PRODUCING BAREROOT SEEDLINGS OF NATIVE SHRUBS Nancy Shaw

ABSTRACT: Bareroot planting stock of native shrub species is being requested for soil stabilization, range and wildlife habitat improvement, and low-maintenance landscaping projects in the Intermountain region. Shrub seedlings of a number of species are successfully grown using modifications of techniques developed for the propagation of conifers and introduced shrubs. Refinement of techniques and solutions to specific cultural problems in the production of individual species should improve the quality of stock being produced.

INTRODUCTION

Bareroot seedlings of introduced hardwood tree and shrub species traditionally used in windbreak and conservation plantings are routinely produced by many Federal, State, and private nurseries. In the Intermountain region the need, and in some cases the legal requirement (McArthur 1981), for native species to revegetate disturbed lands has led to the production of a number of native shrubs as bareroot stock. Seed and transplant stock of species suited to specific habitat types are needed for reclamation of disturbed sites, range and wildlife habitat improvement, and low maintenance landscaping.

The decision to use bareroot or container planting stock depends upon a number of factors:

1. Species required. Although some species are difficult to grow as bareroot stock, others have been successfully propagated (tables 1, 2) using modifications of cultural practices developed for conifers. Information relating to the germination and growth of related species (for example, Rosa, Rhus, or Prunus spp.) has also been app Tied. Cultural practices are being refined based on experience gained in growing native plants at specific nursery sites. Consequently, techniques and information exist that are not presently available in the literature.

2. Characteristics of the planting site. Both container and bareroot seedlings have been successfully planted on a wide variety of wildland sites, although bareroot stock generally does not perform as well on adverse sites (Hodder 1970), particularly rocky areas where there is inadequate soil to pack around the root system.

3. Scheduling. The time from seed collection to lifting of bareroot stock varies from approximately 11 months for fall lifting 1-0 big sagebrush (Artemisia tridentata) to nearly 3 years for species such as Rocky Mountain maple (Acer glabrum) that are lifted as 2-0 stock. For some species sowing and lifting may be scheduled for either fall or spring.

4. Cost. Bareroot seedlings generally cost less than seedlings grown in containers. Consequently, their use may often be justified economically. Handling and transportation of bareroot seedlings must be carefully planned to protect plants from desiccation and overheating before planting (Dahlgreen 1976). However, bareroot seedlings are much less bulky than container seedlings, and if adequate storage facilities are available, they can be transported and maintained with much less difficulty and at a lower cost (Stevens 1981).

PLANNING AND SCHEDULING

For both speculation and contract growing the source of seed or cuttings should be carefully selected. Extensive morphological and physiological variation exists among populations of individual native shrub species (Stutz 1974; Blauer and others 1975; Welch and Monsen 1981). Populations vary in their range of adaptation, growth habit, growth rates, palatability, nutrient value, soil stabilizing capability, and ease of propagation. The opportunity exists to select and market transplants using seed or cuttings from populations adapted to the planting site that exhibit characteristics compatible with specific planting goals.

Seed production of many shrub species is erratic and scheduling problems may make seed collection difficult. Seed of some minor species is not harvested regularly by commercial collectors. Seed banks may be maintained to avoid these problems. Bareroot stock of easily rooted species may be

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propagated from cuttings if seed is unavailable or difficult to germinate.

All steps in the propagation of each species must be carefully scheduled. Seed and cuttings must be collected during the appropriate season (see Plumper and others 1968; U.S. Department of Agriculture, Forest Service 1974; Hartmann and Kester 1975; Vories 1981). Adequate time must be allotted for seed processing, testing, presowing treatments, field or laboratory stratification, and field production. Most seedlings are lifted after one year's growth in the seedbed, although a few species may require two growing seasons. Seedlings may be lifted in either the fall or spring.

