Establishing Big Sagebrush and Other Shrubs from Planting Stock

Reestablishment of big sagebrush and associated native shrubs following wildfire or other disturbance is critical to facilitate vegetation recovery and to provide community structure and services. Poor establishment of shrubs from seed can result from several factors, including adverse environmental conditions, herbaceous competition, the use of maladapted seed, and inappropriate seeding strategies (Monsen and Stevens 2004). The use of planting stock can circumvent some of these problems (Shaw 2004, see graphic below).

Purpose: Bareroot or container seedlings can be used to quickly re-establish big sagebrush and other native shrubs in situations where direct seeding is not feasible or unlikely to succeed. Guidelines are provided for developing a planting plan and timeline, arranging for seedling production, and installing and managing outplantings.

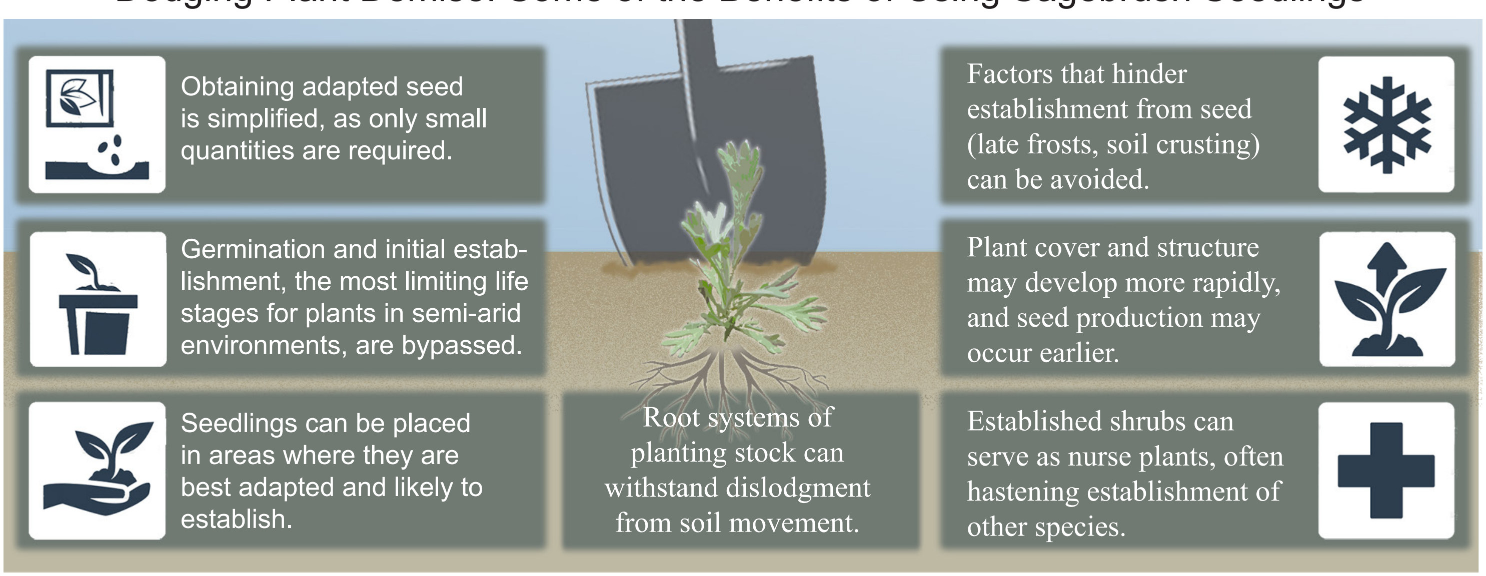
In Brief:

- The use of seedlings can avoid problems like adverse environmental conditions, competition from herbaceous plants, and unsuccessful seedings.
- Knowing your site is key, including information about vegetation composition, slope, aspect, and soil conditions.
- Selecting nurseries based on experience with the target species, type of planting stock required, and location relative to the planting site is essential.
- Proper planting technique and root placement is critical to the long-term survival and growth of bareroot seedlings.

Planning and Site Preparation

Project planning requires knowledge of site history and of pre- and post-disturbance vegetation composition. This aids in the development of management objectives to address site-specific constraints and revegetation timelines. Plan development should include stratification of the site by relatively homogeneous units based on these and additional factors (e.g., slope, aspect, soil conditions). This will aid in identifying appropriate species and sources of materials, as well as the number and size of plants required. Project areas where planting stock may be considered include post-fire landscapes, cheatgrass (*Bromus tectorum*) and crested wheatgrass (*Agropyron cristatum* complex) monocultures, and mining and energy development sites where rapid soil stabilization is required. Depending on site constraints, budget, and project

