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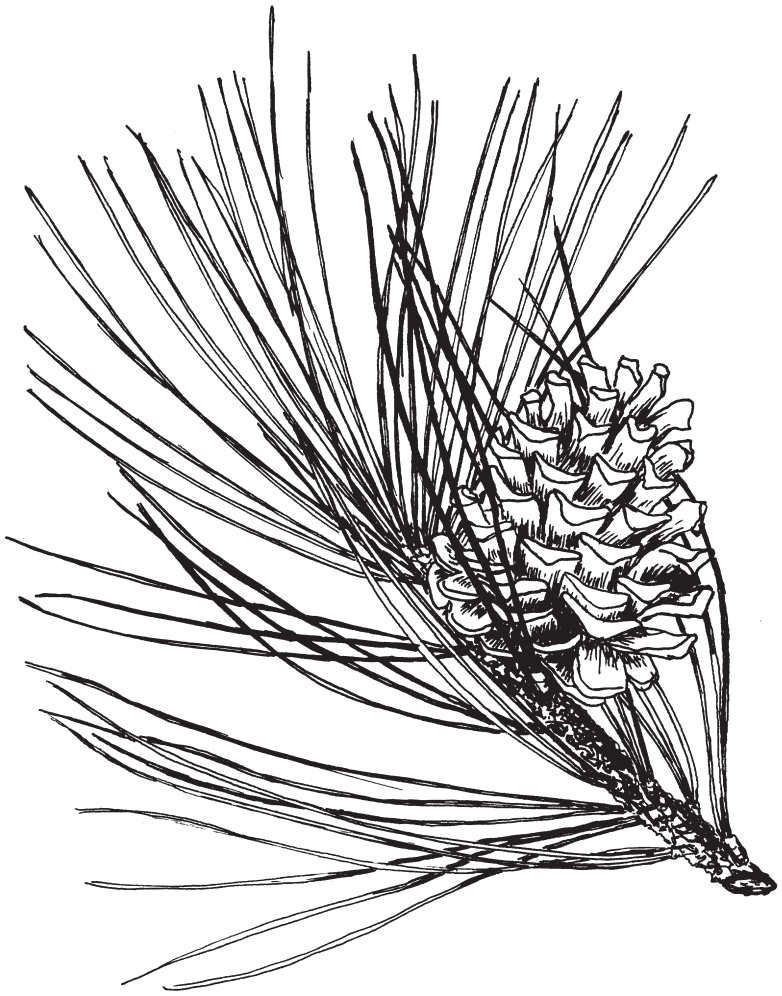

Ponderosa pine drawing by Lorraine Ashland, College of Natural Resources, University of Idaho.

Protocols for Sagebrush Seed Processing and Seedling Production at the Lucky Peak Nursery

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Abstract: This paper presents the production protocols currently practiced at the USDA Forest Service Lucky Peak Nursery (Boise, ID) for seed processing and bareroot and container seedling production for three subspecies of big sagebrush (*Artemisia tridentata*).

Keywords: *Artemisia tridentata*, seed fabric, production protocols, Wintersteiger combine, retractable-roof greenhouse, sagebrush

Introduction

Public lands in the Great Basin are experiencing uncharacteristically severe wildfires. For example, the Murphy Fire in southern Idaho in 2007 burned 243,000 ha (600,000 ac) of native rangeland. This fire resulted in a significant loss of habitat for the wildlife that rely on native vegetation for their survival (that is, mule deer [*Odocoileus hemionus*], elk [*Cervus canadensis*], sagegrouse [*Centrocercus urophasianus*]). Public land management agencies chartered to manage those affected lands and/or wildlife are committed to re-establishing native vegetation.

Since 1960, the USDA Forest Service Lucky Peak Nursery (LPN), located in Boise, ID, has processed native dryland shrub seeds and produced native dryland shrubs for public land management agencies. Production is dependent upon clients' needs. It is not uncommon for LPN to annually process several thousand pounds of seeds, and produce more than 1,000,000 one-year old dryland shrub seedlings.

Because big sagebrush is a dryland shrub of particular importance in restoration efforts, this paper will focus on the production protocols currently practiced at LPN for the following subspecies of big sagebrush: basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), mountain big sagebrush (*A. tridentata* ssp. *vaseyana*) and Wyoming big sagebrush (*A. tridentata* ssp. *wyomingensis*.). This paper is divided into three parts: seed processing, bareroot seedling production, and container seedling production. Seed collection methods are beyond the scope of this paper.