Antelope bitterbrush and other native shrubs have been grown at the Lucky Peak Forest Service Nursery near Boise, Idaho, during the past 10 years. Practices employed for native shrub production at Lucky Peak will be described where applicable throughout this paper.

SEED ACQUISITION AND PROCESSING

Purchase or Collection

Named varieties of several important native shrub species have been released for commercial seed production following extensive testing by the U.S. Department of Agriculture, Soil Conservation Service, and cooperating agencies (U.S. Department of Agriculture, Soil Conservation Service 1982). Seed of these releases is being produced under agricultural conditions in seed orchards or seed fields and is commercially available. The characteristics and range of adaptation of each named variety have been carefully determined. Production of shrub seed under agricultural conditions should result in improved seed quality and availability as appropriate cultural techniques are developed for each species. Other seed sources include plants of selected populations maintained at the nursery, collections from selected wildland stands, or purchases from commercial seed dealers. Seed source information should be provided with purchased seed. Acceptable purity levels for seed used for wildland plantings have been suggested by Plumper and others (1968). Acceptable germination levels are given in table 1. Seed transfer guidelines have not been established for native shrubs. For contract growing, seed of populations known to be adapted to the planting site should be obtained.

Precise timing is essential for the collection of seed from wildland stands. Maturation dates for individual shrub species range from May to February (U.S. Department of Agriculture, Forest Service 1974; Vories 1981; Wasser 1982). The exact seed maturation date for a specific wildland stand will depend upon its geographic location and local weather conditions. Species that ripen in late fall and winter must be collected nearly a year before fall sowing. Seed maturation in stands selected for seed collection should be carefully monitored. Expected crops may not develop and seed of some species such as antelope bitterbrush or snowbrush ceanothus (Ceanothus velutinus) is dispersed very quickly after ripening (U.S. Department of Agriculture, Forest Service 1974; Vories 1981).

Cleaning and Storage

Seedlots must be cleaned carefully to obtain high purity levels. Clean seed is required to maximize uniformity of seed placement and subsequent seedling development in the nursery beds. Sagebrush, rabbitbrush (Chrysothamnus spp.), and other species are often sold at low purities for rangeland seedings. Purchased seed of these species may require additional cleaning for nursery use.

Optimum storage conditions and the effect of various storage methods on the duration of seed viability have not been determined for most native plant species. Dry seed of sumac (Rhus spp.) and other species with water-impervious seed coats will remain viable for 10 to 20 years when exposed to ambient temperature and humidity conditions in open storage (Heit 1967; Hartmann and Kester 1975). Stevens and others (1981) found seed of antelope bitterbrush, fourwing saltbush (Atriplex canescens), and a number of other native shrub species to retain viability for at least 15 years in open storage. Fumigation or insecticides may be required to prevent infestation of open-stored seed.

Cold, dry storage increases the longevity of most medium to long-lived seeds and is desirable if seeds are to be stored for long periods. Seed should be placed in sealed, moisture proof containers and stored at 32° to 50°F (0 to 10°C). Below freezing temperatures (0° to 32°F [-18 to 0°C]) are most effective if the added cost is justified. The most effective moisture contents for cold, dry storage of native species have not been determined. Maximum safe seed moisture contents for cold, dry storage of many tree species is 9 percent. The relative humidity (R.H.) should be less than 70 percent and, if possible, less than 50 percent (Heit 1967; Hartmann and Kester 1975).

Cold moist storage (32° to 50°F [0 to 10"C]) at 80 to 90 percent humidity is required for such species as oak (Quercus spp.) and spring ripening maple species. Seeds of these species should not be allowed to dry prior to storage (Hartmann and Kester 1975).