Dodging Plant Demise: Some of the Benefits of Using Sagebrush Seedlings



size, the following recommendations can be implemented to improve planting success (Shaw 2004, Wirth and Pyke 2011, Davidson 2015):

- Use species and populations adapted to site conditions. On severely disturbed sites, early seral species may be more appropriate than late seral or climax species present in pre-disturbance vegetation.
- Use furrows, pits, and mulches to collect and retain water in arid areas.
- Provide supplemental water via remote irrigation methods to establish seedlings on very arid sites or to maintain seedlings during unusually dry seasons.
- Inoculate seedlings with appropriate species of mycorrhizal fungi, if available, to increase initial plant growth and survival.
- Use erosion control structures, such as weed-free straw wattles, to reduce soil and water erosion and to provide protection for seedlings.
- If high soil surface temperatures are expected, select protected microsites and use planting stock with large stem diameter and high root-to-shoot ratios. Temperatures greater than 130 °F near the soil surface can be lethal to phloem and cambial cells.
- Retain shade (e.g., taller woody and non-woody plants, post-fire standing dead shrubs) during site preparation, but plant seedlings on microsites from which vegetation has been removed.
- Use mechanical or chemical site preparation treatments to reduce competing vegetation.
- Minimize frost heaving by planting larger seedlings, covering the root plug of container seedlings with native soil, and providing a cover of sod, litter, or debris.
- Protect seedlings from late frosts by avoiding frost-prone sites, establishing strips of rock or vegetative mulch to protect developing species, and retaining insulating ground cover material.
- Prevent damage from both above and belowground herbivory (e.g., pocket gophers feeding in the root zone and browsing by jackrabbits, other small mammals, and big game species) (Figure 1).

When designing planting configuration for each project area, consider seed dispersal characteristics, site fragmentation, understory weed cover, and plant survival probabilities. Seedlings can be planted in random patterns or in clusters or islands, using mixtures of species to create natural-appearing stands. Maximal distances between plants or islands should be based on pollination considerations. Logistical and cost considerations should also inform seedling densities and patterns. As an example, the recommended density and distance between individual plants for big sagebrush is 190 plants per acre (16 foot spacing) to 2,700 plants per acre (4 foot spacing) (Wirth and Pyke 2011). In most cases, expect density to increase over time from natural seeding.

Figure 1. Ridged mesh tubes may be used to prevent aboveground seedling herbivory.

Because most shrub seedlings are slow-growing compared to grasses, survival percentages may be reduced and time to maturity may increase substantially if they are planted with seeded grasses or amid competing weedy species. This problem may be alleviated by planting seedlings in microsites from which herbaceous competition has been removed. Organic or plastic mulches may be used to control competition in windbreak or cluster plantings.

Seed Requirements: Quantities, Sources, and Storage

Only small quantities of seed are required to produce planting stock for most projects. Seed requirements are calculated based on the number of seeds per pound of pure seed, seed purity, germination, and nursery-specific culling and mortality rates. At the Lucky Peak Forest Service Nursery near Boise, Idaho, a conservative production estimate for big sagebrush, a small-seeded species, is about 100,000 seedlings from 1 pound of cleaned seed (purity > 80 to 90%, germination > 90%, 2.0 to 2.3 million seeds per pound of pure seed, depending on the subspecies). For antelope bitterbrush, a large-seeded species, the production estimate is about 10,000 seedlings per pound of cleaned seed (purity > 95%, germination > 85%, 15,750 seeds per pound of pure seed, Bonner and Karrfalt 2008, J. Sloan, personal communication). Because production estimates vary among nurseries, it is essential to consult with nursery personnel to determine seed requirements for growing seedlings of individual species.

In or near fire-prone areas or other sites where restoration is anticipated, it makes sense to maintain seed collections from local populations. These collections can be cleaned and tested in advance and kept in storage until needed (Bonner and Karrfalt 2008). Developing a seedbank for seedling production requires little storage space and ensures that seed supplies will be immediately available even during poor seed production years. Planning for collection by provisional seed zone will help to ensure that adapted sources are available for propagation (Bower et al. 2014). If seed is not available, seed collection during the appropriate season for each species must be added to the project planning timeline. In the case of big sagebrush, it is important that the appropriate subspecies be harvested. Geneticists and plant material specialists can aid in selecting appropriate species and populations.

Seed of many Intermountain West shrub species can be stored under ambient conditions in warehouses for two or three years, often longer. A few species (e.g., big sagebrush, winterfat [*Kraschenninikovia lanata*], and rabbitbrush [*Ericameria* spp. and *Chrysothamnus* spp.]), however, are short-lived and require storage in moisture-proof containers at low relative humidity and temperature conditions. Bonner and Karrfalt (2008) provide storage requirements for many shrub species.

