easy test for leaf fluorescence in water under black light is a reliable subspecies indicator. When sagebrush seed is in limited supply after a poor production year and especially after a particularly severe fire season, managers have sometimes been tempted to use less well-adapted lots from distant areas. This approach is rarely successful, especially on more marginal sites.

Sagebrush Seeds – Not Built to Last

Big sagebrush is a relatively long-lived plant that can produce many millions of seeds in its lifetime. The seeds are programmed to germinate in very early spring, soon after

dispersal in the late fall or winter. Seeds can sometimes persist at very low densities in the soil seed bank for a year or two, but recovery from the seed bank after disturbance is rare (Young and Evans 1975, Meyer 1990). The seeds have a correspondingly short shelf life in storage, making it difficult to maintain quality. Extremely small seed size (1-2 million seeds per pound; Meyer 2008) combined with low initial purity makes cleaning to high purity generally cost-prohibitive, as it doubles the cost of the seed.

Consequently, commercially available sagebrush seed lots typically contain a large fraction of 'trashy' non-seed material. Seed cleaned to high purity has a longer shelf life and may become more widely available. Seed lot quality is usually defined on a pure live seed (PLS) basis. Percent purity multiplied by percent viability divided by 100 equals percent pure live seed (e.g., 15% purity x 90% viability/100 = 13.5% PLS).

Key components of maintaining high viability are controlling seed moisture content and storage at cold temperatures. The take-home for managers is to: (1) use a current-year seed lot if possible, (2) purchase seed that has been cold-stored, and (3) have a seed lot that is a year or more old retested for viability immediately prior to purchase. Use of current-year seed lots can often be practical even though seed is produced late in the season. Taking precautions to assure that the seed lot used is of high quality is essential, as poor quality seed is a common cause of seeding failure.



Sage grouse in the 2011 Indian Creek Fire native grass/forb drill seeding project area, which was overseeded with Wyoming big sagebrush. Photo taken September 2013, two growing seasons after the treatments were completed. Establishing juvenile sagebrush plants (circled) can be found throughout the stand.

Let It Snow! Weather and Timing

Because sagebrush seed requires only a short chill following dispersal to be ready to germinate (Meyer 1994), the best time to seed is when sagebrush would naturally be dispersed, namely from late fall into winter. January is generally the best month to aerial-seed. Snow cover seems to be essential for seeding success, whether the snow falls before or after the seeding. The seeds can even germinate beneath the snow and be ready for action in very early spring right after snowmelt (Meyer 1994). Seeding earlier in the fall places the seed at risk for a longer period prior to germination and could potentially cause premature fall germination, which is not the norm for this species because of its late fall dispersal, and likely would result in winterkill. Spring seedings are almost universally unsuccessful, especially on Wyoming big sagebrush sites, because the soil dries too rapidly for the tiny seedlings to get their roots established.

Seeding Methods: To Fly or Not To Fly

Sagebrush seeds must be planted on or very close to the soil surface because of their very small size. There are basically two methods--aerial seeding and surface seeding. Aerial seeding is by definition broadcast seeding. On large-scale seedings, the sagebrush seed is usually applied by helicopter or fixed wing aircraft, either in a mix or following the drilling of larger-seeded species. Important components of successful aerial seeding (in addition to those already mentioned) include the correct seeding rate (commonly expressed as PLS or pure live seed per unit area) of sagebrush relative to other species in the seeding, mixing the seed onsite and during application, and hiring an operator who has experience applying relatively small quantities of very small seeds at a consistent rate. Some form of seed bed preparation can also improve sagebrush establishment, though it is not essential in the post-burn environment. Often drill seeding of other perennials creates microsites for sagebrush establishment from aerial seeding, though this type of seed bed can be quite rough. Other alternatives are chaining or harrowing either before or after seeding.

If the cost of sagebrush seed is limiting, it is better to seed at the correct rate in swaths alternating with unseeded areas than to seed the whole area at a suboptimal rate. This is because the success of the seeding will depend on a sufficiently high ratio of sagebrush seeds to the seeds of other species, particularly highly competitive grass species. Sagebrush seed can be mixed and planted directly with other small-seeded native species that are not too competitive, such as yarrow or Sandberg bluegrass. Mixed sagebrush-yarrow seedings have been particularly successful in northeast Nevada which is a climatically suitable area.