Testing

Purity and germination or viability tests are used to provide an estimate of seed quality. Seeding rates are subsequently based on these tests plus determination of number of seeds per pound. Purity and seed weight are obtained following standardized procedures (AOSA 1981). Association of Official Seed Analysts (AOSA) standards for testing the germination of

Table 1.--Nursery production of native plant species

Species	Seed maturation dates[1]	Seed cleaning[2]	Acceptable purity (percent)[1]	Acceptable germination (percent)[3]	Duration of viability (years)[4]	Storage requirements[5,6,7]	Presowing treatment[8]	Stratification[5,6] Warm (numbers of days)	Cold
Bitterbrush, antelope	6/25-8/15	4-2-4-5	95	90	16+	open or cold,[9] dry	none	none	60-90
Buffaloberry, silver	8/1-9/30	3-6-4	98	80	11-15	cold, dry	none	none	0-90
Ceanothus, redstem	7/10-8/15	6-4	98	85	16+	open or cold, dry	hot water	none	60
Chokecherry, common	7/25-9/15	3-6-4	98	70	4-6	cold, dry	none	none	120-160
Cliffrose, Stansbury	7/5-8/10	2-4-5	95	85	16+	open or cold, dry	none	none	30
Currant, golden	7/20-8/10	3-6-4-5	98	65	16+	dry, sealed	none	none	60
Dogwood, redosier	8/20-9/10	3-6-7-4	95	85	4-6	cold, dry	none	none	60-90
Elder, blueberry	8/15-9/25	3-6-4-5	95	50	16+	cold, dry	none	none	98
Ephedra, green	7/15-9/1	6-2-4	95	85	16+	open	none	none	none
Eriogonum, Wyeth	7/25-8/20	6-2-4	95	75	4-6	- - - -	none	none	none
Hawthorn, river	8/15-10/15	3-6-7-4	95	70	16+	cold, dry	H_2SO_4 (15 min. dry seed only)	none	84-112
Juniper, Rocky Mountain	9/1-12/30	2-6-4	98	60	16+	cold, dry	none	120	120
Maple, Rocky Mountain	8/1-9/30	2-4	90	85	0-3	- - - -	none	none	180
Mountain mahogany, curlleaf	7/10-9/1	2-4-5	90	80	16+	open or cold, dry	none	none	36
Rabbitbrush, rubber	10/15-12/30	2-4	10-15	75	0-3	open	none	none	120
Rose, Woods	9/1-11/30	3-6-4	95	70	16+	cold, dry	none	none	30-365
Sagebrush, big	11/5-1/15	1 or 2-4	8-12	80	4-6	- - - -	none	none	0-10
Saltbush, fourwing	10/20-3/1	1-4	95	50	16+	open	none	none	30-50
Serviceberry, Saskatoon	7/10-9/15	3-6-7-4	95	85	16+	cold, dry	none	none	120-180
Snowberry, common	8/10-9/15	3-6-4	95	80	7-10	open or cold, dry	H_2SO_4 (60 min)	20-60	60-300
Sumac, skunkbrush	6/20-10/10	3-6-4	95	40	16+	open or cold, dry	hot water	none	30-90
Winterfat common	9/25-11/25	2-4	50	85	0-3	cold, dry	none	none	none

[1]Purities listed are recommended minimum acceptable levels for rangeland seedlings (Plummer and others 1968).

[2]Key: 1. Hammermill; 2. Barley debearder; 3. Dybvig with water; 4. Two screen fan machine; 5. Gravity table; 6. Dry; 7. Seed grindermacerator. Jorgenson, K.; Stevens, R., Ephraim, UT: Data on file at Great Basin Experimental Area; 1982.

[3]Recommended minimum acceptable levels for rangeland seedings. Jorgensen, K.; Stevens, R., Ephraim, UT: Data on file at Great Basin Experimental Area; 1982.

[4]Open warehouse storage. Stevens and others (1981).

[5]Vories (1981).

[6]U.S. Department of Agriculture, Forest Service (1974).

[7]Heit (1967).

[8]Treatments used at Lucky Peak Nursery.

[9]Open storage - ambient conditions. Cold, dry storage - dried seed stored under refrigeration at 0° to 50°F (-18° to 10°C) in sealed containers (R.H. of 70 percent or less).