Propagating Plant Materials

Nurseries should be selected based on experience with the target species, type of planting stock required, and location relative to the planting site. Private and state nurseries produce seedlings under contract or on a speculation basis for the private and public sector, but there are some restrictions on state nurseries. Federal nurseries produce seedlings under contract for federal and state agencies.

The goal in seedling production is to produce stock that best fits environmental conditions at the planting site. Both container and bareroot seedlings of big sagebrush and other shrubs can be grown and outplanted successfully (Figure 2, Bonner and Karrfalt 2008, Dettweiler-Robinson et al. 2013, McAdoo et al. 2013). There are advantages and disadvantages to the use of each. As examples, container seedlings are generally more costly, though differences vary among species and nurseries. Some species, however, are easier to grow as container stock and the production period may be shorter. Nursery personnel can aid in determining seedling types, sizes, and production specifications to provide suitable high-quality planting stock.

Specifications should be included in contracts to guide grading and culling. Specifications are usually morphological (e.g., height, root length, stem diameter, dry weight, root-to-shoot ratio) because these traits are visible and generally easy to measure (Landis et al. 2010). At the Lucky Peak

Figure 2. Propagation of big sagebrush seedlings at the Lucky Peak Forest Service Nursery near Boise, Idaho: A) bareroot seedlings field seeded in May for fall harvest, and B) greenhouse-grown container seedlings about five months post-planting.

Forest Service Nursery near Boise, Idaho, for example, the standard specifications for Wyoming big sagebrush container seedlings produced in 6.3 in^3 tubes are: 6-inch height, 8-inch root length, and .08 inch stem caliper (C. Fleege, personal communication). Other measurable characteristics are physiological (e.g., dormancy level, measurements of stress resistance such as cold hardiness or root growth potential). Recommendations for use of larger containers or production of larger bareroot stock may be made if plantings are targeted for unstable or dry sites or in situations where more rapid development is essential.

The time requirement for seedling production varies with species, stock type, seedling size, and nursery location. Bareroot stock of many shrub species, including big sagebrush, can be produced in one growing season (Figure 3), but some slower-growing species require two or sometimes three growing seasons (Bonner and Karrfalt 2008). Bareroot seedlings are harvested when they are dormant in late fall and can be fall planted in some areas or held in cold or freezer storage over winter for spring planting. Container stock of many species can be produced in one year or less, with schedules varying among nursery facilities. Seedlings can be hardened off and stored outdoors or kept in cold or freezer storage until planted.

Figure 3. Bareroot big sagebrush seedlings harvested after one growing season at the Lucky Peak Forest Service Nursery near Boise, Idaho. (Scale: each ruler is 12 inches).

Planting

When to Plant

Selection of planting dates depends upon the species and planting location. Cool, overcast, humid days with light rain or snow provide optimal planting weather. Bareroot and container stock of shrub seedlings have been spring planted throughout the Intermountain West where adequate spring moisture occurs. Seedlings must be held in a dormant or hardened condition and planted before native plants of the same species at the planting site break dormancy. Non-dormant stock must be planted after danger of frost has passed, which may not occur until soils have begun to dry. In spring, drier, low elevation areas see rapid increases in daytime temperatures, which may result in water stress and plant mortality unless seedlings receive supplemental water.

Fall planting can be successful in areas with mild climates if soil temperatures and water availability permit development of new roots before winter (Wirth and Pyke 2011). Supplemental watering is essential if the soil is dry. Seedlings need adequate time for root development before the onset of cold weather. If root development does not occur before the ground freezes, the seedlings are left poorly anchored and vulnerable to frost heaving.

Planting Techniques and Tools

Proper planting technique and root placement is critical to the long-term survival and growth of seedlings. When planting bareroot stock, the roots should be placed vertically in the planting hole and fanned out against its wall. For container stock, careful handling is advised to maintain the integrity of the soil around the root plug. Seedlings should not be planted too high and root plugs should be covered with native soil to prevent desiccation and frost heaving. Soil must be carefully compacted around root systems to eliminate air pockets without crushing the roots (Figure 4, 5). When planting in heavy clay soils, however, avoid compacting soil around the planting hole as this can contribute to frost heaving.

The following tools are useful for eliminating competing vegetation and for planting seedlings (Shaw 2004; Landis et al. 2010):

- **MacLeod**: a combination hoe and rake used to remove competition and surface debris.
- **Hoedad or planting hoe**: these are available in many styles and can be used on steep, rocky and compacted sites. The back and side of the blade can be used to remove competition.
- **Planting bar**: a tool with a wedge-shaped blade and foot pedals, which is useful for planting in rocky and sandy soils. It can cause compaction if used in clay soil.