For more intensive restoration activities on a smaller spatial scale and even in large scale seedings, sagebrush can also be surface-seeded. This can include broadcast seeding or



(Top) sagebrush and forb seeding on the 2013 Willow Fire with helicopter and bucket used for aerial seeding. Photo taken January 16, 2013. (Below) Fixed wing aerial application used for sagebrush seeding.

planting with an implement such as Truax or no-till drill (Monsen and Meyer 1990, Monsen et al. 2004). Because the seeds are so tiny, they are best not drilled at the same depth as larger-seeded species. One approach is to place sagebrush seed with seeds of other small-seeded species in a separate box on the drill and use a technique such as pulling the hose, so that the seeds are dribbled on the surface, ideally using a roller type imprinter or press wheel to firm the seed bed and press the seed into the surface. This also has the advantage of separating the seed from larger-seeded species on a small spatial scale. However, drilling can sometimes be successful even without separating the seed, especially with adequate seed bed preparation. If the seed bed is loose and sloughing, sagebrush seed can become buried too deeply even if not drilled. Conversely, seeding onto a hard, crusted seed bed is also not ideal. Pipe-harrowing following broadcast seeding can improve success, especially if the seed bed is hard or rocky.

Seeding rates that result in an average of 40 to 80 seeds per m² (4 to 7 per ft²) usually result in adequate stands of sagebrush. This corresponds to a rate of 0.08 to 0.2 lb per acre on a PLS basis for a lot that averages 1.8 million seeds per pound.

Seed at PLS lbs per acre rates between 0.16 and 0.2 for Wyoming big sagebrush, between 0.08 and 0.10 for basin big sagebrush, and between 0.10 and 0.12 for mountain big sagebrush. These rate differences correspond to subspecies differences in seed size. To determine the bulk seeding rate equivalent to a PLS pound, take the reciprocal of the desired PLS rate expressed as a proportion (e.g., 1 pound PLS per acre at 10% PLS = $1/0.10 = 10$ pounds bulk seed). As sagebrush seed is usually sold at ca. 10-15% purity, this corresponds to approximately 1-2 pounds per acre of bulk seed. The bulk seeding rate should always be adjusted according to the PLS of the lot.

Competition, Nurse Plant Effects, and Seeding in Mixes

The success of a sagebrush seeding is strongly dependent on the level of competition both from species already present on the site and species in the seed mix. Planting into a dense stand of annual grass weeds like cheatgrass or medusahead almost always results in failure. This is one reason that planting the first winter after a fire in sagebrush is highly recommended—the hotter fires generated by woody fuels are more effective at destroying the annual grass seed bank and creating a window of opportunity for shrub seedlings. If a seeding fails the first year due to unfavorable weather, it is possible to seed again in a later year, but this is much more difficult due to increased competition from weeds or other seeded species. Usually such follow-up seedings require some seed bed preparation to be successful and are carried out using mechanical equipment on the ground.

Sagebrush is also subject to the negative effects of competition from seeded grasses, especially from more competitive introduced forage grasses or when any perennial grasses are seeded at high rates. It is sometimes possible to successfully establish big sagebrush in seedings that include introduced perennial forage grasses, but a reasonable balance must be maintained. Adding a token amount of sagebrush seed that fails to establish does not demonstrate that mixed seedings always fail. Reducing the seeding rates for perennial grasses



(Top) Fixed wing aerial ESR sagebrush seeding on the 2006 Susie Fire north of Carlin, NV. Seeding was done every third swath in crucial big game winter range and sage grouse habitat. Photo looking south toward Carlin taken October, 2011. (Below) 2006 Susie Fire aerial sagebrush seeding seven years after treatment. Area was seeded in stripes with a fixed wing aircraft.

and seeding less competitive native grass species are both tactics that increase the chances for sagebrush establishment.

Seeding into established perennial grass stands can be a good way to create more structurally complex vegetation, and natural sagebrush encroachment into pasture plantings was long viewed as a problem (Meyer 1994). If the herbaceous perennial vegetation is grazed by livestock or wildlife, there are often openings that permit shrubs to establish over time. Seeding sagebrush into small-scale mechanical scalps or after low-impact tillage in perennial vegetation can also work well (Meyer 1994).