Table 2.--Nursery production of native plant species[1].

Species	Sowing date	Hand or broad-cast sowing	Pruning Top	Pruning Root	Lifting considerations	Production period	Persistent leaves	Vegetative propagation	Special considerations
Bitterbrush, antelope	Fall[2]				Lateral roots strip easily	1-0	X[3]		Treat seed with captan
Blueberry, elder	Fall		X	X	Thick taproot	1-0			Stratified seed germinates over 2-year period.
Buffaloberry, silver	Fall					1-0 or 2-0			
Ceanothus, redstem	Fall					1-0	X		Short seed collection period. Insect predation of seeds common. Seedlings subject to damping off, stem rot.
Chokecherry, common	Fall					1-0			
Cliffrose, Stansbury	Fall				Lateral roots strip easily	1-0	X		
Currant, golden	Fall					1-0		Hardwood cuttings	
Dogwood, redosier	Fall					1-0 or 2-0			
Ephedra, green	Fall, spring				Fragile roots	1-0			
Eriogonum, Wyeth	Fall, spring			X	Taproot	1-0	X		Insect predation of seeds common.
Hawthorn, river	Fall					1-0			Dry fresh seed several weeks prior to acid treatment. Seed lots frequently do not germinate uniformly.
Juniper, Rocky Mountain	Summer					2-0	X		
Maple, Rocky Mountain	Fall					1-0 or 2-0			
Mountain mahogany, curlleaf	Fall					1-0	X		
Rabbitbrush, rubber	Fall, spring	(X)	X	X	Large taproot	1-0	X	Wildings	
Rose, Woods	Fall					1-0			
Sagebrush, big	Fall, spring	(X)	X	X	Large taproot	1-0	X	Wildings	
Saltbush, fourwing	Fall		X	X	Large taproot, brittle stems	1-0	X		Low seed fill.
Serviceberry, Saskatoon	Fall					1-0			
Snowberry, common	Late summer, early fall					1-0 or 2-0		Stem cuttings	Warm stratification more effective than acid treat
Sumac, skunkbush	Fall				Large taproot	1-0		Root cuttings	
Winterfat, common	Fall, spring	X	X	X	Large taproot	1-0	X		Fluffy seed - not free flow-ing.
Willow, Scouler			X	X	Extensive root system	1-0		Hardwood stem cuttings	

[1] Based on production experience at Lucky Peak Nursery.
[2] Species normally sown in fall may be artificially stratified and sown in spring.
[3] Normally deciduous, but may retain leaves in nursery.

individual native shrub species have not yet been established. Consequently, each seed laboratory has developed or adopted procedures for germinating commonly tested species.

Individual populations of a single shrub species may vary widely in germination requirements. In addition, the prolonged stratification periods required to release the dormancy of many shrub species (Vories 1981) decrease the usefulness of germination tests. Tetrazolium chloride tests of seed viability are frequently substituted for germination tests. At present, tetrazolium chloride test results for native shrubs are generally higher and more consistent than germination results, as not all viable seed will germinate under the less than optimum germination conditions provided.

Conditioning

Some native shrub species require presowing treatments to release various forms of seed dormancy (Heit 1971; U.S. Department of Agriculture, Forest Service 1974; Vories 1981; table 1). Acid or mechanical scarification, dry heat, hot water, hormone applications, and other chemical treatments are commonly used. The level of treatment required varies with accession and condition of the seedlot.

Dormancy requirements of many native shrub species are met by fall seeding. Heit (1968) found fall seeding of many dormant species fulfilled cold stratification requirements and provided increased seedling production, more uniform stands, maximum first year production, and less disease loss compared to spring sowing. He provided fall sowing recommendations for 55 shrub species. Species requiring moist, warm stratification may be sown during the late summer or early fall, watered, and covered with a layer of polyethylene or other mulching material. Artificially stratified seed of dormant species and seed of nondormant species such as rabbitbrush and winterfat (Ceratoides lanata) may be sown in spring.