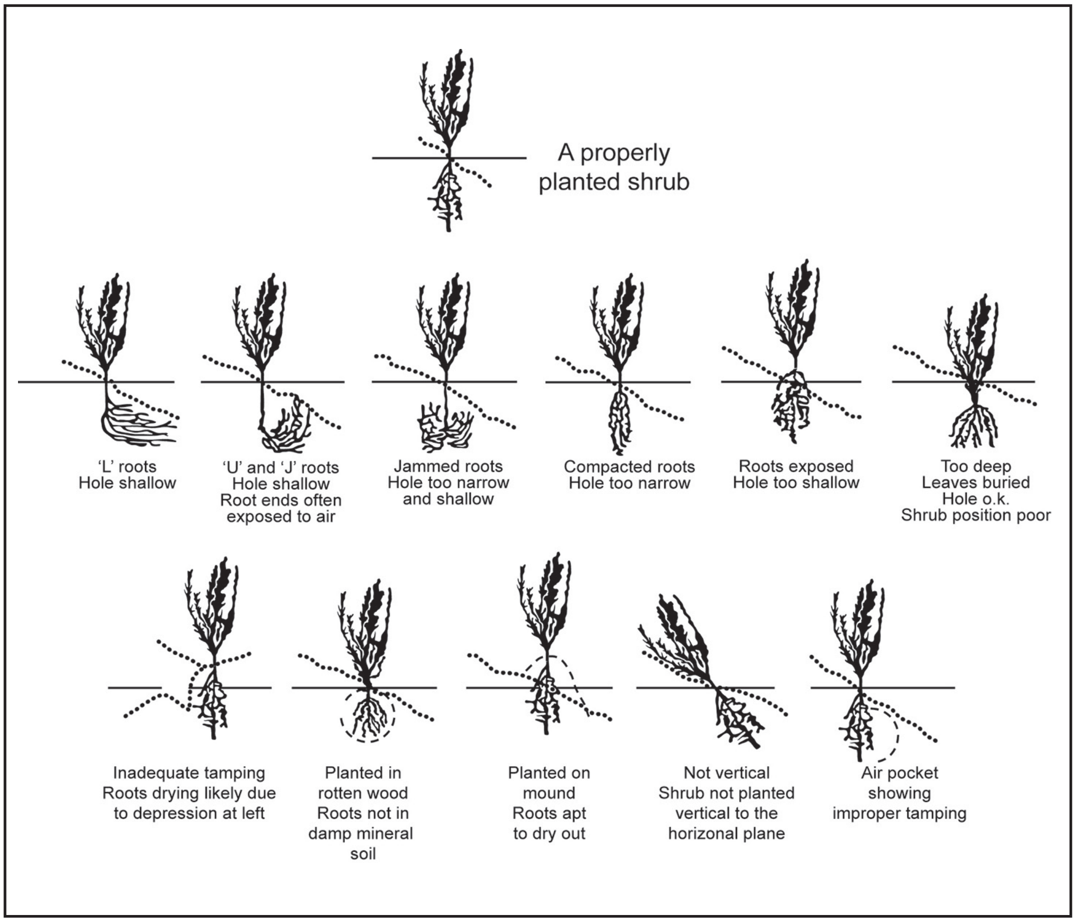
- **Planting shovel**: on this tool the reinforced blade is particularly useful for planting large stock and for planting in deep, loose soils.
- **Dibble**: a tool for planting container stock in light-textured soils. Hollow tips that match specific container sizes are available. These reduce compaction compared to solid tips and extract a core of soil that can be used to cover the top of the root plug.
- **Power auger**: gas-powered augers can be used to prepare planting holes for planting crews. They are most effective on moderate terrain with deep soil free of rocks, roots or excessive surface debris and when larger stock is being planted.
- **Transplanter**: a tractor-drawn mechanical planter that can be used to plant seedlings on flat or rolling topography that is not rocky. Transplanters are most economically used on large projects with good access. Capabilities vary among models.

Monitoring

Post-planting monitoring should be employed to evaluate seedling establishment and inform future restoration practices. Standard methods for monitoring restoration seedings and plantings may be used to assess stand development during the first two to three years. These include such measurements as seedling density, cover and vegetation gaps (e.g. Herrick et al. 2005; Wirth and Pyke 2007). Intermittent monitoring thereafter can aid in evaluating plant community development, selecting or modifying management actions, and planning future projects.

Figure 4. (*Left*) Planting big sagebrush in a microsite from which competing vegetation has been removed. The root plug should be covered with a layer of native soil to prevent wicking and frost heaving. Plants should be watered in if soil is dry.

Figure 5. (*Below*) Proper planting of bareroot seedlings and common planting errors (modified from Weadick 1976).



In addition to the standard methods, additional monitoring might include: 1) causes of mortality or predation; 2) general plant health; 3) growth rates; 4) structural development; 5) time of first seed production; and 6) spread from seed or vegetative structures. Post-planting monitoring can also provide valuable economic information such as cost per surviving seedling.

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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.