Seed Processing

Initial Drying

Wildland collections are made soon after the seeds are ripe (November), and generally continue until all seeds have fallen from the plants (usually December). The collected material is delivered to LPN for processing. All material must be thoroughly dried prior to processing. The collected material (which could contain leaves, twigs, stems, snow) is placed in shallow layers on conifer seed drying racks. A 1.5-mil polypropylene fabric (DeWitt N-Sulate™, DeWitt Company, Sikeston, MO) is placed on the bottom of each rack prior to filling with collected material to prevent seeds from falling through the screen mesh. The individual racks are stacked in such a manner to allow for airflow, which facilitates drying. The stacks of drying racks remain in the seed drying room at 24 °C (75 °F) until such time as we can begin processing the seeds. The time interval from "racking" to processing can vary from a few days to a few weeks. The longer duration of drying appears to have no detrimental effect on viability. All seed testing (purity, germination, and so on) is conducted at the Idaho State Seed Laboratory (Boise, ID).

Manual Seed Extraction

Once the seed material is sufficiently dried, it is run over a Hance Model 36 Scalper (Hance Corporation, Westerville, OH) (top screen of 14; bottom screen of 1/16). Workers position themselves on either side of the machine and hand-rub the material as it cascades down the inclined screen. This rubbing separates the seeds from the stem and screens out the coarse material, achieving a purity of 12%. This level of purity is suitable for aerial seeding by our clients. While this is an effective method, it is very time-consuming. An M2B Clipper (Seedburo Company, Chicago, IL) or similar machine could be substituted for the Hance Scalper.

Mechanical Seed Extraction

Debearders and hammermills are machines typically used to separate the seeds from the stem. In 2008, however, LPN effectively used a Wintersteiger small plot combine (Wintersteiger, Incorporated, Salt Lake City, UT) to mechanically perform this operation. This combine was set up as a stationary seed plant, with its built-in hammermill and scalper. With the front reel disengaged, one worker systematically fed the conveyor system. Another worker positioned at the rear of machine ensured adequate seed processing. This mechanical method was extremely effective in processing seeds. The target purity of 12% was achieved with some adjustments to the combine. Table 1 shows the settings for the Wintersteiger combine.

Table 1. Wintersteiger small plot combine settings for processing sagebrush seeds at Lucky Peak Nursery.

Concave	Blower	Drum Speed	Screen Incline	Screen Opening
00	Low to medium	High	Flat	3rd to 4th notch

Comparisons

Table 2 compares manual versus mechanical extraction results. Using the Wintersteiger combine, we were able to process a larger quantity of material in a shorter period of time while achieving the same test results. This was significant, as it allowed us to meet our clients' time-critical project deadlines.

Table 2. Comparison of manual versus mechanical processing methods for sagebrush seeds at Lucky Peak Nursery.

Process	Raw Weight in kg (lbs)	Processed Weight in kg (lbs)	Work Days	Purity	TZ
Manual	30 (65)	26 (58)	1	12	93
Mechanical	932 (2054)	830 (1830)	5	12	93
Total	962 (2119)	856 (1888)	6		

Mechanical Separation

Seeds processed to this point are suitable for aerial seeding. It is not suitable, however, for nursery seedling production; further processing is required. The MTDC dry dewinger was developed by the USDA Forest Service Missoula Technology Development Center for processing conifer seeds. With its variable speed drive, gum rubber-lined drum, and interior flapper, it will separate the sagebrush seeds from the capsules (feeder setting at 4; drum speed at 7.5). The vacuum attachment removes fine debris as it exits the machine. This debris often contains viable seeds, and is retained for further processing.

Air Separation

A Westrup Air Separator (McKenna Engineering Equipment Company, Incorporated, Fairfield, CA) performs the final processing step, separating the filled seeds from fine trash and empty seeds. At this point, the end product is virtually pure seeds and ready to be used for seedling production. Table 3 provides a calendar of events of seed ripening, with some processing results we could reasonably expect from the three subspecies of sagebrush of interest to LPN.

Seed Storage

Once the sagebrush seeds are processed to the level of purity possible with our machines, and once the moisture content has reached 10% or less, they are packaged in plastic resealable bags (minimum 4-mil thickness; preferably 6-mil) for long-term freezer storage at -12 °C (10 °F). There appears to be some evidence that sagebrush seeds will remain viable for some period under those conditions, based on the information presented in the Table 4. These seeds were collected, processed, and freezer-stored in 1999, and then re-tested in 2009. Additional research on this subject is being conducted jointly between the USDA Forest Service National Seed Laboratory (Dry Branch, GA) and the Rocky Mountain Research Station.

Table 4. Viability of one sagebrush seedlot stored for 10 years at Lucky Peak Nursery.

Seedlot	Year	Viability (TZ %)
BS61990005	1999	60
BS61990005	2009	59

Bareroot Sagebrush Seedling Production

Seed Preparation

No stratification is necessary prior to sowing. Sowing is usually scheduled in mid-May.

Seed test results are used when calculating the seed need (germination, seeds/lb, purity). The volume of seeds needed is based upon the industry standard sowing calculation formula. We use a target sowing density of 1800 to 2000 seeds/m^2 (160 to 180 seeds/ft^2). We assume a large percentage of viable seeds will not germinate and develop due the critical timing of irrigation water during the germination phase.