Seed should be artificially stratified if it is unlikely that an adequate stratification period would be provided in the nursery. Artificial stratification is also an alternative if seed is not available at the time of fall seeding or when fall seeding is impossible due to weather conditions. Spring sowing also provides a means of controlling seedling size.

Sowing

Newly developed nursery drills such as the Love-Oyjord are capable of sowing seeds with a wide range of sizes and shapes. Seed must be carefully cleaned to facilitate uniform distribution and prevent clogging of the drill drop tubes. Seed of big sagebrush, which averages well over 2,000,000 seeds per pound (4,400,000 per kg) (Plummer and others 1968), for example, can be successfully seeded through such drills if first cleaned to a purity of 80 percent or greater. Other nursery drills that were developed for conifer seed are difficult to calibrate and cannot be used to sow small-seeded species.

Seeding Rate

Optimum seedling densities have not been established for native shrubs. Densities selected depend upon the species sown, geographic location of the nursery, size requirements for lifted seedlings, and other nursery conditions. Most shrubs grow rapidly compared to conifers and can be lifted as 1-0 stock. Fourwing saltbush, blueberry elder (Sambucus cerulea), big sagebrush and related species develop extensively branched shoot systems, large taproots, and spreading, lateral root systems, particularly when grown at low densities. Although they grow rapidly, species such as common chokecherry (Prunus virginiana) and curlleaf mountain mahogany (Cercocarpus ledifolius) usually produce one main shoot and only moderate sized root systems. Slowly developing species such as silver buffaloberry (Shepherdia argentea) and Rocky Mountain maple may be lifted as 2-0 stock and are normally planted at higher densities than species on a 1-0 rotation. Desired densities for native plant species range from 16 to 25 per square foot (172 to 269/m^2) at the Lucky Peak Nursery.

For many shrub species, the amount of seed required to produce a requested number of seedlings may be only estimated. Culling rates and seedbed mortality figures have not been established for individual species at most nurseries because too few seedlots have been sown to provide adequate data. In addition, these figures tend to vary with the seed accessions being grown. At the Lucky Peak Nursery, seedbed mortality for bitterbrush is estimated to be approximately 35 percent and the culling rate 15 percent. A seedbed mortality figure of 40 percent and culling rate of 20 percent are used for all other native plant species.

The following equation may be used to calculate the amount of cleaned seed required to grow a specified number of plantable seedlings. Data for typical seed lots and constants for production at the Lucky Peak Nursery were used to calculate the amount of seed needed to produce 1,000 plantable seedlings of antelope hitterbrush and fourwing saltbush.

$$Wt. (lbs.) = \frac{N}{(P)(G)(n)(1-M)(1-C)}$$

Symbols	Antelope bitterbrush	Fourwing saltbush
N = number of plantable seedlings required	1,000	1,000
P = purity (decimal)	.95	.95
G = germinability (decimal)	.90	.50
n = number of seeds per pound	21,900	58,000
M = seedling mortality (decimal)	.35	.40
C = culling rate (decimal)	.15	.20
Wt(lbs.) = weight of seed required to produce N seedlings	.10 lb	.08 lb

Seeding Depth

Shrub seeds vary in size from those of the common chokecherries (4,790 per pound [10 538 per kg]) to rockspirea (Holodiscus discolor) (5,340,000 per pound [11 748 000 per kg]) (Grisez 1974; Stickney 1974). Seeds should be sown at approximately 1.5 times seed diameter, or slightly deeper in light soils or for fall seedings (Williams and Hanks 1976). Small-seeded species are easily sown too deep. They should be drilled into shallow, open furrows and mulched lightly to regulate the planting depth.