Perennial or even weedy annual vegetation can also sometimes have a positive effect on sagebrush establishment, largely because of its reliance on snow cover for successful establishment. On barren, windswept sites or in years with little snowfall, existing vegetation can act to trap snow on a small scale and provide microsites for sagebrush recruitment. One predicted effect of climate change is that years with adequate snowfall will become less frequent, making sagebrush establishment more difficult. Research has shown that local redistribution of snow cover with snow fencing can enhance sagebrush establishment under conditions of inadequate snowfall (Monsen et al. 1992). This means that if sagebrush can be established on even part of the landscape, it will act as

a seed source as well as a nurse plant to provide a microenvironment for continued recruitment. Planting early seral shrubs like rubber rabbitbrush (*Ericameria nauseosa*) with sagebrush can also facilitate continued sagebrush recruitment by trapping snow and otherwise improving seed bed conditions. Perennial grass stands can also fulfill this function if they are not too dense. Even Russian thistle has been observed to act as a nurse plant for big sagebrush on mine disturbances. Another approach has been to seed sterile wheat or rye the first year, then seed sagebrush and other species the following year, so that the standing litter from the cereal seeding creates favorable microsites for sagebrush recruitment. This approach has mostly been applied on severe disturbances.

Authors

Susan E. Meyer
USDA Forest Service
Rocky Mountain Research Station
Shrub Sciences Laboratory
smeyer@fs.fed.us

Thomas W. Warren
Bureau of Land Management
Elko District
t1warren@blm.gov

References

Bower, A. D., J. B. St. Clair, and V. Erickson. 2014. Generalized provisional seed zones for native plants. *Ecological Applications* 24: 913-919.

Meyer, S. E. 1994. Germination and establishment ecology of big sagebrush: implications for community restoration. In: Monsen S. B., and S. G. Kitchen, eds. [Proceedings, Ecology and Management of Annual Rangelands](#). 1992 May 18–22; Boise, ID. Gen. Tech. Rep. INT-313. USDA Forest Service, Intermountain Research Station: 244–251.

Meyer, S. E. 2008. *Artemisia* L.: sagebrush. In: Bonner, Franklin T.; Karrfalt, Robert P., eds. [The Woody Plant Seed Manual](#). Agric. Handbook No. 727. Washington, DC. U.S. Department of Agriculture, Forest Service. p. 274-280.

Monsen, S. B. and S. E. Meyer. 1990. Seeding equipment effects on establishment of big sagebrush on mine disturbances. In: Munkshower, F. ed. Fifth Billings Symposium on Disturbed Land Rehabilitation. Volume 1, Hardrock waste, analytical, and revegetation. 1990 March 25–30; Billings, MT. Pub. 9003. Bozeman: Montana State University, Reclamation Research Unit: 192–199.

Monsen, S. B., S. E. Meyer, and S. L. Carlson. 1992. Sagebrush establishment enhanced by snowfencing. In: Rangeland Technology and Equipment Council, USDA Forest Service Technology and Development Program 2200-Range: 1992 Annual Report: 6-8.

Monsen, S. B., R. Stevens, N. L. Shaw (Compilers). 2004. Restoring Western Rangelands, Volume 1. GTR-136-Vol 1. USDA Forest Service, Rocky Mountain Research Station: 1-294.

Richardson, B. A., H. G. Ortiz, S. L. Carlson, D. M. Jaeger, and N. L. Shaw. 2015. [Genetic and environmental effects on seed weight in subspecies of big sagebrush: applications for restoration](#). *Ecosphere* 6:art201.

Still, S. H., and B. A. Richardson. 2015. Projections of contemporary and future climate niche for Wyoming big sagebrush (*Artemisia tridentata* subsp. *Wyomingensis*): A guide for restoration. *Natural Areas Journal* 35:30-43.

Young, J. A., and R. A. Evans. 1975. Germinability of seed reserves in a big sagebrush (*Artemisia tridentata*) community. *Weed Science* 23: 358–364.

Great Basin Factsheets are developed and produced collaboratively by the groups below. Jeanne Chambers edited the factsheets, Lael Gilbert created the design and was responsible for layout, and Nolan Preece shot the photo for the masthead, which is of Monitor Valley in central Nevada.