Pure sagebrush seeds are mixed with ground alfalfa meal (1:1 v:v) to increase weight and decrease static electricity. This allows the seed mix to flow through the seeder drop tubes without incident. Alfalfa meal has been used operationally at LPN since 1998, and has proven to be far superior to rice hulls as a seed mix in all our native grass, forb, and shrub seedings. A pinch of orange dust is added to each mix to increase visibility during and following seeding.

Sowing

Seeding is done with an Oyjörd seeder (JE Love Company, Garfield, WA) with the "Small Lot Device." Seeding consists of eight rows per 122-cm (48-in) wide seedbed. Once the total estimated bed length is determined for a seedlot, a gear setting (determining the revolution of the "pan") is identified on the calibration chart that will provide a whole number when it is divided into the total length. This

Table 3. Sagebrush seed maturation calendar and processing results from Lucky Peak Nursery.

Flowering Date	Ripening Date	Pre-Ripe Color	Ripe Color	Kg Pure Seeds/100 kg Collected (lb/100 lb)	Seeds/kg (Seeds/lb)	Bareroot Seedlings/kg Seeds (seedlings/lb seeds)	Container Seedlings/kg Seeds (seedlings/lb seeds)
July to September	November	Light Brown	Black	8.8 (4)	4,400,000 (2,000,000)	220,000 (100,000)	220,000 (100,000)

quotient is then used to divide the total seed volume of the seedlot. The end result virtually ensures the correct amount of seeds will be dispensed over the correct distance.

The seeds are covered by a 0.6-cm (0.25-in) sand layer following seeding. Ample irrigation is provided immediately after seeding and throughout the development of the plants. Germination should be expected within 7 days.

Production

Ample irrigation is applied to the sagebrush during the summer. The sagebrush receives 112 kg/ha (100 lb/ac) N (as urea) in two equal applications during the growing season. In mid-September, the sagebrush seedlings are root-wrenched at a depth of 25 cm (10 in) to slow height growth and to enhance the development of a fibrous root system. In many cases, the plants are also topcut to a uniform height with a tractor-mounted topcutter.

Harvest and Storage

Typically, we will harvest and process all seedlings in the fall. The maximum value for plant moisture stress (PMS) for sagebrush is -0.8 MPa (-8 bars). Molding can be a severe issue with sagebrush storage, so we ensure the foliage remains dry. No additional water is sprayed on the seedlings; seedling roots are not washed. Processed seedlings are packaged horizontally in waxed boxes without bags/liners, and freezer-stored at -2 °C (28 °F) for up to 5 months.

Container Sagebrush Seedling Production

Seed Preparation

No stratification is necessary prior to sowing. Sowing is usually scheduled in early-May.

Seed test results are conducted prior to calculating the seed need (germination, seeds/lb, purity). As pure seeds are sown into the cells, no mix is added. The number of seeds/cell is a function of seed test results, and can vary from three to seven seeds/cell.

Sowing

All container sagebrush seedlings are grown in a Cravo® retractable-roof greenhouse (Cravo Equipment Limited, Brantford, ON Canada). Because the roof and sides can open, molding issues on the foliage are minimized.

All containers are steam-sterilized at 71 °C (160 °F) prior to being filled. This is a very effective method in controlling diseases, as well as being a very efficient and safe operation. The minimum container size we use is the Styroblock® 112/106 (103 cm^3 [6.3 in^3]). The soil mix is a 75:25 peat:vermiculite mix. The seeds are mechanically sown with a Bouldin & Lawson® Precision Needle Seeder (Bouldin & Lawson, LLC, McMinnville, TN). Following sowing, a 14-g (0.5-oz) polypropylene fabric mulch (DeWitt Seed Guard™, DeWitt Company, Sikeston, MO) is laid over the top of the containers to keep the seeds moist during the germination phase (Schmal and others 2007). The fabric has been used operationally since 2003; it ensures adequate moisture will be maintained and helps moderate soil temperatures. The fabric will increase the soil temperature by 2.5 °C (5 °F) during the evening, and decrease it by 2.5 °C (5 °F) during the heat of the day. This greatly aids in uniform and rapid germination. The fabric will be removed when germination is greater than 90% and stored for future use.

Production

Because sagebrush seedlings will grow rapidly when provided ample irrigation, we limit the amount of water and fertilizer the plants receive. It is our intention to manage the shoot growth in such a way that a well-balanced plant is produced at the end of the rotation. Too much shoot growth on the plants will adversely effect diameter growth and greatly increase the risk of mold. We use a fertilizer mix of $4N:25P_2O_5:35K_2O$ at a rate of 40 ppm N.

Harvest and Storage

We will typically harvest and process all seedlings in the fall. Molding can be a severe issue with sagebrush storage, so we ensure the foliage remains dry. Processed seedlings are packaged vertically in small plastic bags (10 seedlings/bag) in cardboard boxes with plastic liners and freezer-stored at -2 °C (28 °F) for up to 5 months.

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