Seed of shrubs such as winterfat and rabbitbrush do not flow freely. These and any other species that cannot be satisfactorily seeded with available equipment may be hand sown in drill marks and covered. Alternatively, seed may also be broadcast mechanically or by hand. Small seeds can be broadcast on a prepared seedbed and covered using a lightweight drag. The seedbed may be prepared using a roller, cultipacker, or other imprinter. Trashy or fluffy seed such as winterfat, rabbitbrush, Apache-plume, (Fallugia paradoxa), or western virginsbower (Clematis ligusticifolia) can be broadcast on an imprinted or rough surface. However, these seeds cling together and are not effectively covered with drags. They should be incorporated in the soil surface by running an imprinting implement such as a cultipacker over the seeded beds.

NURSERY CULTURE

Cultural requirements for most native shrub and tree species have not been determined. Practices in use include a combination of standard propagation techniques modified through on-site experience and observations of seedling development, growth rates, and morphological characteristics of individual species.

Mulching

Mulching fall-sown seedbeds reduces erosion, frost-heaving, drying, and crusting; protects seeds from cold; and reduces weed growth. Spring-sown seed may be mulched to retard surface evapotranspiration and regulate seeding depth. Well-watered seedbeds may be covered with a polyethylene film or any of a variety of materials commonly used as mulches (Hartmann and Kester 1975). Seedbeds may be rapidly covered by hydromulching. Mulch net, burlap, or snow fencing may be placed over the mulch to protect it from high winds. Mulches provide a uniform environment for overwinter stratification. They may be left in place to prevent premature germination where late frosts are a hazard. Rapid germination results when they are removed (Heit 1968; Hartmann and Kester 1975; Williams and Hanks 1976).

Irrigation

Once established, many species from arid sites require less irrigation than species from more mesic sites. Although it may not be possible to provide separate irrigation regimes for individual species, it may be possible to group species from similar vegetative communities within compartments or nursery fields.

Throughout the germination period, the soil surface must be kept moist to maximize seed germination and seedling emergence. This may be difficult to accomplish as the soil surface is subject to wide fluctuations in temperature and moisture supply. This problem is accentuated for small-seeded species sown at shallow depths and for seedlots with low germination rates and long germination periods. If a number of species are fall-planted without mulching, germination of individual species may occur at various times during a 2- to 3-month period. Fall or spring mulching of fall-sown seedbeds and removal of mulch after the danger of spring frosts has passed serves to minimize this problem by promoting more uniform germination, reducing the length of the germination period, and decreasing the length of time the surface of the seedbeds must be kept moist. Fungal infections are of concern in the production of antelope bitterbrush, fourwing saltbush, mountain mahogany, and other native plants. Emergence may be enhanced by surface-sterilizing the seeds or dusting the seeds with a fungicide such as captan (Booth 1980). If seedling mortality is noted, water should he applied only sparingly.

Fertilization

Native plants are generally faster growing and less demanding of nutrients than conifers. If adequate nutrient levels are established before seeding, deficiencies of most elements are not likely to occur (Smith 1979). Nitrogen applications are usually necessary, particularly if high carbon-nitrogen ratios develop as a result of mulching. Conifers and shrubs normally receive similar fertilizer treatments at the Lucky Peak Nursery. Two thousand pounds per acre (2 245 kg/ha) of 6-2-0 Milorganite is incorporated into the soil prior to sowing. Annionium nitrate (34-0-0) and superphosphate (0-46-0) are applied as side dressings.

Weed Control

Soil fumigants may be applied to nursery beds before shrub seeding to reduce weed problems. However, late August or early September fumigation with methyl bromide (98 and 67 percent) at 249 and 349 lbs/acre (280 and 392 kg/ha) followed by seeding of broadleaf species has produced unsatisfactory results in northern Plains nurseries (Riffle 1976). Poor seed germination and erratic growth during the first growing period following fumigation were attributed to decreased endomycorrhizal spores in the soil and endomycorrhizal development on seedlings (Riffle 1980). The use of fumigants such as Mylone that eliminate root pathogens but are not harmful to mycorrhizal fungi was recommended.

Most native shrub seedlings are weeded mechanically or by hand as herbicide recommendations are not available for individual species. Lohmiller and Young (1972) believed that herbicide recommendations established for agricultural species could be transferred to related wildland shrubs following simple testing. They found that preemergence herbicide techniques developed for peanuts and soybeans could be applied to several leguminous shrubs.

Several introduced hardwood species as well as antelope bitterbrush and common chokecherry have been included in the Western Forest Tree Nursery Herbicide Study (Abrahanison 1980; Ryker 1979). Ryker (1979) found postsowing and postgermination applications of bifenox reduced height growth of antelope bitterbrush and common chokecherry while postsowing and postgermination applications of DCPA were safe for common chokecherry. Enide has been used as a post-emergence herbicide for antelope bitterbrush at the Lucky Peak Nursery. Nursery managers should test promising herbicide treatments by applying them to test plots of individual species at the nursery site before large scale application (Sandquist and others 1981).

Pruning

Many shrub species grow rapidly, producing highly branched shoots (fourwing saltbush, big sagebrush) or shoots with numerous large leaves (blueberry elder, smooth sumac) during the first growing season. Large plants dominate smaller or later germinating seedlings, resulting in a lack of plant uniformity. Top pruning larger seedlings encourages more uniform growth and improves shoot/root ratios because smaller seedlings are released from competition. Top pruning early in the season promotes the development of larger branches on the lower stems (Williams and Hanks 1976). Seedlings may also be top or side pruned in the nursery during the dormant season or in the packing shed after lifting to provide a more desirable size for packing and planting.

Roots are pruned to increase seedling uniformity, stimulate fibrous root development, and improve shoot/root ratios. Severing the taproot of bitterbrush, fourwing saltbush, blueberry elder, and other species early in the growing season serves to stimulate lateral root growth. The fibrous roots that develop are stronger and less easily damaged during lifting. Pruning taproots of rapidly growing species one or more times during the growing season at increasing depths (for example, 4, 6, and 8 inches [10, 15, and 20 cm] also prevents the development of a thick root at the normal lifting depth. If these thick taproots are damaged during lifting, the open wound can easily be infected with disease organisms.

Lateral root pruning is used to increase fibrous root development, control seedling size and facilitate lifting. Roots of some species (for example, shrubby penstemon [Penstemon fruticosus]) may intertwine in the nursery bed and must be separated by hand during sorting.

SEEDLING HARVESTING AND STORAGE

Lifting

Shrub seedlings are frequently lifted in the spring, and usually break dormancy earlier in the spring than do conifers. They may also be lifted in the fall for immediate planting, when weather and soil conditions are favorable. Fall lifting and overwinter storage is a third option, especially for stock that must be planted early in the spring before weather conditions would permit lifting. Fall lifting and overwinter seedling storage also serve to reduce the spring workload and free bed space for sowing. Seedlings should not be lifted in the fall until they are adequately hardened by exposure to low temperature or frosts, or following leaf fall (Williams and Hanks 1976).

Species with fragile root systems or brittle shoots are easily damaged during lifting, packing, and planting. Plants that produce extensive root and shoot systems that have not been adequately pruned are bulky and difficult to pack and plant without damaging the plants or reducing survival.

Grading

Grading criteria have not been established for most native plant species. If possible, seedling specifications should be developed with the customer before sowing. Several factors should be considered in establishing specifications for individual species and orders. First, past outplanting experience may indicate morphological or size characteristics of seedlings that are correlated with transplanting success. For example, Carpenter (1983) recommends that only those antelope bitterbrush seedlings with branched stems should be used as this characteristic seemed to be indicative of an adequate root system for field planting (table 3). Second, seedling size requirements are related to planting site conditions; larger seedlings are generally required for more adverse sites. Third, size specifications may be modified to fit the proposed planting method. Seedlings with bulky root and shoot systems are difficult to plant using standard planting tools or mechanical tree planters. Fourth, customers may have individual preferences based on planting goals or past experience.

Table 3.--Grading and first year field survival of antelope bitterbrush seedlings at Lucky Peak Nursery. Nursery bed density 17.6 seedlings per square foot (180 seedlings/m²).

Grading Criteria	Size Class I	Size Class II	Size Class III
Shoots			
length (inches)	4.7 (4-6)	6.5 (6-8)	8.8 (>8.0)
branching	branches <1/3 length of main stem	branches equal main stem length	branches equal main stem length
dry wt. (g)	0.5	1.2	1.9
Roots			
length (inches)	9.5 (8-10)	9.8 (8-10)	10.7 (10-12)
description	taproot - few short lateral roots	taproot - few lateral roots	taproot - few lateral roots
dry wt. (g)	0.4	0.8	1.0
Outplanting			
Percent of plantable seedlings	13	79	8
survival (percent)	88	88	90

Storage

Fall-lifted seedlings of deciduous species may be held in frozen storage at 28°F (-2°C) for extended periods. Seedlings must be protected from desiccation. At the Lucky Peak Nursery antelope bitterbrush and other shrubs may be fall-lifted for immediate planting at local sites. Seedlings not planted are packed in Kraft bags with polyethylene liners and stored in coolers at 28°F for spring planting (Carpenter 1983; Carpenter, personal communication). Fall-lifted seedlings with persistent leaves are subject to mold infection if held in cold storage and may be more successfully stored by "heeling in", although the success of this technique depends upon local weather conditions. At Lucky Peak spring-lifted shrubs are refrigerated at 32° to 34°F (0° to 1°C) in Kraft bags for periods of 1 to 3 months prior to planting.

VEGETATIVE PROPAGATION

Some species of native plants are more easily and economically produced from cuttings than from seed. Vegetative propagation is also used to maintain the genetic identity of stock with desirable characteristics. Such easily rooted species as willows (Salix spp.), poplar (Populus spp.), and cottonwood are often produced from hardwood cuttin s. Oldman wormwood (Artemisia abrotanum), Absinthium (A. absinthium), willow (Salix spp.), and currant (Ribes spp.) have been grown from cuttings at t e Lucky Peak Nursery.

Hardwood or semi-hardwood cuttings of the wormwood species root readily and may be collected and planted immediately without callusing. Cuttings may be made when the plants are dormant or during the growing season. Most species that can be propagated vegetatively in the nursery are grown from hardwood cuttings. Hardwood cuttings are inexpensive and are easily collected, handled, stored, and propagated. Cuttings may be collected from stands near the planting site or from cutting blocks maintained at the nursery. Cuttings are taken during the dormant period from healthy, moderately vigorous plants growing in full sunlight. Wood from the previous season's growth should be selected. Individual cuttings should include at least two nodes and may be from 4 to 30 inches (10 to 76 cm) in length and from 0.25 to 1.5 inches (0.6 to 3.8 cm) in diameter (Hartmann and Kester 1975; Williams and Hanks 1976).

Cuttings of species that do not root readily may be treated with a root-promoting substance such as indolebutyric acid, naphthaleneacetic acid, or indoleacetic acid. Indolebutyric acid at concentrations between 500 and 10,000 ppm (0.05 to 1.0 percent) is commonly used with higher concentration usually being more effective for hardwood cuttings. Fungicides such as captan or benomyl may be applied in combination with rooting compounds. Cuttings should be allowed to callus for several weeks in cold storage before planting. Dormant cuttings are planted 2 to 4 inches (5 to 10 cm) apart within rows of the nursery bed with at least one bud above ground. They should be watered frequently as roots begin to develop. Willow, currant, wormwoods, poplar, and other rapid-growing species can normally be lifted as 1-0 stock.

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